# *RELATIONSHIP BETWEEN CLIMATE CHANGE STRATEGY, RISK MANAGEMENT, CARBON ACCOUNTING AND CORPORATE FINANCIAL PERFORMANCE*


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*To all those who try to make the world a better place*

*I met a traveller from an antique land*
*Who said: "Two vast and trunkless legs of stone*
*Stand in the desert . . . Near them, on the sand,*
*Half sunk, a shattered visage lies, whose frown,*
*And wrinkled lip, and sneer of cold command,*
*Tell that its sculptor well those passions read*
*Which yet survive, stamped on these lifeless things,*
*The hand that mocked them, and the heart that fed:*
*And on the pedestal these words appear:*
*'My name is Ozymandias, king of kings:*
*Look on my works, ye Mighty, and despair!'*
*Nothing beside remains. Round the decay*
*Of that colossal wreck, boundless and bare*
*The lone and level sands stretch far away."*

*Ozymandias*

*Percy Bysshe Shelley, 1792 - 1822*

# DECLARATION

This dissertation is the result of my own work and includes nothing, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or whole, to any university or institution for any degree, diploma or other qualification.

Signed:____________________________________________________________

Date:_______________________________________________________________

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# Abstract

The aim of this study is to examine the various climate change management practices adopted by firms and how these practices affect their financial performance. We examine three dimensions of climate change management: Strategy, Risk Management and Carbon Accounting and Reporting. We demonstrate that devoting corporate resources in the implementation of climate change strategies, in the identification, assessment and management of climate change risks and in the accurate and precise accounting and reporting of carbon emissions enhances the financial performance of firms. Furthermore we detect a positive relationship between carbon emissions reductions and increased financial performance. Finally we show that the above relationships between corporate climate change practices, carbon reductions and financial performance have the tendency to become stronger throughout the years. In order to prove the validity of our claims, we develop specific climate change corporate indexes that measure the level of corporate commitment regarding climate change strategy, risk management and carbon accounting and reporting. We use the above indexes to assess the level of corporate commitment of the largest companies in the oil and gas sector and in the banking sector in order to prove our research hypotheses.

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# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ACC_REP | Core Business Carbon Accounting and Reporting |
| ADV_ACC | Advanced Carbon Accounting Practices |
| CARB_RED | Carbon Reduction |
| CCS | Carbon Capture and Storage |
| CDM | Clean Development Mechanism |
| CDP | Carbon Disclosure Project |
| Ceres | Coalition for Environmental Responsible Companies |
| CERs | Certified Emission Reductions |
| CHP | Combined Heat and Power |
| CO2 | Carbon Dioxide |
| CONP_MGM | Carbon Compensation Strategies |
| CSR | Corporate Social Responsibility |
| ETS | Emissions Trading Systems |
| EU ETS | European Union Emissions Trading System |
| EUA | European Union emissions Allowances |
| GHGs | Greenhouse Gases |
| GRI | Global Reporting Initiative |
| ORG_MGM | Climate Change Organizational Management Strategies |
| PHYS_RISK | Physical Risk Management |
| REG_RISK | Regulation-induced Risk Management |
| REP_RISK | Reputation - induced Risk Management |
| RES | Renewable Energy Sources |
| ROA | Return on Assets |
| ROE | Return on Equity |
| TECH_MGM | Carbon Reduction Technology Strategies |
| TOBIN | Tobin’s Q |

# LIST OF APPENDICES

# 1 INTRODUCTION

Climate Change has been widely acknowledged as one of the major sources of risk by the global community. As a natural phenomenon, is has been associated with global temperature rise which directly affects global meteorological patterns. However this global temperature rise is not considered a natural phenomenon but it is rather being attributed to human activities, which during the last one hundred years have resulted in the rise of Greenhouse Gases (GHGs) emissions, and particularly Carbon Dioxide ($CO_2$), at concentration levels that are beyond normal. 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% that the global temperature will rise more than 2°C in the next twenty 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 climate change poses are not confined strictly to the environmental and direct physical impacts of global temperature rise but they also involve social, economic and financial impacts.

The first agreement on climate change, the creation of the United Nations Framework Convention on Climate Change (UNFCCC), took place in the 1992 Rio Earth Summit. The aim was to achieve an agreement on the stabilization of the GHG concentrations in the atmosphere at a level that would not pose a threat to the climatic models. However, the main driver in the development and adoption climate change mitigation policies was the creation of the Kyoto Protocol (Kolk and Pinkse, 2008; Haque and Deegan, 2010), which went into effect in 2005 and forms a legally binding agreement that sets emission reduction targets for industrialized countries. The need to reach Kyoto targets gave rise to the adoption of national and international climate change mitigation policies. These include putting a price on carbon emissions in the form of carbon taxes, mandatory process and product standards or by establishing carbon trading programs (Bebbington and Larrinaga-Gonzalez, 2008). As a result, GHG-intensive activity sectors will face direct regulation risks in the form of increased costs, related to their obligation to have GHG emission allowances matching the amount of their emissions, which will eventually affect their profitability.

Specific economic sectors, such as agriculture, fishing, forestry, insurance, real estate and tourism, that are particularly exposed to the direct physical impacts of climate change due to their dependency on the natural environment, will face increased physical risk (Wellington and Sauer, 2005; Lash and Wellington, 2007). On the other hand, GHG intensive business sectors such as oil and gas, aluminum, cement and pulp industries are more exposed to risks associated with current or impending regulation regarding the reduction of GHG emissions (ABI, 2005; Busch and Hoffmann, 2007). Finally, non-intensive business sectors will most likely face the indirect effects of climate regulation through increased energy prices, which could affect their production costs.

These increased risks that companies face have caught the attention of various stakeholders, such as institutional investors, banks, accounting firms, governmental agencies, NGOs and consumers, who have been demanding information disclosure regarding the corporate climate change practices of firms. On the financial front there is evidence that institutional investors view climate change as a major source of risk (Solomon *et al*., 2011). Consequently, they have begun to pay more attention to the corporate climate change practices of firms and to demand information regarding corporate climate change mitigation policies. The reason why institutional investors insist on companies disclosing information, especially those belonging to GHG-intensive sectors, is that inadequate disclosure of climate change related risks could reduce an investor's ability to estimate a firm's performance and future cash flows (Venugopal et al., 2009). Finally, the need to accurately measure a company's GHG emission profile has given the accountancy profession a new role regarding the physical and financial accounting of carbon emissions and emission allowances. Therefore, accounting firms have also stressed the importance of climate change related corporate disclosures and place special attention on the accurate and precise accounting and reporting of GHG emissions.

The aim of this study is to examine the various climate change management practices adopted by firms and how these practices affect their financial performance. We are going to examine three dimensions of climate change management: Strategy, Risk Management and Carbon Accounting and Reporting. We claim that devoting corporate resources in the implementation of climate change strategies, in the identification, assessment and management of climate change risks and in the accurate and precise accounting and reporting of carbon emissions, enhances the financial performance of firms. We also demonstrate that this relationship between corporate climate change practices and financial performance has the tendency to become stronger throughout the years. Finally, we claim that reducing carbon emissions enhances a company's financial performance. In order to prove the validity of our claims we have developed specific climate change corporate indexes that measure the level of corporate commitment regarding climate change strategy, risk management and carbon accounting and reporting. Specifically, eight corporate indexes for measuring the level of corporate commitment regarding the implementation of climate change strategies, the identification and assessment of climate change risks and the adoption of carbon accounting practices were developed. Three indexes are related to Climate Change Strategy, *Climate Change Organizational Management*, *Carbon Reduction Technology* and *Carbon Compensation.* Three indexes are related to Climate Change Risk Management, *Regulation-induced Risk*, *Reputation - induced Risk Management* and *Physical Risk Management.* Two indexes are related to Carbon Accounting and Reporting, *Core Business Carbon Accounting and Reporting* and *Advanced Carbon Accounting Practices*. We will use the above indexes to assess the level of corporate commitment of the largest companies in the oil and gas sector and in the banking sector.

In order to measure the level of corporate commitment regarding climate change practices we weighed the corporate indexes according to the level of difficulty in implementing the climate change practice included in each respective index. In order to assign proper weighs to our indexes, we developed and validated critical factors of climate change strategy, climate change risk management and carbon accounting by using respective survey instruments. Three questionnaires were developed according to extensive literature review, which were sent to three different survey target groups. Regarding carbon emission reductions we used $CO_2$ emissions data as provided by the Carbon Disclosure Program (CDP). Finally, we examined the relationship between our indexes and the financial performance of the largest companies in the oil and gas sector and in the banking sector.

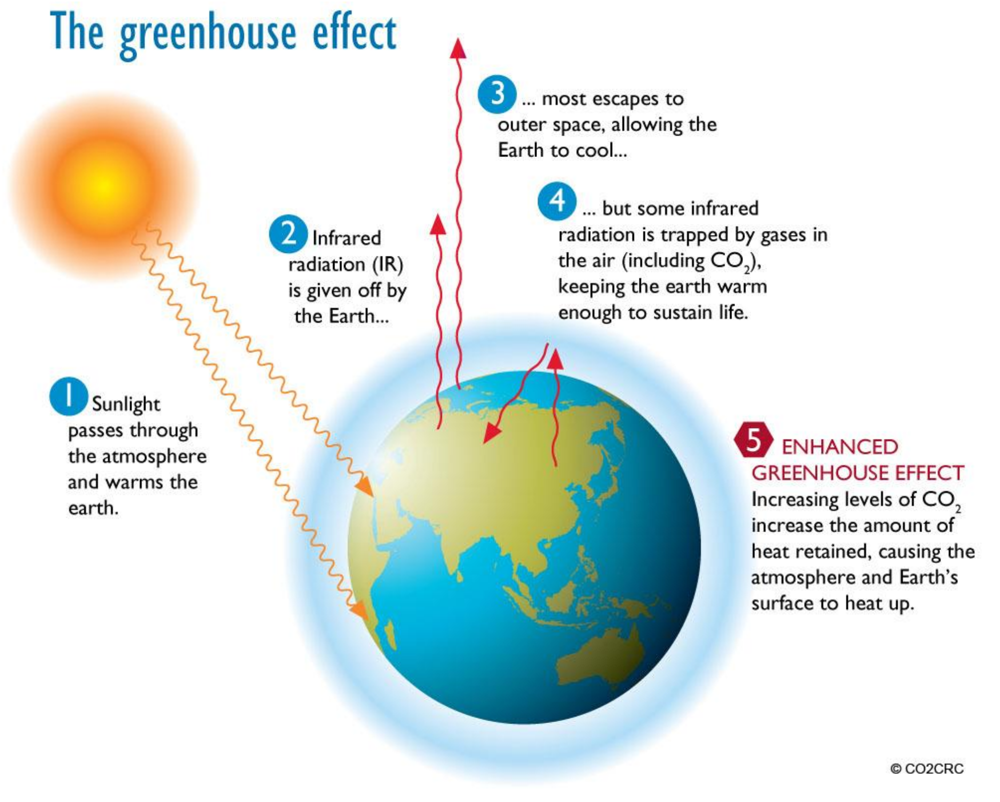
This study contributes to the discussion on the need of further enhancing corporate commitment of firms towards the implementation of climate change practices by identifying specific climate change strategies, risk management and carbon accounting practices that are most likely to have a positive effect on corporate financial performance. International academic research has also studied the relationship between environmental management and corporate performance. Several indicators have been used to measure corporate commitment regarding environmental management, sustainability or corporate disclosures. However, majority of this research focuses on general environmental management or corporate sustainability. Very few studies have attempted to address the issue of climate change management separately from the general concepts of environmental or sustainability management. Furthermore, majority of research on climate change and its relationship to business management is theoretical. There is little empirical research that examines the effect of climate change of corporate performance. Moreover attempts to measure climate change corporate performance have focused on developing aggregate indexes.

Thus the novelty of this study lies first to the fact that it focuses only on climate change and its relationship to corporate performance. Furthermore, we do not use aggregate indexes to measure climate change corporate commitment. Instead, we examine three dimensions of climate change management, strategy, risk management and carbon accounting and reporting. Moreover, we develop different indexes to measure each climate change management dimension, which allows us an in-depth analysis of the various climate change practices of firms. Indexes were developed by using data collected with the help of three survey questionnaires which were sent to climate change experts in three different fields: strategy, risk management and accounting. For the questionnaires used to develop critical factors regarding climate change practices, the target sample included climate change experts who are either currently employed in companies included in the Financial Times Global 500 (FT 500) list or work as external partners with these companies. Consequently, this study contributes to international research by exploring and analyzing patterns of corporate responses related to strategy, risk management and carbon accounting, and how they affect the financial performance of firms.

The structure of this study is the following: in the next chapter we are briefly going to discuss some basic scientific evidence regarding climate change as a natural phenomenon, as well as the mitigation policies that have been adopted and regulations that are current in place. The reason we go through this stage is because we believe that increased corporate commitment to climate change management during the last ten years has been the result of the creation of an international climate change regime involving climate change mitigation policies and regulation at national and international level. Therefore we consider it important to briefly discuss climate change policy and regulation. Next, we will examine the effects of climate change on business activities and analyze why there is a need for companies to develop climate change management practices.  Then we will proceed with a review of previous academic research related to climate change strategy, risk management and carbon accounting and reporting. Along with the relevant literature review, we will develop our initial climate change indexes, which we will empirically test for validity and reliability. To do so, we will conduct an extensive survey, during which, climate change experts will assess the difficulty level of implementing the specific climate change practices included in each respective climate change index. After the validation of the indexes is completed, we will use them to assess the level of corporate commitment of selected firms regarding their climate change strategy, risk management and carbon accounting and reporting practices, and examine their relationship to financial performance. The above procedure and the results of our empirical analysis will be presented in the methodology section. Finally we will provide a discussion of our findings, outline the limitations of our research and present propositions for future research.

# 2 Climate Change and Mitigation Policies

The climatic conditions on Earth are determined by the continuous flow of energy from the sun. Solar thermal energy penetrates the Earth's atmosphere and warms its surface. As the temperature increases on the surface, the Earth itself sends, in the form of infrared radiation, thermal energy back from its surface into the atmosphere. A portion of this energy is absorbed by gases in the atmosphere - such as carbon dioxide, methane, nitrous oxide etc. (commonly known as greenhouse gases GHGs) - thereby causing this energy to be trapped into the atmosphere and maintain the average temperature of the earth at about 15 ° C. These temperature levels are necessary for maintaining life on earth for humans, plants and animals. Without these gases, the Earth's temperature would be fixed on -18 ° C, making our planet uninhabitable for most life forms. Carbon dioxide ($CO_2$) is the most important of GHGs for the maintenance of the desired temperature levels on Earth. The natural $CO_2$ emission processes and the $CO_2$ absorption processes are responsible for maintaining a balanced concentration of $CO_2$ in the atmosphere. Through plant and animal decomposition and respiration, volcanic eruptions and ocean release, $CO_2$ is released into the atmosphere and it is then reabsorbed by photosynthesis and dissolved in water (Figure 2.1).




Source: Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), Australia

**Figure 1: The greenhouse effect**

The cause of climate change is the excessive use of fossil fuel resources, such as coal and lignite, oil and natural gas, the combustion of which releases vast amounts of $CO_2$ into the atmosphere. In this way the 'blanket' of GHGs which covers the Earth holds more and more energy which, in turn, increases the average temperature of the planet. Human intervention in the natural $CO_2$ cycle over the last 150 years has been decisive. The extensive burning of fossil fuels, the intense livestock farming which contributes to increased methane emissions, coupled with deforestation which decreases Earth's absorbing capacity of GHGs, they have irreversibly disturbed the balance in the CO2 cycle. Negative impacts on ecosystems and human populations are already being observed- such as the melting of sea ice in the Arctic - even with the current increase in temperature at 0,8 ° C compared to pre-industrial levels. These impacts could potentially lead to even more global warming and further environmental, social and economic implications.

According to the latest Intergovernmental Panel on Climate Change (IPCC) report, each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere while the globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 (0.65 to 1.06) °C over the period 1880 to 2012 (Figure 2). Furthermore, it is clear that global warming does not necessarily mean a warmer climate for everyone, in all regions of the world. As the planet's temperature increases, the climate system changes and this results to the increase of extreme and unpredictable weather. Other areas will be become warmer, others colder, while global humidity levels with be affected accordingly resulting either to increased drought levels or excessive amounts of rainfall.

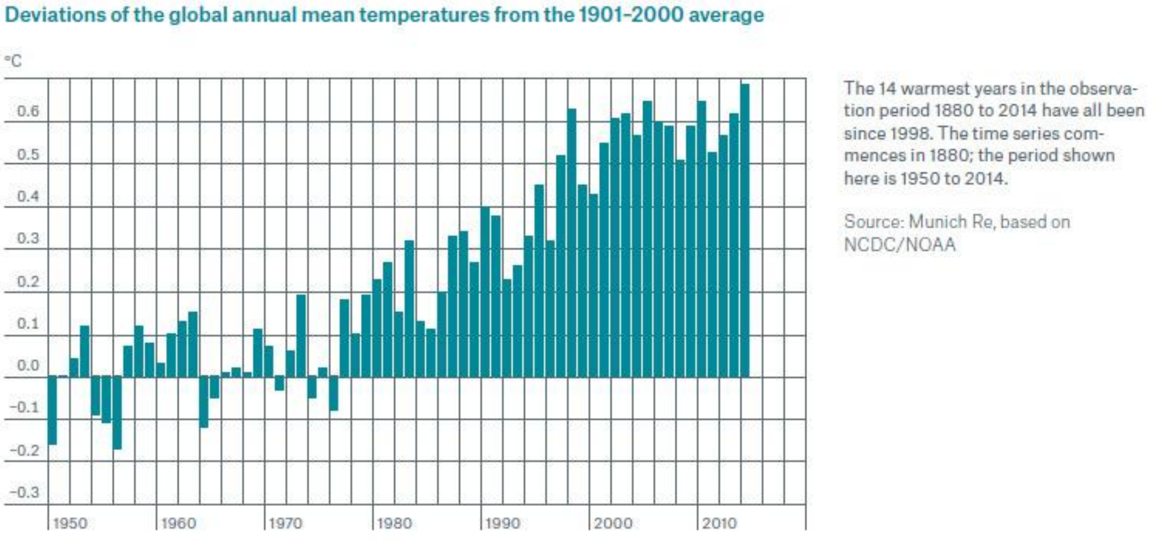
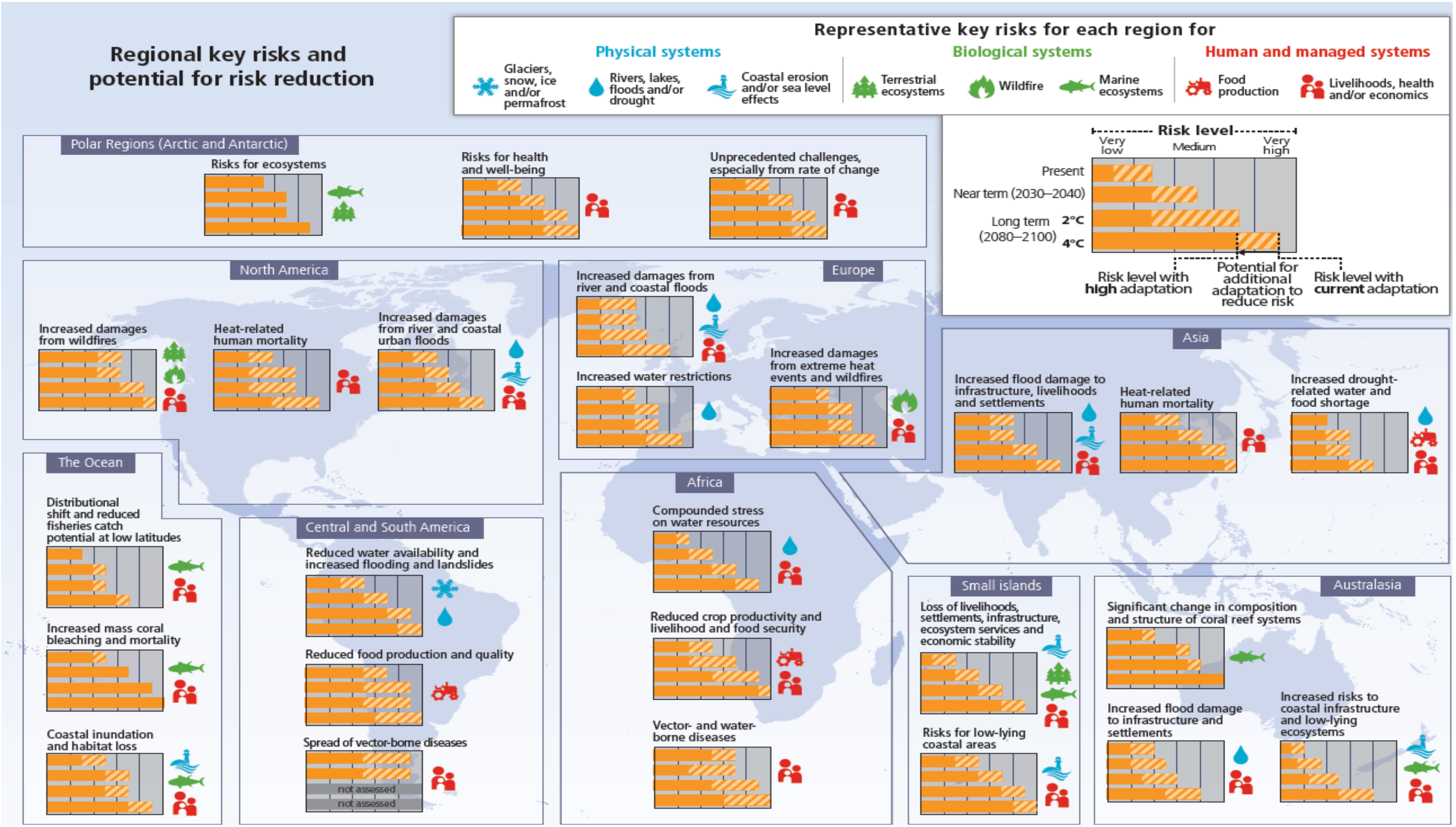



**Figure 2: Deviations of global annual mean temperatures**

The 4th Assessment Report of the IPCC further stresses that:

1. In the coming decades, water supplies stored in glaciers and snow-covered areas will be reduced, causing water shortage for more than 1 billion people
2. Between 20% and 30% of all living organisms on the planet will be at increased risk of extinction if the rise in global average temperature exceeds 1,5-2,5 ° C.
3. At lower geographical latitudes, especially in dry and tropical regions, even a small temperature increase of 1 ° C - 2 ° C, is expected to endanger food provision security.
4. After 2080 millions of people will be affected by floods because of the rise in sea level every year. At particular risk will be densely populated areas and areas which are at a low altitude and with limited adaptation capacity.

The current regional climate change risks related to physical, biological and human systems are presented in Figure 3. Regarding the physical risks of climate change and their implications to natural ecosystems, these are summarized in Table 1.




Source: IPCC Climate Change 2014 Synthesis Report

**Figure 3: Global Climate Change Risks**

**Table 1: Physical Risks of Climate Change**

| | |
|---|---|
| Higher mean temperatures | Increased evaporation and decreased water balance.<br>Increased severity of droughts (see below).<br>Reduced alpine winter snow cover.<br>Reduced range of alpine ecosystems and species.<br>Increased stress to coral reefs. |
| Higher maximum temperatures, more hot days and more heat waves | Increased incidence of death and serious illness, particularly in older age groups.<br>Increased heat stress in livestock and wildlife.<br>Increased risk of damage to some crops.<br>Increased forest fire danger (frequency and intensity).<br>Increased electric cooling demand and reduced energy supply reliability. |
| Higher minimum temperatures, fewer cold days and frost days | Decreased cold-related human morbidity and mortality.<br>Decreased risk of damage to some crops and increased risk to others.<br>Extended range and activity of some pest and disease vectors.<br>Reduced heating energy demand. |
| Decrease in precipitation | Decreased average runoff.<br>Decreased water quality.<br>Decreased water resources.<br>Decrease in hydro-power potential.<br>Impacts on rivers and wetland ecosystems. |
| Increased severity of drought | Decreased crop yields and rangeland productivity.<br>Increased damage to foundations caused by ground shrinkage.<br>Increased forest fire danger. |
| Decreased relative humidity | Increased forest fire danger.<br>Increased comfort of living conditions at high temperatures. |
| More intense rain | Increased flood, landslide and mudslide damage.<br>Increased flood runoff.<br>Increased soil erosion.<br>Increased pressure on disaster relief systems. |
| Increased intensity of cyclones and storms | Increased risk to human lives and health.<br>Increased storm surge leading to coastal flooding, coastal erosion and damage to coastal infrastructure.<br>Increased damage to coastal ecosystems. |
| Increased mean sea level | Salt water intrusion into ground water and coastal wetlands.<br>Increased coastal flooding (particularly when combined with storm surge). |

Source: Australian Greenhouse Office, Department of the Environment and Heritage, 2006.

The worldwide acceptance that the rise of GHGs concentration in the atmosphere is the result of human activities, has triggered the adoption of measures and policies both at national and international level, that have as a purpose to reduce GHGs emissions. The first agreement on climate change, the creation of the United Nations Framework Convention on Climate Change (UNFCCC), took place in the 1992 Rio Earth Summit. The aim of this agreement was the stabilization of GHG concentrations in the atmosphere at a level that would not pose a threat to the climatic models. However the main driver in the development and implementation of climate mitigation policies, which eventually prompted several changes in the corporate strategies of companies, regarding management of their GHG emissions, was without any doubt the adoption of the Kyoto Protocol in 1997 (Kolk & Pinkse 2008; Haque & Deegan 2010).

The Kyoto Protocol went into effect in 2005 and it forms a legally binding agreement that sets emissions reduction targets for industrialized countries by a specific percentage that has been agreed on by the signatory parties. In achieving their emission reduction targets, countries that have ratified the protocol are allowed to use three flexible mechanisms: The Clean Development Mechnanism (CDM), Joint Implementation (JI) and Emissions Trading Systems (ETS). The CDM is a procedure under which industrialized countries may invest in projects that contribute to emissions reductions in developing countries and receive credit units, known as Certified Emission Reductions (CERs), that they may later use to achieve their emission targets or trade in ETSs. JI is the same as CDM but instead of investing in developing countries, industrialized countries must invest in those countries whose economies are in a transition phase  such as the ex Soviet bloc (Chasek et al. 2013). Finally, the ETS allows the buying and selling of emissions credits among industrialized countries in order to meet their emission reduction commitments.

The need to reach Kyoto targets gave rise to the adoption of national and international climate change mitigation policies. These include putting a price on carbon emissions, through carbon taxes, the establishment of carbon trading programs, setting mandatory process and product standards for industry or provide incentives to invest in low-carbon technologies (Bebbington and Larrinaga – Gonzalez 2008). Based on its binding commitments to reduce its GHG emissions, the European Union launched its own mandatory emissions trading scheme, the European Union Emissions Trading System (EU ETS). The EU ETS, which was set in effect for the first time in 2005, constitutes EU’s main mechanism in achieving its own personal target of a 20% reduction in its emissions by 2020, and forms the largest ETS worldwide, covering 11000 installations (Perdan and Azaparic, 2011). Additionally, several other mandatory GHGs trading schemes have already been set into operation such as the Regional Greenhouse Gas Initiative in the USA, New Zealand Emissions Trading Scheme, Tokyo metropolitan trading scheme and the New South Wales Greenhouse Gas Abatement scheme in Australia (Pedan and Azapgic, 2011).

According to the EU ETS, each country is required to set a limit, a “cap”, in the number of emission credits ( European Union Allowances) and then distribute them, using an allocation method (free allocation, auctioning etc), to companies participating in the ETS. Companies may meet their cap either by reducing their emissions and selling the surplus, or by increasing or letting their emissions remain higher than the cap and buy allowances from other companies that participate in the EU ETS market in order to meet the cap. The scheme covers electricity generation, power stations, oil refineries and offshore installations, iron and steel, cement and lime, paper, food and drink, glass, ceramics, engineering and vehicles. The EU ETS has been split in three compliance periods: Phase 1 which ran from 2005 to 2007, formed the initial learning phase of the scheme and did not have any penalties for non-compliance, Phase 2 involved initial free allocation of emission credits for most industry sectors and a penalty of €100 for each tonne of emissions for installations that did not have the required allowances, Phase 3, which is currently at place, runs from 2013 to 2020, will involve auctioning of the initial emission allowances with only a small portion being allocated for free (Lovell *et al*., 2010). Furthermore, the cap of emission allowances will gradually decrease each year, in order for the EU to achieve its emission reduction targets.

However, although near-term, moderate emission reduction goals can be achieved with the use of such economic price instruments, ambitious emissions reduction targets in the future, will be very hard if not impossible to achieve without the pervasive diffusion of low-carbon technologies (Sandén and Azar, 2005). Diffusion of renewable energy sources (RES) in the electricity sector could provide the basis for achieving mass reductions in $CO_2$ emissions in the long-term future. In order to reduce its overall $CO_2$ emissions, the EU has set a target of 20% final energy consumption based on RES. Furthermore EU leaders have committed to a 80% - 95% reduction of $CO_2$

emissions at 1990 level by 2050 which, as it has been estimated, will not be possible unless a 95-100% decarbonisation of the electricity sector is achieved by 2050 (EU, 2011). Building on the above, the need for technological, institutional and social transition of the electricity system towards the use of low carbon technologies in electricity production is of utmost importance.

As we have discussed above, the negative impacts climate change on ecosystems and human populations are already being observed. Along those lines, the urgent need to reduce GHG emissions has resulted in adoption of the climate change regulations at national and international level. These include putting a price on carbon emissions in the form of carbon taxes, mandatory process and product standards or by establishing carbon trading programs (Bebbington and Larrinaga-Gonzalez, 2008). Consequently, companies, who operate in this climate change regime, are also expected to take into account the negative implications of climate change on their business activities, and implement corporate climate change practices that address climate change risks, and adopt corporate climate change mitigation strategies. As we will discuss in the next section, specific economic sectors are directly influenced by climate change, either through its physical consequences on corporate activities or through climate change regulation. Energy production companies, for example, are particularly exposed to climate change regulation, as they are among the highest $CO_2$ emitting sectors. On the other hand, companies who do not belong to GHG intensive sectors are also expected to be influenced by climate change regulation. For example, as there is a tendency for energy suppliers to pass costs of regulation to consumers through increased energy prices (Lass and Wellington, 2007; Wellington and Sauer, 2005), companies, that utilize low energy-efficiency technologies in their production process, will also face increased operational costs.

In the next section we will discuss the effects of climate change on business. We will then examine the various strategies that business adopt in order to reduce their exposure to the adverse effect of climate change. We will also analyze the various climate change risks and how they affect corporate activities. Finally, we will analyze the corporate practices related to the accounting and reporting of carbon emissions, which is considered of outmost importance in assessing the climate change exposure of a company.

# 3 CLIMATE CHANGE AND BUSINESS

As climate change affects both directly and indirectly corporate activities, some companies will face more risks than others depending both on the nature of their business, and on the strategies they adopt regarding climate change (Porter and Reinhardt, 2007; Schwartz, 2007). Climate change and GHG reduction policies create systemic risks across the global economy, by affecting energy and food prices, national income and health expenditures. On the other hand they create direct and indirect risks at sector and company specific level (Hoffman, 2006; Wellington and Sauer, 2005; ACCA, 2009; Ceres, 2010a). Most of these risks have been identified even partly estimated by insurance companies, which have become increasingly concerned about climate risks and how they affect both firms' physical assets, potential regulatory costs and even litigation costs regarding corporate environmental liabilities (ACCA, 2009).

Specific economic sectors, such as the agricultural sector, fishing, forestry, real estate and tourism are particularly exposed the direct physical impacts of climate change due to their dependency to the natural environment (Lash and Wellington, 2007, Wellington and Sauer, 2005 ; ACCA, 2009) therefore facing increased physical risk. On the other hand, GHG – intensive or energy intensive business sectors such as energy –production, aluminum, cement and pulp industries are more exposed to risks associated with current or impending regulation regarding $CO_2$ emissions (Busch and

Hoffman, 2007; ABI, 2005). As a result, some companies will most likely face increased operational costs as we move towards a carbon constrained economy (Busch and Hoffman, 2007). These costs will most certainly affect their profitability and create significant competitive risks not only for GHG intensive industries such energy production but also for the majority of industrial manufacturing sectors, as there is the tendency for energy suppliers to pass the increased costs of regulation to their consumers (Lash and Wellington, 2007; Wellington and Sauer, 2005). With the dramatic increase in climate change impacts, there is a pressing need for business to develop appropriate climate change mitigation strategies for the risks posed by the projected climate change policies.

On the financial front there is evidence that institutional investors view climate change as a major source of risk (Solomon *et al*., 2011) and have also began to pay more attention to corporate climate change practices of firms, demanding more information disclosure from companies regarding their corporate climate change mitigation policies. If a company is not seen as adequately addressing and managing physical or regulatory risks posed by climate change, investors might be reluctant to invest in the company until it has developed a specific corporate climate change strategy (ACCA, 2009). What investors are particularly interested in, when assessing the climate risk profile of a company, is information regarding GHG emissions, exposure to carbon regulations, such as taxes or mandatory product and process standards, or corporate strategies regarding renewable energy investments (Solomon *et al*., 2011; Delloite, 2007). Mainstream institutional investors, for example, like Goldman Sachs, Bank of America, JP Morgan and Citigroup have already adopted sustainability criteria such valuating GHG - intensity of projects and promoting low - carbon technologies such as renewable energy (Hoffman, 2006; ACCA, 2009).

As a result, during the last years, there is an increasing demand on firms disclosing information regarding corporate climate change-governance practices. This demand has also given rise to the creation of voluntary climate change information disclosure schemes such as the Carbon Disclosure Project (CDP) and the GHG Protocol Initiative (Andrew and Cortese, 2011). Both of these schemes were the result of the collaboration between government agencies, NGOs and institutional investors in their try to create a reporting benchmark regarding climate change governance practices of firms. Using different methodologies, data regarding GHG emissions and corporate climate change practices are assembled and being codified into annual reports which are later made available to policymakers, investors, corporations, academics and the public. These data are later used from various stakeholders in order to assess the climate change vulnerability of the companies participating in the voluntary information disclosure schemes.

The reason why various stakeholders and institutional investors in particular, insist on companies disclosing information, especially those belonging to GHG – intensive sectors, is the fact that inadequate disclosure of climate change related risks will reduce the investor's ability to accurately measure and manage the exposure of his portfolio to the reverse effects of climate change (Venugopal *et al*., 2009) therefore causing him to falsely estimate firms' performance and future cash flows. Moreover, academic research on credit risk management has shown that by incorporating sustainability criteria in financial assessment of projects, for example, banks can not only lower the chances of having to deal with credit default cases but have also more chances of gaining an advantage against their competitors by improving their credit risk management assessment procedures (Weber *et al*., 2010; Weber *et al*., 2008; Nitsche and Hope, 1996; Thompson, 1998).

Additionally, accounting firms have also stressed the importance of climate change related corporate disclosures and place special attention on both the physical and financial accounting of GHGs. Accountants were initially involved with climate change reporting issues due to the creation on the EU ETS (Lovell and MacKenzie, 2011) and the financial implications of the treatment of emission allowances in financial reports. Indeed, during the last years carbon markets have began to have material impacts on the balance sheets with carbon allowances being treated as assets or potential liabilities and affecting financial cash flows (Ascui and Lovell, 2011; Lovell *et al*., 2010; KPMG, 2008). These impacts are also expected to rise during the third phase of the EU ETS in which the majority of allowances are expected to be auctioned rather than being given away for free, thereby further affecting the financial results of firms.

Since now we have only referred to climate change regulation only as a source of business risk. Nevertheless, climate change regulation could under certain circumstances help companies gain a competitive advantage and increase their profitability. This claim is based on the fact that competiveness is not related only to the cost of raw materials or to the ability for mass productions of goods, but also to the ability of firms to be innovative and improve their production processes (Porter & Van der Linde, 1995; Williams *et al*., 2002). Therefore, according to Porter and Van der Linde (1995), well designed environmental regulation can stimulate the development of innovative technologies and production processes, which on their turn could make up for the regulation costs imposed on firms and even offer a competitive advantage. For example, investing in carbon reduction projects could generate a positive return on investment by offering tax credits for energy reduction or the development of carbon capture and storage (CCS) technology could leave firms with a surplus of emissions credits to be traded in carbon markets thus offering a new source of revenue (Ernst & Young, 2010). However empirical research has shown that firms are not always able to counterbalance the costs of environmental regulations, the probability to do so increases when the production process is relatively flexible, when the company belongs to a high competitive sector and when environmental regulation is adaptable, i.e. there are pollution permits trading systems in place (Ambec and Lanoie, 2007).

As the effects of climate change become more intense and as carbon regulation evolves and becomes more specialized in addressing carbon reduction issues, corporate stakeholders will demand that companies develop and implement climate change mitigation strategies, address climate change risks and provide information regarding their carbon emissions profile. The aim of this study is to examine corporate practices related to climate change strategy, risk management and carbon accounting and to develop corporate indexes that measure the level of corporate commitment to the above practices. Moreover, we aim to prove that companies who devote resources in implementing climate change practices achieve enhanced financial performance. In order to develop our climate change indexes we are going to conduct an extensive survey, during which, climate change experts will assess the difficulty level of implementing the specific climate change practices included in each respective climate change index. In the next three subsections of this study, we are going to discuss climate change practices related to strategy, risk management and carbon accounting and present the questionnaires that we will use in order to develop our climate change indexes.

## 3.1 Climate Change Strategies

Strategy, as a term, comes from the Greek word “strategia” which can be narrowly defined as “the art of the general”. It is a concept that has been adopted from the military and been adapted into a business term describing the means and tactics a firm uses to realize its purposes and missions. Several definitions have been given for the concept of strategy. Henry Mintzberg describes strategy as a “plan” on how to get from one point to another, as a “pattern of actions”, as a “position” on which particular products or services should a firm offer to a particular market and as “perspective”, a shared mentality of how things should be done. Kenneth Andrews defines corporate strategy as ‘’the pattern of decisions in a company that determines and reveals its objectives, purposes, or goals, produces the principal policies and plans for achieving those goals, and defines the range of business the company is to pursue, the kind of economic and human organization it is or intends to be, and the nature of the economic and non-economic contribution it intends to make to its shareholders, employees, customers, and communities”. Finally, Michael Porter, who focuses on competitive strategy, explains the concept of strategy as a means of “being different” or “deliberately choosing a different set of activities to deliver a unique mix of value”.

Regarding climate change, it is only recently that firms have begun to treat it as more than a Corporate Social Responsibility (CSR) 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 climate change physical, economic and social impacts. 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 is a number of different strategies that a firm can adopt ant those depend both on the strategic choices it top management makes as well as on 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 on the use of alternative fuel sources, such as natural gas and renewable energy sources (RES), as well as the development of efficient Combined Heat and Power (CHP) technologies (please see Table 4). 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. Finally, the need of developing climate change risk management processes is also denoted, as insurance and reinsurance companies have already began to quantify the cost of climate change risks on companies, e.g. cost of climate change related extreme weather events.

Weinhofer and Hoffman (2010) divide climate change strategies into three different groups: $CO_2$ compensation, $CO_2$ reduction and Carbon independence. $CO_2$ compensation strategies involve actions taken by firms to balance their carbon emissions, for example, through ETS, buying CERs or investing in emissions reduction projects. $CO_2$ reduction strategies focus on the improvement of $CO_2$ emitting production processes or on the design of new products, whose production emits fewer emissions. Finally, $CO_2$ reduction strategies involve the design of processes and products that are carbon free or which radically reduce carbon emissions.

In their study of emergent corporate climate change strategies, Kolk and Pinkse (2005) also distinguish between innovation strategies and compensation strategies. They describe innovation strategies as process improvements that reduce energy consumption, for example installation of energy-efficient technologies for carbon intensive industries such as oil and gas and chemicals, or processes focused on the reduction of $CO_2$ emissions through supply chain processes for automotives or electronics companies. In the same line with Weinhofer and Hoffman (2010), compensation strategies include internal transfer of carbon emissions through emissions trading or participation in carbon offset projects.

Jeswani *et al.* (2008) separate corporate climate change strategies into two categories: operational activities for energy efficiency and GHG reduction and management activities. They lump all strategies described by Weinhofer and Hoffman (2010) and Kolk and Pinkse (2005) in to the operational activities category i.e. technology development, carbon trading and the other Kyoto flexible mechanisms, and they go further to describe managerial activities of firms: top management commitment for GHG reductions, development of environmental management systems (ISO 14001 etc.), GHG reduction targets (both absolute emission reduction targets as well as business intensity targets), development of a corporate GHG inventory and implementation internal and external auditing procedures for GHG emissions assurance.

Along those lines, Lee (2012) also proposes six different types of carbon management activities. These include emission reduction commitment, such as setting GHG reduction targets, product development, process and supply improvement, as well as development of new market and business activities. They also examine organizational involvement, which they define as top management involvement in climate change initiatives and encouragement of employees to also take climate change initiatives. Finally, they describe the external relationship development strategies, which includes participating in emissions trading schemes, influencing and facilitating the design and implementation of climate change regulation at national and international level, and participating in climate change reporting programs.

Hoffman (2005) offers seven strategic dimensions of corporate climate change strategies. First, the *operation improvement* dimension, which includes assessment of the emissions and energy profile of the company as well as using cost/benefit analysis for current or alternative use of specific technologies, such as RES or CCS. Also, enhancing *human resource management, anticipating and influencing climate regulations,* as well as using GHG reductions to *enhance corporate reputation,* are considered among the strategies proposed. Moreover, strategies concerning *access into new sources of capital* in the form of government subsidies for low carbon technologies or commodity trading of GHG emissions, and the identification of *new market opportunities* for alternative products or services should be examined when designing a climate change strategy. Finally, *improving risk management* processes is considered to be of outmost importance as climate change poses several risks both at company level as well as at asset level (product and process risks).

Finally, a number of various NGOs and research organizations have also released climate change strategies categorization schemes. More specifically, the Carbon Disclosure Project (CDP), the Coalition for Environmental Responsible Economies (Ceres), the Global Reporting Initiative (GRI), the Climate Disclosure Standards Board (CDSB) and RobecoSam (for more details on these organizations please see Table 2) classify managerial climate change strategies into three, broadly defined, categories: *Board Oversight* (CDP, GRI, RobecoSam, Ceres, CDSB) which involves management commitment to climate change corporate targets, management responsibility and executive compensation, *Climate Change Risk Management Integration* into core business strategy (CDP, GRI, CDSB) and *Carbon Reduction Targets* (CDP, CDSB, Ceres).

**Table 2: Selected Climate Change NGOs and Research Organizations**

| | |
|---|---|
| CDP DRIVING SUSTAINABLE ECONOMIES | CDP (Carbon Disclosure Project) is an international, not-for-profit organization providing the only global system for companies and cities to measure, disclose, manage and share vital environmental information. CDP works with market forces, including 822 institutional investors with assets of US$95 trillion, to motivate companies to disclose their impacts on the environment and natural resources and take action to reduce them. CDP now holds the largest collection globally of primary climate change, water and forest risk commodities information and puts these insights at the heart of strategic business, investment and policy decisions (https://www.cdp.net). |
| Ceres Mobilizing Business Leadership for a Sustainable World | Ceres (Coalition for Environmental Responsible Economies) is a non-profit organization advocating for sustainability leadership. Ceres mobilizes a powerful network of investors, companies and public interest groups to accelerate and expand the adoption of corporate strategies and public policies on climate change and other environmental and social challenges across the global economy (http://www.ceres.org). |

| | |
|---|---|
| GRI Empowering Sustainable Decisions | Global Reporting Initiative (GRI) is an international independent organization that helps businesses, governments and other organizations understand and communicate the impact of business on critical sustainability issues such as climate change, human rights, corruption and many others. It has also developed a global reporting system under which companies or organization disclose information about the economic, environmental and social impacts caused by its everyday activities. The reports also present the organizations' values and governance model, and demonstrate the link between their strategy and their commitment to a sustainable global economy (https://www.globalreporting.org). |
| CDSB Climate Disclosure Standards Board | The Climate Disclosure Standards Board (CDSB) is an international consortium of business and environmental NGOs committed to advancing and aligning the global mainstream corporate reporting model to equate natural capital with financial capital. CDSB offers companies a framework for reporting environmental information and provides investors with decision-useful environmental information via the mainstream corporate report, enhancing the efficient allocation of capital. Regulators also benefit from compliance-ready materials (http://www.cdsb.net). |
| ROBECOSAM We are Sustainability Investing. | RobecoSAM is an investment specialist focused exclusively on Sustainability Investing. It offers asset management, indices, engagement, voting, impact analysis, sustainability assessments, and benchmarking services. Together with S&P Dow Jones Indices, RobecoSAM publishes the globally recognized Dow Jones Sustainability Indices (DJSI). Based on its Corporate Sustainability Assessment (CSA), an annual ESG analysis of 3,800 listed companies, RobecoSAM has compiled one of the world's most comprehensive databases of financially material sustainability information. The data of the CSA is also included in USD 84.6 billion of assets under management by Robeco (http://www.robecosam.com). |

Building on the above, we identify five different types of climate change strategies that we are going to examine in this research.

1. **Climate Change Governance**, which involves strategies regarding top management engagement and accountability.
2. **Climate Change Risk Management Integration**, regarding how risk management processes are implemented by firms i.e. the "pattern of actions" described in strategic management theory.
3. **Carbon Reduction Targets**, which form the actual purpose of a proactive or innovative climate change strategy.
4. **Carbon Reduction Strategies**, which include the development of carbon efficient technologies and the implementation of business processes that reduce $CO_2$ emissions. The technology dimension is closely related to Porter's competitive strategy approach, which emphasis the role of innovation in order for a firm to gain advantage against its competitors.
5. **Carbon Compensation Strategies,** which involves carbon trading and $CO_2$ emission offsetting projects.

The specific corporate practices related to its type of climate change strategy, and the related research, are presented in Table 3. Building on these climate change practices, we are going to create a climate change strategy questionnaire, which we are going to use in order to conduct an extensive survey, during which, climate change experts will assess the difficulty level of implementing the specific climate change strategies included in Table 3. The questionnaire is presented in Appendix A.

**Table 3: Climate Change Strategies and Related Research**

| Climate Change Strategy | Corporate Practices | Related research |
|---|---|---|
| Climate Change Governance | 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) |
| | Company management has clear responsibilities for achieving climate change goals | CDP (2015); GRI (2015); RobecoSam (2015);Ceres (2014); CDSB (2012); Hoffman (2005) |
| | Executive compensation (monetary) is linked to climate change performance | CDP (2015); GRI (2015); RobecoSam (2015);Ceres (2014) |
| Climate Change Risk Management Integration | 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) |
| | Climate change risks and opportunities are identified at asset level | CDP (2015); GRI (2015); CDSB (2012);Hoffman (2006) |
| | Climate change risks and opportunities are identified at company level | CDP (2015); GRI (2015); CDSB (2012);Hoffman (2005) |
| | Company has processes that allow the prioritization of risks and opportunities related to climate change | CDP (2015); GRI (2015); CDSB (2012) |
| Carbon Reduction Targets | Company has short-term absolute[1] $CO_2$ emission reduction targets | CDP(2015); CDSB (2012); Lee (2012); Jeswani et al. (2008); Hoffman (2005); Dunn (2002) |
| | Company has short-term $CO_2$ emission intensity[2] reduction targets | CDP(2015); CDSB (2012); Lee (2012); Jeswani et al. (2008); Hoffman (2005); Dunn (2002) |
| | Company has long-term absolute $CO_2$ emission reduction targets | CDP(2015); CDSB (2012); Lee (2012); Jeswani et al. (2008); Hoffman (2005); Dunn (2002) |
| | Company has long-term $CO_2$ emission intensity reduction targets | CDP(2015); CDSB (2012); Lee (2012); Jeswani et al. (2008); Hoffman (2005); Dunn (2002) |

[1]Absolut emission reduction refers to $CO_2$ reduction in absolute numbers, regardless of business activities.
[2]Intensity ratios express $CO_2$ impact per unit of physical activity or unit of economic output

| **Climate Change Strategy** | **Corporate Practices** | **Related research** |
|---|---|---|
| Carbon Reduction Strategies | Fossil fuel switching, from coal to natural gas | Kotchen and Mansur (2016); Lamb et al. (2015); Cadez and Czerny (2016); IEA (2015); Dunn (2002) |
| | Increased boiler efficiency, by implementing the best available technology | Cadez and Czerny (2016); Qu M Abdelaziz and Yin (2014); Li *et al.* (2014); Namioka *et al*. (2012) |
| | 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); |
| | Energy source switching, from fossil fuels to renewable energy sources | Cadez and Czerny (2016); IEA (2015); da Graça Carvalho (2012); Boiral (2006); Hoffman (2006); Neuhoff (2005); Dunn (2002) |
| | Capture and Storage of CO2 | Cadez and Czerny (2016); IEA (2015); Boot-Handford *et al.* (2014); Gerbelová *et al*. (2013); Scott *et al*. (2013); Szulczewski *et al*. (2012) |
| | Replacement of carbon-based products by non-carbon based products[3] | Cadez and Czerny (2016); Weinhofer and Hoffman (2010); Jeswani *et al*. (2008) |
| | Implementation of end-use energy efficiency processes[4] | Cadez and Czerny (2016); Jeswani *et al.* (2008); Boiral (2006); Hoffman (2005) |
| | Optimization of current business processes in order to reduce CO2 emissions | Cadez and Czerny (2016); Weinhofer and Hoffman (2010); Jeswani *et al*. (2008); Boiral (2006); Hoffman (2005); Kolk and Pinkse (2005) |
| | 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) |
| Carbon Compensation Strategies | Participating in emissions trading schemes. | CDP (2015); Cadez and Czerny (2016); Lee (2012); Jeswani *et al.* (2008); Boiral (2006);Hoffman (2005); Kolk and Pinkse (2005); Dunn (2002) |
| | Creating project-based carbon credits. | CDP (2015); Cadez and Czerny (2016); Lee (2012); Jeswani *et al.* (2008); Boiral (2006);Hoffman (2005); Kolk and Pinkse (2005); Dunn (2002) |
| | Purchasing carbon credits. | CDP (2015); Cadez and Czerny (2016); Lee (2012); Jeswani *et al*. (2008); Boiral (2006);Hoffman (2005); Kolk and Pinkse (2005); Dunn (2002) |

[3]e.g. replace plastic products with wooden ones
[4]e.g. turning down heating and cooling during non-working hours, reduce non-necessary travel etc

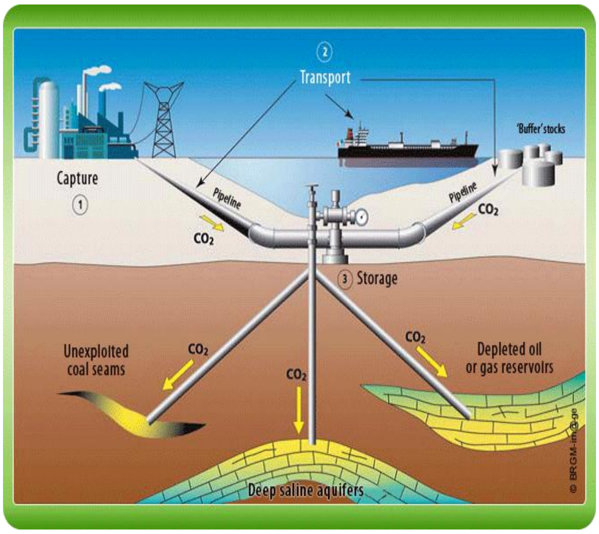
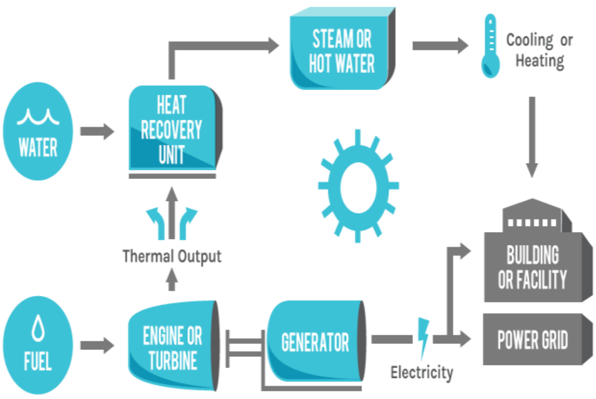
Regarding Climate Change Governance, decision-makers in firms are generally considered those who are in position to make changes in an organization, to choose the business environment in which it operates and engrave its course in the long-term. In Linnenluecke *et al*.'s (2015) study on executives' 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 commitment of corporate management in climate change, as well as the degree to which they have access in information regarding climate change impacts on their firm, are of utmost importance, in the development of effective climate change strategies.

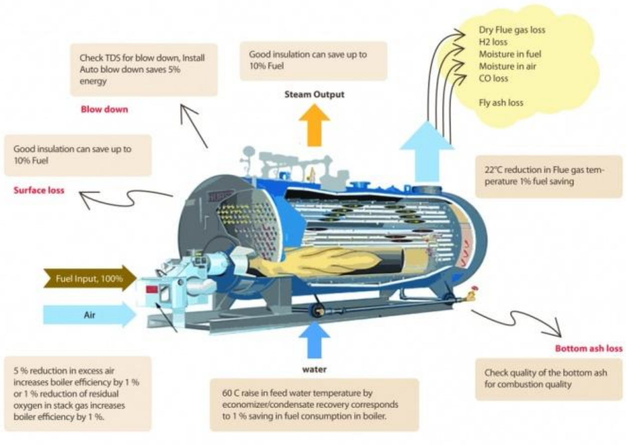
As far as Carbon Reduction Strategies is concerned, particular attention is placed on the technology and carbon reduction business process. During the last decade, in order to reduce $CO_2$ emissions, governments have been focusing on designing efficient climate change policies such as ETSs or carbon taxes. However, although near-term, moderate emission reduction goals can be achieved with the use of such economic price instruments, ambitious emissions reduction targets in the future, such as the European Union (EU) 2050 targets for 80% reduction of $CO_2$ emissions at 1990 levels, will be very hard if not impossible to achieve without the pervasive diffusion of low-carbon technologies (Sandén and Azar, 2005).

Moreover, empirical evidence has also shown that by adopting a proactive climate change innovation strategy firms do actually gain advantages concerning energy efficiency, reducing financial risks, avoiding social shaming from NGOs or targeting and boycotts and flexibility in adapting to stricter environmental regulation (Boiral, 2006; Lash and Wellington, 2007). Furthermore, investing in innovation can give firms competitive advantages that could offer them a larger market share or open the path for new markets. Finally, companies that have already adopted specific climate change strategies can lobby the government for stricter climate change regulations, for example specific production and product environmental standards, and thus use climate change regulation in order to shield themselves from competition or entrants of new firms in the business sector (Lash and Wellington, 2007).

In this study, we are going to examine some indicative climate change technologies based on the research of Cadez and Czerny (2016) on climate change strategies of carbon-intensive firms. The following carbon reduction technologies are examined: natural gas, Combined Heat and Power Technology (CHP), renewable energy sources (RES), Carbon Capture and Storage (CCS). For more information on these technologies please see Table 4.

**Table 4: Carbon Reduction Technologies**

| | |
|---|---|
|   | Carbon Capture and Storage (CCS) is a technology that refers to the capture of carbon dioxide produced from the use of fossil fuels in power plants or industrial facilities, its transportation to a pre-determined location, and its injection (storage) into geological formations from which it cannot escape. Suitable geological formations can be offshore or terrestrial, for example in depleted oil or gas fields or in water aquifers, and several kilometers below ground or sea level. |
|   | The Combined Heat and Power production systems (CHP - also known as cogeneration) generate both electricity and thermal energy in a single, integrated system. This comes in contrast with the conventional electricity production process where electricity is produced at a central station, while separate technology at local level is used for heating and cooling. In a CHP system, thermal energy produced by electricity is recovered and used for heating or cooling. Because CHP harnesses the heat that would otherwise be lost in the conventional electrical or mechanical energy production, the total efficiency of these integrated systems is much higher than that of individual electrical and thermal/cooling systems. |

<table>
<tr>
<td></td>
<td>Renewable energy is from an energy resource that is replaced by a natural process at a rate that is equal to or faster than the rate at which that resource is being consumed. Any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy).</td>
</tr>
<tr>
<td></td>
<td>Natural gas is a mixture of hydrocarbons consisting principally of methane and a very minor proportion of ethane, propane, butane and pentane. The determining factor for its creation is its origin, and particularly if it comes from a pure natural gas field or from oil fields. Natural gas is the cleanest source of primary energy, after renewable energy sources. The amount of the emissions released in the atmosphere is significantly lower than conventional fuels, while its improved energy efficiency reduces overall consumption and thus air pollution.</td>
</tr>
<tr>
<td>
</td>
<td>Boiler Efficiency is defined as the ratio of heat absorbed in steam to the heat supplied in fuel, usually measured in percent. It broadly refers to how effectively a boiler converts fuel into usable heat. There are a number of ways to increase industrial boiler efficiency, i.e. by replacing old boiler burners, installing air preheaters, turbulators, air infiltration reduction systems, blowdown heat exchangers etc. for more information please visit http://www.nationalboiler.com/</td>
</tr>
</table>

## 3.2 Climate Change Risk Management

Given the fact that risk is inherent in almost every aspect of human activity, there is little consensus regarding the appropriate definition of risk. One on the most popular definitions lies in its distinction from the concept of uncertainty given by Frank Knight in 1921:

“Uncertainty must be taken in a sense radically distinct from the familiar notion of risk, from which it has never been properly separated…. The essential fact is that ‘risk’ means in some cases a quantity susceptible of measurement, while at other times it is something distinctly not of this character; and there are far-reaching and crucial differences in the bearings of the phenomena depending on which of the two is really present and operating…. It will appear that a measurable uncertainty, or ‘risk’ proper, as we shall use the term, is so far different from an immeasurable one that it is not in effect an uncertainty at all’’

Since then, many academics have given different definitions of risk:

“The combination of the probability of a *hazardous* event and its negative consequences.” (Smith, 2013)

“Risk is a combination of the chance of a particular event, with the impact that the event would cause if it occurred. Risk therefore has two components – the chance (or *probability*) of an event occurring and the *impact* (or *consequence*) associated with that event. The consequence of an event may be either desirable or undesirable…In some, but not all cases, therefore a convenient single measure of the importance of a risk is given by: Risk = Probability × Consequence.” (Sayers *et al*.,2002)

“Risk might be defined simply as the probability of the occurrence of an undesired event [but] be better described as the probability of a *hazard* contributing to a potential *disaster*…importantly, it involves consideration of *vulnerability* to the hazard”. (Stenchion, 1997)

"Risk is the chance of something happening that will have an impact upon objectives. Risk is measured in terms of likelihood and consequences" (AS/NZS 4360 - Risk Management Standard)

According to ISO 31000, *risk* is the "effect of uncertainty on objectives" and an *effect* is a positive or negative deviation from what is expected.

*Uncertainty* on the other hand is a state where lack of complete or accurate information leads to inadequate or incomplete knowledge or understanding of a situation. In this context, uncertainty exists whenever the knowledge we have about an event, about the consequences of an event, or likelihood of an event taking place, is inadequate or incomplete.

Therefore risk management can be defined as "the systematic application of management policies, procedures and practices to the tasks of identifying, analysing, evaluating, treating and monitoring risk.'' (AS/NZS 4360 - Risk Management Standard)

The science of risk management deals with the identification, analysis and perception of risk by offering practical strategies for the prevention, reduction and transfer of risk (UNDP, 2002). For managers, the management aspects of environmental protection are linked with the principles of risk management. The main objective has always been to avoid the costs associated with industrial accidents, consumer boycotts or lawsuits. However climate change in relation to other environmental problems such as e.g. the ozone hole, biodiversity protection, etc., has the characteristic that occurs discontinuously, systemic (affecting all economic sectors) and under great uncertainty regime ( for example to what degree will the temperature of the earth increase) (Winn et al. 2011).

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

Busch and Hoffmann (2007) divide corporate climate change risks into two broad categories: The first involves risks that have to do with carbon constrains arising from oil markets, which are easily affected by sociopolitical factors e.g. political conflicts, government interventions, supply chain restrictions etc, and thus are subject to sudden price increase and high market uncertainty. The second involves risks that are attributed to the direct and indirect effects of climate change which includes the physical impacts of climate change, the effect of climate change policies on business profitability, changes in consumer preferences for climate friendly products and increased insurance premiums for firms with climate risk exposure. In order to manage those risks, the authors propose a carbon risk management framework that includes recognizing the risks that are relevant to a company, determining the degree of exposure to those risks and developing climate change risk management strategies to mitigate or adapt to those risks. In determining risk exposure, managers should take into account the company's assets and the location of its operations, its dependency on carbon fuels or its energy intensity production, the technological alternatives for productions and general technological trajectories of the economy and the company's position in the value chain.

Weinhofer and Busch (2013) apply the general concepts of risk management, i.e. risk identification, risk assessment and risk response in order to examine the corporate strategies adopted by companies in the electric utilities sector for managing climate change risks. According to their research, risk identification involves gathering information on climate change and its negative impact on business activities, as well as information regarding the company's internal and external business environment. The information collected could be based on experts' opinion on the physical impacts of climate, on published academic research, on conferences about the physical effects of climate change and on media news. At this stage it is also important to record all the climate change risks that are inherent in the business activities of the firm by conducting a bottom- up process where company employees report possible climate change related risks.  During the risk assessment stage, company management should be able to determine the probability of occurrence as well as the magnitude of the impact on business activities caused by climate change risks. Typical climate change risk assessment measures could involve scaling climate change forecasts to the geographical area of the firm's operational activities, assessing the availability of water, e.g. for hydropower electricity production plants, conducting scenario analysis, for example regarding the power volatility of production plants etc.

Regarding risk response, the authors use the three basic strategies i.e. risk reduction, risk avoidance and risk transfer to evaluate corporate responses to climate change risks. Reducing climate change risks for electric utilities could involve stocking the necessary energy resources, maintaining energy supply resources, compensating reduced power generation with production from other existing plants owned either by the company itself or by a partner of the company, expanding the capacity of existing power plants and increasing their efficiency, adapting the technical protection of power plants in order to protect against physical damages etc. In avoiding climate change risks, companies can enhance their innovation processes by increasing power plant efficiency through new operational processes and by incorporating extreme climate change patterns into the design of new electrical grids and electrical production plants. Finally, transferring climate change risks could be done though the use of financial hedging instruments, such as financial insurance against damages to power plants and electrical grids or though investing in weather derivatives in order to hedge water or wind availability.

Although climate change mitigation strategies regarding for example $CO_2$ emission reduction has received considerable attention during the last twenty year, little attention has been given on how the natural environment affects organizational management, i.e. how are organizations adapting on the physical impacts of climate change and how they enhance their resilience capacity to address and recover from natural catastrophes (Winn *et al.*, 2011; Linnenluecke *et al.*, 2008; Hoffman, 2006). Pinkse and Gasbaro (2016) examine how firm awareness regarding climate change physical risks and perceived vulnerability on their exposure to those risks influence the adoption of climate change adaptation strategies. Risk perception of climate change physical impacts, perceived uncertainty about those risks, as well as knowledge about local ecosystems are among those factors that influence firm awareness of climate change impacts. According to the authors, risk perception is affected by the timeline of climate events and whether the physical changes noticed are extreme or are gradually evolving. Perceived uncertainty is highly influenced by the information used in climate change impact assessment as well as by the beliefs of a company's management in climate change science. Finally, a company's knowledge on local ecosystems is affected by the geographical impacts to physical changes and the organizational structures that a company has to deal with harsh weather conditions.

Perceived firm vulnerability to climate change physical risks is closely related to perceived impacts of climate change risks, which includes both the direct physical impacts on a firm's business operations as well as the indirect impacts on a firm's market and business environment (e.g. the supply chain). Moreover, it is affected by a firm's past experience with climate change risks, from lessons learnt from previous extreme weather events and form its ability to quantify and assess the financial implications of extreme weather events. Also, important to perceived firm vulnerability is the degree to which climate change impacts can be controlled for and it depends on the rarity of extreme weather events, on the degree of insurance coverage and on the need for coordinated response with business partners.

Finally, all of the above affect a firm's response to the physical risks of climate change which, according to the authors, can be divided into taking "Routine measures" , i.e. developing risk monitoring and assessment procedures, taking technical measures to endure impacts, using financial instruments for risk sharing, developing emergency and restorations plans etc. and "Non-Routine measures", which could involve 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 in order to reduce climate change exposure.

Linnenluecke *et al.* (2011) divide corporate responses to extreme weather by using an organizational theory approach. According to the authors, extreme weather events cause organizations to enhance their *adaptation*, i.e. their long-term readjustment of their processes and products to the physical impacts of climate change and their *resilience* i.e. their capacity to absorb or recover from extreme weather events. Adaptation is characterized by incremental changes to business processes, which can be either proactive or reactive to a extreme weather events and includes the reorganization of corporate strategies in order to "achieve improved performance by reaching an equilibrium with the environment". Resilience involves enhancing the capacity of a company to absorb unexpected weather events and to persist despite external environmental disturbances by using non-routine measures.

Despite the fact that implementing strategies that enhance the adaptation and resilience of firms, greatly improves their ability to protect themselves to the adverse implications of climate change, in order for firms to successfully adjust themselves to extreme weather events, they have to link both adaptation and resilience processes into one single action framework, something which, according to the authors, most companies have yet to accomplish. Finally, the authors propose a five step procedure for integrating both concepts which involves the development of anticipatory adaptation measures, resilience and impact resistance measures for addressing extreme weather events exposure, recovery and restoration measures, assessment of the resilience capacity of the company after the incurrence of an extreme event and the readjustment of anticipatory adaptation according to the assessment of the resilience measures taken in the previous stages.

Regarding climate change regulation risk, even though the Kyoto Protocol sets specific GHG reduction targets for most industrialized countries, the fact that policymakers at national level have left many regulation issues open has increased climate change regulation uncertainty (Engau and Hoffman, 2011). Hoffman (2005) suggests that companies should try to participate in climate change regulation development and implementation by collaborating with the government as a means to reduce regulation uncertainty. However, research in international business activity has shown that it is generally difficult for foreign firms to built relationships policy makers compared to domestic firms and since economic activity nowadays has been internationalized to a high degree, lobbying for climate change regulation could prove inefficient as a climate change risk mitigation strategy.

According to Engau and Hoffman (2011), firms adopt different strategies when it comes to copying with climate change uncertainty. The authors divide climate change regulation strategies into offensive, defensive and passive. Firms belonging in the first category attempt to reduce the causes of uncertainty by systematically searching for information regarding climate change regulation risks on their own or in cooperation with other firms in the same sector. Finally, they try to directly influence policy makers and adopt flexible climate change strategies that allow them to easily adjust themselves to a changing regulatory environment. Defensive strategies also focus on cooperation and flexibility but also involve stabilization strategies such as engaging in long-term contracts e.g. with suppliers or customers in order to decrease uncertainty and imitation strategies, where they stay one step behind their competitors. Finally, passive strategies focus on reorganizing internal business processes to reduce uncertainty, postponing business decisions to minimize regulation exposure or withdrawing from specific business environments that are characterized by a high degree of uncertainty.

In this study we will use the principles of risk management. Typically, risk management involves three stages: risk identification, risk assessment and risk response (Smith, 1995; Merna and Al-Thani, 2008). During the first stage, risk identification, company management determines which type of risk is relevant to its business activities. As argued above, risk identification is highly influenced by risk awareness and the information available to risk managers regarding the effects of the particular risk on their business. In the second stage, risk assessment, the exposure of the firm to the particular risk, the probability of the risk and potential implications to business are estimated. Most times, this stage leads to the calculation of the cost - in monetary value - to the business should the particular risk event take place. Finally, risk response involves all the potential measures a company can take to minimize its exposure to the particular risk. Our purpose is to measure the climate change risk management effort of firms and to examine whether identifying, assessing and managing climate change risks affects a firm’s financial performance. More information on the measurement instrument developed for this purpose is given in the Methodology section of this research. Below, we briefly discuss the climate change risks that will be included in this research.

At this point it is appropriate to mention briefly the reasons why businesses adopt strategies to deal with the consequences of climate change. As we noted above, climate change and the impact policy responses that constitute systemic risk sources affecting prices in the energy market, national income, consumption, health and the prices of agricultural products (Hoffmann, 2006; Wellington and Sauer, 2005). However, apart from the systemic effects on the economy, climate change is a source of regulatory, physical, competitive, litigation and reputation risk for companies (Lash and Wellington, 2006; Wellington and Sauer, 2005; Nikolaou *et al*., 2015). These risks do not uniformly affect all businesses. Some sectors, depending on the nature of business activities, will be more exposed than others. Even within the same industry, the vulnerability of a company will be determined by its ability to develop the individual risk management strategies.

### 3.2.1 Regulation Risk

This type of risk includes the impacts of regulation regarding GHG emissions both at national or international level on corporate activities. Depending on the nature of their business activities, some companies will face higher costs in adapting to climate change regulation, for example, firms who belong to $CO_2$ intensive industries, such as oil and gas or chemical companies. However, since the demand of many GHG intensive products (such as energy) is highly inelastic, the increased costs that GHG intensive companies will face, due to climate change regulation, will most likely affect the production costs of the majority of companies, depending on their place in the global business value chain. Therefore, climate change regulation will most likely create risks also for non-GHG intensive firms.

Climate change regulation can be classified into two categories "command and control" regulation and "market-based" regulation.

*Command and control regulation* includes policies that prescribe how much $CO_2$ an individual source is allowed to emit - also known *as performance standards* - and what type of control equipment it must use in order to meet the standards set by the regulators. Such standards are usually defined in terms of emission intensity rates. Despite the introduction of potentially more cost-effective methods for regulating emissions, this type of regulation is still commonly used and is sometimes statutorily required. It is almost always available as a “backstop” if other approaches do not achieve desired pollution limits. Command and control regulation also includes *technology-based standards* which force companies to use a particular pollution control technology, such as installing scrubbers on smokestacks.

*Market-based regulation* is based on creating incentives for firms to reduce $CO_2$ emissions. In a market based regulation regime, each firm can choose on its own how to most cost-effectively achieve the required $CO_2$ emission level. Some firms can reduce emissions more cheaply than others (because of the age of their equipment or the technology they are using), allowing them to reduce their emissions more than other firms and eventually compensate for those firm who face higher costs and can do less regarding emissions reduction. Taken together, the overall environmental objective will be achieved at the lowest possible total costs.

"The key criterion in determining if a policy is ‘market-based’ is that it provides a financial incentive designed to elicit a specific behavior from those responsible for the pollution. Some policy options are applicable as economy-wide solutions where greater efficiencies can be achieved, while others are more generally targeted to a particular market segment or sector." (C2ES, 2015). Classic 'market-based' approaches for emissions reduction involve taxes, subsidies and cap-and-trade schemes. A tax sets a price on each unit of $CO_2$ emissions. By introducing a *carbon tax*, the firm or facility that produces emissions incurs an additional cost based on the amount of $CO_2$ emitted. Therefore, there is an incentive to reduce the emissions produced by changing production processes or by adopting new energy efficient technology. Moreover, taxes provide a continuous incentive for innovation as the more emissions are reduced, the less tax a company pays. *Subsidy programs* include government assistance, in the form of tax credits, for specific technologies that reduce $CO_2$ emissions in a similar way to taxes. They are in fact a form of negative taxes (C2ES, 2015) because they provide a specific financial mechanism to motivate a particular environmentally beneficial out-come.

*Cap-and-trade* programs are a form of “quantity-based” regulation (C2ES, 2015). Instead of putting a price on each unit of $CO_2$ emissions, a total quantity of emissions (a “cap”) is set by the regulator. Then, companies buy and sell emission allowances (tradable certificates that allow a certain amount of emissions) based on their needs. The limited number of these allowances creates demand and supply market forces. If a firm can reduce emissions below its requirements, so it has excess allowances, it can sell those allowances in emissions trading markets to a firm that finds it more difficult (costly) to reduce emissions.

### 3.2.2 Physical risk.

Physical risk refers to the impacts of climate change on business activities related to the natural environment: extreme weather events, such as increased intensity of cyclones and storms, floods, hurricanes, typhoons etc, changes in temperature and precipitation extremes, for example impacts such as reduced water supplies, droughts. Since climate change is characterized by a high degree of uncertainty regarding the time and scale of its impacts in the natural environment as well as the fact climate change has different impacts across regions and economic sectors, extended research has been made on how it will affect global economic activity (Linnenluecke *et al,*. 2011). Some sectors of the economy such as the agriculture, fisheries, forestry, insurance, real estate and tourism are particularly vulnerable to the physical risks of climate due to their direct dependence to the natural environment (Pinkse and Gasbarro, 2016; Winn *et al*., 2011; Lash and Wellington, 2006; Wellington and Sauer, 2005). For example, luck of snow for a prolonged period could seriously damage the winter - tourism industry (ski resorts, etc.), extreme weather events could damage energy transportation systems, water shortage and temperature extremes could affect water supply and agricultural production (Busch and Hoffman, 2007). In Figure 4 and Figure 5, we provide a few examples of the physical risks of climate change and their effect on specific business sectors.

In this research we are going to focus on two main types of physical risks related to climate change. One involves the risks associated with extreme weather events and the other with precipitation extremes which include heavy rainfall or extreme droughts.

### 3.2.3 Reputation Risk

Reputation has been given different definitions in academic literature. Fombrun (1996) defines reputation as "a perceptual representation of a company's past actions and future prospects that describe the firm's overall appeal to all its key constituents when compared to other leading rivals". Bebbington *et al*. (2008) perceive corporate reputation as a social construction of its shareholders while Delgado-García *et al*. (2013) consider reputation as "an intangible asset with value enhancing potential, characterized by the imbalance between the length it takes to build it up and its fragility".

Corporate reputation is usually measured via various reputational indexes, which focus mainly on financial performance, quality of management, social and environmental responsibility performance, employee quality and quality of goods and services (Bebbignton *et al*, 2008). In this sense, corporate reputation is closely related to CSR and can be enhanced through CSR reporting (Brammer and Pavelin, 2006). These authors find that there is a positive relationship between corporate social performance and reputation and that this relationship is stronger in sectors that are associated with salient social and environmental issues.

Delgado-García *et al*. (2013) examine the effect of corporate reputation on firm risk. The divide risk into unsystematic, i.e. risk that cannot be captured by overall market trends and include those forces that affect only the particular firm itself and systematic risk i.e. risk that affects the whole market and not just the firm. More specifically, they find that a good reputation reduces a firm's unsystematic risk and total risk but increases systematic risk. They explain these results in terms that a firm, by having a good reputation decreases uncertainty regarding its operational activities and attract more stakeholders. On the other hand, the higher the reputation of the firm, the higher the demands of the stakeholders. This means that in the case of a market downturn, a firm faces higher reputational risks than other firms with not such enhanced reputation, because stakeholders will demand that it keeps the high-quality standards that have helped increase its reputation.

| BUSINESS SECTOR | RELEVANT SHORT- AND LONG-TERM PHYSICAL CLIMATE IMPACTS | ILLUSTRATIVE EFFECTS ON VALUE CHAIN |
|---|---|---|
| AGRICULTURE, FOOD, AND BEVERAGE | • Water scarcity and droughts<br>• Increased frequency and severity of floods and storms<br>• Changing rainfall patterns and increased rainfall intensity<br>• Increased weather extremes and variability<br>• Rising average temperatures<br>• Shifts in seasons<br>• Rising sea level and increased saline intrusion<br>• Changes in pest and disease distribution and prevalence<br>• Loss of biodiversity | • Decreased crop yield and potential crop failures<br>• Loss of productive land (e.g., due to increased soil salinity)<br>• Altered growing conditions and seasons<br>• Increased exposure to pests and diseases<br>• Increased irrigation demand and costs<br>• Commodity price volatility<br>• Distribution network problems<br>• Disruptions to farmers and labor force<br>• Water conflicts with communities and other users (and damaged corporate reputation) |
| APPAREL | • Water scarcity and droughts<br>• Increased frequency and severity of floods and storms<br>• Changing rainfall patterns and increased rainfall intensity<br>• Increased weather extremes and variability<br>• Rising average temperatures<br>• Rising sea level<br>• Changes in pest and disease distribution and prevalence | • Fluctuating availability, quality, and cost of agricultural raw materials<br>• Disruptions for operations and workers at manufacturing facilities<br>• Disruptions in supply chain and distribution network, including transport, warehouses, and stores<br>• Shifting consumer preferences (e.g., less reliable seasonal cycles and temperatures) |

Source: Ceres, Calvert Investments, David Gardiner & Associates, Oxfam America, 2012

**Figure 4: Climate Change Physical Risks for Selected Sectors (1/2)**

| BUSINESS SECTOR | RELEVANT SHORT- AND LONG-TERM PHYSICAL CLIMATE IMPACTS | ILLUSTRATIVE EFFECTS ON VALUE CHAIN |
|---|---|---|
| ELECTRIC POWER | • Increased intensity and duration of extreme weather events, such as heat waves, storms, and floods<br>• Warmer average temperatures<br>• Storm surge<br>• Rising sea level<br>• Water scarcity and overall variability in water supply and precipitation patterns | • Reduced output (e.g., inadequate quantity and quality of water for hydroelectric plants or to cool nuclear and fossil fuel plants)<br>• Damage to infrastructure and facilities<br>• Changing seasonal power demand and increased peak demand during extreme heat or other conditions<br>• Increased electricity losses in transmission and distribution systems due to heat load |
| INSURANCE | • Virtually all physical effects, including hurricanes and storms, wildfires, floods, droughts, sea-level rise, thawing permafrost, and increased exposure to diseases | • Increased claims, losses, and liabilities<br>• More difficulty pricing physical perils<br>• Reduced availability and affordability of some types of insurance<br>• Potential need for new products to address physical climate risks<br>• Reduced value of investment portfolio |
| MINING | • Water scarcity and drought<br>• Precipitation extremes and flooding<br>• Increased intensity and duration of extreme weather events, such as storms<br>• Rising sea level<br>• Rising temperatures<br>• Thawing permafrost and land ice<br>• Increased wildfires<br>• Increased exposure to diseases | • Constrained exploration, processing, refining, and site rehabilitation<br>• Damage to infrastructure and facilities<br>• Higher decommissioning costs<br>• Altered access to mining deposits and coastal facilities<br>• Disrupted transportation routes and reduced port availability<br>• Risks to worker health and safety<br>• Water conflicts with communities (and damaged corporate reputation) |
| OIL AND GAS | • Increased intensity and duration of extreme weather events, such as storms and floods<br>• Rising sea level, higher storm surges, and increased coastal erosion<br>• Land and sea ice melting and permafrost thawing<br>• Water scarcity and droughts | • Damage to infrastructure and facilities<br>• Rising risks to employee safety and health<br>• Altered access to fossil fuel reserves<br>• Constrained production of water-intensive oil and gas resources, such as oil sands, and water conflicts with communities and other users (and damaged corporate reputation)<br>• Disruption of transport and distribution systems |
| TOURISM | • Increased weather extremes and variability<br>• Increased frequency and severity of floods and storms<br>• Rising temperatures<br>• Rising sea level and coastal erosion<br>• Droughts<br>• Increased wildfires<br>• Changes in precipitation patterns and snow reliability | • Damage to infrastructure and facilities<br>• Decreased attractiveness of tourism destinations<br>• Disruptions of transportation (e.g., flights and cruises)<br>• Loss of ski trails, coral reefs, and other natural tourism attractions<br>• Altered tourist seasons<br>• Conflicts with communities over coastal and other development |

Source: Ceres, Calvert Investments, David Gardiner & Associates, Oxfam America, 2012

**Figure 5: Climate Change Physical Risks for Selected Sectors (1/2)**

### 3.2.4 Litigation risk.

Businesses have increased GHGs emissions may be confronted with lawsuits, as with the tobacco companies, pharmaceutical companies, etc. (Lash and Wellington, 2006; Wellington and Sauer, 2005). Along those lines, corporate disclosures regarding climate change practices can provide a sort of ''protection" against potential lawsuits. Hanley and Hoberg (2012) find that corporate disclosure forms an effective hedging strategy against all types of lawsuits. They claim that for investors, in order to file a lawsuit against a company, two conditions must be met. First, the investors must suffer monetary losses and second, they must e able to prove that the losses suffered where due to misinformation or lack of sufficient information from the part of the firm. Therefore, enhancing information disclosure reduces the chances of having to suffer economic damages from lawsuits.

Additionally, in their research on the relationship between environmental performance and environmental disclosure, Cho and Patten (2007) find that firms who have worse environmental performance disclose more information regarding their environmental practices than firms with better environmental performance. In this case, environmental disclosure is used as a vehicle to mitigate public scrutiny regarding environmental issues. The same results are also obtained in the study of Cho *et al.* (2012), where environmental performance is found to be negatively related to the level of disclosure with ''worse performing companies making more extensive disclosures''

So far, we have considered a positive relationship between litigation risk and corporate disclosures. However, academic research has shown that this is not always the case, especially for firms who have suffered severe litigation costs. More specific, Rogers and Van Burskirk (2009) find that firms do not respond to a litigation event by increasing disclosures, rather they reduce the amount of information provided to investors after a litigation event. In the same line, Laux and Stocken (2012) also find that an increase in expected legal damages increases misreporting. This phenomenon is stronger when the firm's management is optimistic about the firm's future prospects, when the costs of litigation are considered low and when the firms has a weak internal control system.

### 3.2.5 Competitive risk.

As mentioned above, the business operating costs will increase under the pressure of climate legislation. This may adversely affect the competitiveness of companies and thus their profitability and ability to raise capital. For investors, the parameters of the competitive position of the company relative to other companies in the industry and how these are affected by the restrictions in GHGs emissions are particularly important during the financial evaluation of investments (Weber *et al*., 2010; Busch and Hoffmann, 2007; Wellington and Sauer, 2005).

Companies that have a negative picture regarding climate change (whether it has to do with the policy of the company, its products or its operating procedures) may come up against the consumer shift and investors in markets sensitized to environmental issues (Lash and Wellington, 2006; Wellington and Sauer, 2005; Nikoalou *et al*., 2015). This is particularly important in industries with high competition, such as car manufacturers and fuel supply companies, where the loyalty of consumers to the name brand is an important feature of the company's value.

In this research, we will examine two dimensions of competitive risk related to climate change. One involves the uncertainly in market signals due to the increases costs of regulation, which affects operational costs of particular economic sectors. The other involves competition risks related to changing consumer behavior. As the negative effects of climate change become more evident, consumers are expected to change their preferences towards products that are ‘’carbon friendly’’ or towards companies that actively manage their GHG emissions.

Building on the above, we are going to create a climate change risk management questionnaire, which we are going to use in order to conduct an extensive survey, during which, climate change experts will assess the difficulty level of identifying the impacts, calculating the financial implications of the impacts, identifying management methods and calculating the cost of management methods related to the climate change risks described above. The questionnaire is presented in Appendix B.

## 3.3 Carbon Accounting and Reporting

Accounting is used by managers to analyze various aspects of the economic activities of a company. Furthermore, it forms a vehicle of disclosure regarding the financial statements of firms. According to the International Accounting Standards Committee "The objective of financial statements is to provide information about the financial position, performance and changes in financial position of an enterprise that is useful to a wide range of users in making economic decisions". As discussed in the previous sections, climate change poses significant risks that could affect a firm's corporate performance. Climate change regulation, for example, have increased compliance costs for firms operating in carbon intensive sectors either in the form of obtaining emission permits or complying to specific industry standards. Additionally, the increase in extreme weather event or change in precipitation patterns has increased insurance costs for companies that heavily depend on the natural environment. Due to increasing public awareness public awareness regarding the effects of climate change on the physical, economical and social environment, various stakeholders have begun to demand more information regarding the climate change exposure of firms. Information regarding carbon emissions is being made publicly available in the form of business reports, in website and on the media, while public reporting and participation involuntary and mandatory reporting programs at national, regional and local level are being adopted as mainstream climate change strategies worldwide.

As demand for increased disclosure rises, companies have begun to implement business processes that allow them to assess, measure and manage GHG emissions, to develop their GHG accounting capabilities by setting emission baseline's on which future emission trends are calculated and to make provisions for purchasing emission allowances (Kolk *et al.*, 2008; Linnenluecke *et al.*, 2015). Finally, the need for developing climate change strategies have spurred the emergence of firms who conduct climate change related research, for example assessing carbon exposure of companies, firms who are offering management consulting on carbon emissions reduction strategies, or provide carbon offsetting services, through the implementation of CDM projects (Corbera *et al.*, 2009; Dhanda and Hartman, 2011; Schaltegger, and Csutora , 2012).

*Carbon Accounting* is the estimation, calculation, measurement, monitoring, reporting, validation, verification and auditing of $CO_2$ emissions. This involves, apart from the general impacts of corporate activities on climate change and vice versa, the GHG emissions released to the atmosphere, the GHG emissions removed from the atmosphere (for example through CCS technology), GHG emission rights and obligations and emission reductions. It also involves the legal financial instruments liked to the above initiatives, including carbon taxes and emissions trading schemes. Moreover, all the above actions involve climate change impacts and emissions released at global or national level, at corporate, project, or product level, and at supply chain level. Finally, the ultimate purpose of carbon accounting is the production of information that will be used for mandatory or voluntary reporting, disclosure, research , compliance, auditing, as well as for benchmarking and marketing purposes (Ascui and Lovel, 2011).

Carbon accounting has its origins in the conceptual framework of social accounting which examines the role of accounting science not in the narrow boundaries of an organization but a s an enabler in the formation of social processes (Hopwood and Miller, 1994). In this sense accounting can be viewed as ‘’ the mirror with which the public can interpret and understand corporate operations, hence a transparent provision of business data relating to economic, social and environmental issues’’ (Ngwakwe, 2012). Academic research has shown that accounting science has begun to engage in sustainability related issues. Nevertheless, this involvement is still weak due to the lack of formalized sustainability reporting standards (Ngwakwe, 2012). The majority of conceptual work on sustainability accounting can be attributed to Gray (1992) who proposed that accounting science should move from its traditional paradigm and incorporate environmental and social aspects of corporate activities. Internal and external auditing regarding the ethical foundation of a firm’s activities, reporting of energy consumption or waste management, environmental impact assessment, corporate disclosure and reporting o social and environmental activities, accounting for environmental assets and liabilities are among the aspects of accounting science should take into account Following the same school of thought, Elkington (1997) introduced the term ‘’triple-bottom line’’ (TBL), which emphasizes the necessity that firms report not only on issues regarding their financial performance but also on their social and environmental performance. Finally, financial markets have begun to address sustainability issues, such as responsible investing, or incorporation of sustainability reporting in mainstream financial reports (Hopwood, 2009; Schaltegger and Cscutora, 2012).

The need for accounting and reporting for social and environmental aspects for corporate activities has spurred the development of reporting schemes that aim to create corporate reporting standards. The Global Reporting Initiative (GRI), launched in 1997, was the result of collaboration between the United Nations Environmental Program (UNEP) and Ceres and aims to provide guidelines for the implementation of the TBL reporting framework at corporate level (Linnenluecke *et al*., 2015). The GRI framework prescribes methodologies and standards, which firms can use to disclose information regarding their economic, environmental and social performance (GRI, 2015), thus contributing to enhanced corporate transparency and accountability.

Carbon accounting can be framed into five categories: Physical Carbon Accounting, Political Carbon Accounting, Market-Enabling Carbon Accounting, Financial Carbon Accounting and Social/Environmental Carbon Accounting. The first category, physical carbon accounting, can be viewed ‘’as a matter of physical measurement, estimation or calculation and attribution of GHGs through the biophysical environment’’. Political carbon accounting involves the monitoring of GHGs emissions at national level including the establishment of national GHG inventories. Market-enabling carbon accounting involves the creation of supply and demand forces for GHG emission rights through the establishment of cap-and-trade systems. Additionally, it involves the standardization of quantification and measurement of GHG emissions that would allow the precise estimation of CERs achieved through the Kyoto Protocol flexible mechanisms. Financial carbon accounting has also emerged as a result of the implementation of ETSs where emissions are now traded as a commodity. Furthermore, companies participating in ETSs have to treat carbon emission rights as potential assets or liabilities which also enhance the need of developing financial accounting standards. Finally, the social/environmental dimension of carbon accounting is closely related to the social and environmental dimension of accounting in which corporate disclosures and reporting holds prominent role (Ascui and Lovel, 2011).

Stechemesser and Guenther (2012) provide an alternative classification of carbon accounting at national, project organizational and product scale. Carbon accounting as national scale involve the physical measurement of the direct and indirect emissions of human activities at national or sub-national scale, as well as, the measurement of emissions caused by natural disturbances. The aim of accounting at national scale is to ‘’realize emission strategies, to increase public interest and to influence international accounting standards’’. Carbon accounting at project scale involves the measurement of carbon emissions in corporate projects, of carbon emissions avoided by the implementation of projects (emissions offsetting), the monetary assessment of these emissions and the calculation of the relevant offset credits. The objective of project carbon accounting is to establish calculation methodologies for carbon emission offsets and to inform project-developers and investors on the value of these offsets.

Regarding carbon accounting at organizational scale, the authors distinguish between carbon management accounting and carbon financial accounting. Carbon management accounting focuses on the monetary and physical carbon accounting at company level. Since climate change poses significant business risk, assessing the climate change exposure of a firm is of outmost importance to managers and investors. Therefore, measuring and monitoring $CO_2$ emissions is important for the implementation of carbon management strategies. Regarding carbon financial accounting, in the same line with Haupt and Ismer (2013), it refers to the carbon-related financial issues, focusing on the treatment of emissions rights and permits in financial statements. Summarizing, organizational accounting involve the voluntary or mandatory disclosure of GHG emission, their valuation in monetary and physical terms, the auditing and reporting of $CO_2$ related information. Finally, carbon accounting at product scale covers direct and indirect emissions related to the production and use of specific products and the implementation of corporate strategies that reduce emissions in the entire life cycle of the product.

Schlategger and Csutora (2012) also distinguish between different levels of carbon accounting: scientific, political and economic , and corporate carbon accounting. Scientific carbon accounting involves information provided by scientific organizations regarding the physical measurement of carbon dioxide concentrations in the atmosphere. It’s main purpose is to raise public awareness and to motivate politicians to implement carbon reduction policies at national and international level. Political and economic carbon accounting ‘’translates the scientific information into physical and monetary economic figures and politically relevant scenarios on the macro level’’.

Finally, corporate carbon accounting refers to the physical and monetary accounting of emissions at corporate level, and it also include carbon emissions related to ETS, carbon limits and carbon taxes.

As we have discussed before, climate change is a particularly complex environmental problem because it manifests itself in a spatial and temporal scale that is characterized by a high degree of uncertainty, and because it has widespread environmental, economic and social impacts. Moreover, with the introduction climate change regulation in the form of either command and control regulation or market based regulation, such as ETSs, carbon taxes etc., financial analysts and investors have begun to take into account the value relevance of emission rights and allowances and their effect of financial corporate performance (Schlateger and Csutora, 2012).

In response to carbon trading schemes or in anticipation of future carbon-pricing legislation many companies have begun to develop internal price of carbon schemes. ‘’Broadly speaking, internal carbon pricing is most frequently used as a shadow price which can be added to future investments and operational costs as a way of hedging against future policy decisions to implement any carbon-pricing mechanisms.’’ (The New York Times, 2015). Furthermore, ‘’carbon pricing systems encourage innovation and help ensure sustained economic competitiveness’’ (CDP, 2015). According to the CDP some of the benefits of using internal price of carbon schemes are to mitigate the effect of government legislation regarding carbon emission reductions, to help them comply with government legislation, to avoid transaction costs associated with trading permits in national schemes in favor of factoring in these prices internally, to justify investments that may have smaller margins without a carbon price and to manage risk for future investment.

‘’In some exceptional circumstances, a carbon price can underpin a more expansive company scheme. In 2012, Microsoft made the decision to use an internal carbon fee which was charged to individual business groups using Microsoft services. The funds from this internal tax were then used to invest in energy-efficiency initiatives, renewable energy and carbon offset projects in order to meet net carbon neutrality targets. Since 2014, 100 percent of Microsoft’s energy consumption is sourced or offset due to these projects. In just three years, the company has reduced its emissions by 7.5 million tons of $CO_2$ and saved more than $10 million on energy costs. This year it expects its scheme to amount to $20 million of internal charges.'' (The New York Times, 2015)

Moreover, carbon regulation in the form of carbon taxes and cap-and-trade systems has created new accounting demands (Linnenluecke *et al*., 2015). Since the introduction of ETSs, there has been an increasing debate on the accounting policies regarding emissions allowances and their treatment either as asset or liabilities, and on the different carbon hedging instruments that have been created (Haupt and Ismer,, 2013). Among the most popular carbon accounting practices adopted by firms are the classification of emission allowance as intangible assets (Lovell *et al*., 2010; Bebbington and Larringa-Gonzalez, 2008), the initial recognition of emissions allowances at cost (for purchased allowances ) or a nil value (for granted allowances) – in the second phase of the EU ETS, a proportion of the initial $CO_2$ allowances where given for free by governments to companies participating in the EU ETS, while in the third phase of the EU ETS the number of free allowances has been reduced to a great extent-and the measurement of emission allowance either at the initial cost value or through revaluation according to their fair value ( Lovell *et al*, 2010; Haupt and Ismer, 2013). Therefore, the need for developing credible and reliable accounting methods, standards and procedures, regarding the measurement and assurance of carbon emissions, is more than evident. This allow the precise accounting of carbon offset credits, the monitoring of direct and indirect emissions and the verification and certification of emissions and emission allowances through standardized and verified internal or external auditing procedures (Schlateger and Csutora, 2012).

To provide guidance for the reporting of emissions and emission allowance for companies participating in the EU ETS, the International Accounting Standards Board (IASB) issued IFRIC 3: Emissions Right through the International Financial Interpretations Committee (IFRIC) in 2004. IFRIC 3 was an attempt of the International Financial Reporting Standards (IFRS) committee to set specific guidelines regarding the treatment of emissions allowances in financial statements of firms that participated in the EU ETS (Lovell and McKenzie, 2011). However, because at the time of its introduction it gave neither specific guidance on the treatment of emission allowances of non-participants in the EU ETSs, who were also able to acquire allowances for trading or investment purposes , nor on carbon derivatives, and because it didn't set specific measurement models for the emission allowances as liabilities, it was rejected by the majority of stakeholders and finally withdrawn (Lovell *et al*., 2010; Haupt and Ismer, 2013; Lovell and McKenzie, 2011).

Subsequently, associations for responsible business of investor groups such as the CDP or the CDSB have developed reporting schemes that include performance scores, targets and reporting methodologies regarding the amount of emissions produced, the nature of these emissions, i.e. whether they are the result of the production processes of the firm or have their origin on electricity consumption or they are associated with the supply chain of the firms. Accounting firms have also began to provide advice on issues related to the assessment, accounting reporting and auditing of carbon emissions related information, (KPMG, 2008), since many firms lack the organizational capabilities to develop carbon accounting business processes on their own. Furthermore, the need for internal and external validation of carbon emissions has also strengthened the role of accounting firms, as there is an increasing demand for carbon assurance services, which enhance the quality of carbon-related information (Moroney *et al.*, 2012).

Regarding the development of assurance services or sustainability reporting ‘’challenges arise from the requirements of relevance, completeness, reliability, neutrality and understandability because of the broad and complex subject matter in sustainability reports’’ (Simnett and Nugent, 2007). Table 5 provides a description of issues related to sustainability assurance.

In responding to the increased stakeholder demand for accurate and reliable information regarding the impacts of corporate activities on climate change, the World Resource Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), created the Greenhouse Gas (GHG) Protocol in 1998. Today, the GHG Protocol constitutes the most complete guide of accounting and reporting standards for business, in order to develop a valid and reliable GHG inventory. As with classical accounting theory, carbon accounting must also use globally accepted principles. Principles can be broadly defined as the general approaches utilized in the recognition and measurement of accounting event.

**Table 5: Sustainability Assurance**

| | |
|---|---|
| **Assurance** | The outcome of an independent verification process, the term is often used interchangeably with the term verification. It is increasingly used to describe the evaluation and assessment services provided by independent accounting and other firms, usually based on specific assurance standards or frameworks. |
| **Level of assurance** | Assurance providers often offer two levels: ‘reasonable assurance’ (i.e. high but not absolute) or ‘limited assurance’ (i.e. moderate). The higher the level of assurance, the more rigorous the assurance process is, as defined in the standards and procedures used for the specific assurance engagement |
| **Assurance Providers** | • Accountancy firms. They are normally connected to global networks; are focused on business; have expertise in financial and non-financial reporting; they have their own systems, controls and audit/assurance procedures (including for climate change/GHG data)<br>• Engineering firms. They normally offer technical certifications and engineering expertise; they understand complex processes and are used to risk-based analysis; they apply a multi-disciplinary approach.<br>• Sustainability services firms. Their focus and expertise is on sustainability related issues; they are smaller than the others assurance providers’ general categories and are usually locally based; they are also often recognized because of their experience with stakeholder issues. |

Source: GRI 2015

According to the GHG Protocol, information regarding GHG emissions should be relevant, complete, consistent, transparent and accurate (GHG Protocol ). Relevance ensures that a company’s GHG inventory includes the GHG emissions –both internal and external – that are properly attributed to the corporate activities of the company. Completeness assures that all GHG emissions resulting from the company’s corporate activities are reported. Consistency involves the use of methodologies that allow the comparison of GHG emissions over time. Transparency addresses issues that involve the audit of information disclosed and the assurance standards. Finally, accuracy ensures that the quantification of GHG emissions is precise and it does neither underestimate nor overestimate the amount of emissions that are attributed to a company’s corporate activities. In the same line of though, Bowen and Wittneben (2011) also develops a framework for developing measurement and reporting standards for carbon emissions. According to their research, carbon measurement techniques have to be accurate, i.e. reflect the actual emissions produced by its entity.

They also have to consistent through a spatial and temporal scale, and verified by credible authorities. Finally, measurement techniques have to incorporate ‘’indicators of uncertainty’’ regarding the valuation of CO2 emissions.

The GHG Protocol sets also the organizational boundaries of reporting emissions – which company entities or activities should be included in the GHG inventory. According to the protocol, accompany can follow two different approaches in setting up its organizational boundaries. It can use either the control approach, where a company reports 100 percent of the GHG emissions from operations over which it has financial o operation control, and the equity approach, where a company account for the GHG emissions which correspond proportionally to its share of equity in the operation. Furthermore, it sets operational boundaries, which means that it clearly defines the direct and indirect emissions of a company’s operational activities. Direct emissions are those who come from sources that are owned or controlled by the company. Indirect emissions are the consequences of the activities of the company but occur at sources owned or controlled by another company. The Protocol uses the term ‘’scope’’ to define the operational boundaries in accounting and reporting GHG emissions. Therefore, scope 1 emissions refer to the direct emissions of the company, scope 2 refers to indirect emissions based on the electricity consumed by the company and scope 3 covers all other indirect emissions. For more information please see Figure 6 and Table 6.

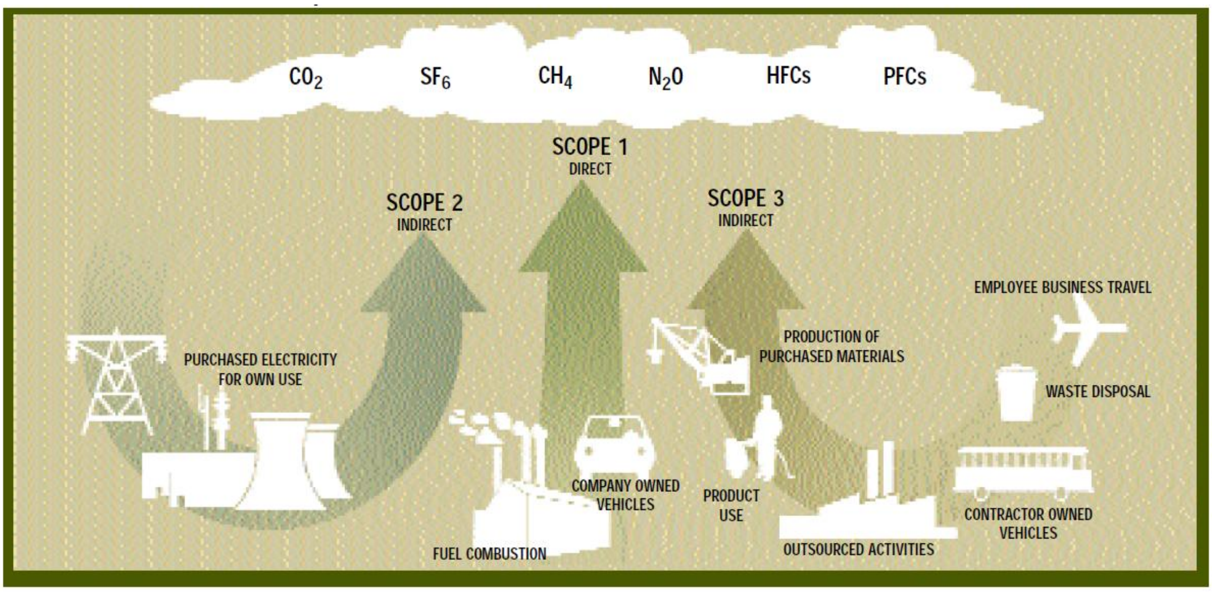



**Figure 6: Operational Boundaries of GHG emissions**

**Table 6: Operational Boundaries of GHG emissions**

| | |
|---|---|
| **Scope 1: Direct GHG emissions** | Scope 1 emissions include direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment. |
| **Scope 2: Electricity indirect GHG emissions** | Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated. |
| **Scope 3: Other indirect GHG emissions** | Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services. |

Source: The GHG Protocol

Along those lines, tracking emissions over time is important in developing a complete and reliable GHG inventory. Mergers, acquisitions, divestments, outsourcing of emitting activities etc. alter a company's profile and subsequently its emissions profile. Therefore, in order to achieve consistency over time, historic emission data will have to be recalculated over time. The first step in tracking emissions is to set a baseline year that is a specific year against which ca company's emissions are tracked over time. According to the GHG protocol companies can choose between a target base year and rolling base year. The target base year is used to define a GHG reduction target, for example $CO_2$ reduction 25% below the emissions target based year 2000. A rolling base year is a base year that changes, usually shifts forward by a certain number of years at regular intervals of time. In this research, we take into account baseline years that are either stable (target-base approach) or rolling, but at a time interval that is more than five years. Taking also into account the need for reducing $CO_2$ emissions below 1990 emission levels, the reason we chose not to take into account rolling base years with a time interval less than five years is because we believe that companies that calculate their emissions and se emission targets based on the emissions of the previous one or two years, do not set considerable emission reduction targets. Finally, the company must decide when it should recalculate emissions, for example when the company undergoes structural changes or when it decides to use an improve methodology to increase emission data accuracy.

Finally, the GHG protocol provides guidelines on the quantification of project based reductions, carbon offsets and credits. According to the protocol, the following accounting issues must be addressed when a firm calculates the amount of $CO_2$ emissions avoided by the implementation of a $CO_2$ reduction project. First, the alternative baseline scenario should be taken into account, i.e. what would have happened with the company's emissions if the project had not been implemented. Second, the project must clearly reflect additional $CO_2$ reductions, which means that implementing the project removes more emissions from the atmosphere that would exit if the project had not been implemented. Finally, the accounting methodology used for the calculation of $CO_2$ emission reductions should avoid double counting of the emissions avoided, that is, if the $CO_2$ reductions take place to a source not controlled by the firm, the ownership of the source should be clarified to avoid double counting.

Building on the above literature, we are going to create an index that measures the level of corporate commitment regarding carbon accounting. This index will include three dimensions of carbon accounting:

1. Internal Price of Carbon
2. Identification and Calculation of Carbon Emissions including scope 1, scope 2 and scope 3 emissions, emissions baselines and calculation methodologies.
3. Reporting and Verification of Carbon Emissions. This factor will include internal and external verification of emissions, the verification level achieved by a company, and the reporting of emissions in voluntary and mandatory reporting schemes.

Building on the above practices, we are going to create a carbon accounting questionnaire, which we are going to use in order to conduct an extensive survey, during which, climate change experts will assess the difficulty level of implementing of the specific climate change practices described above. The questionnaire is presented in Appendix C.

# 4 LITERATURE REVIEW AND RESEARCH HYPOTHESES

## 4.1 Environmental management and financial performance

Firms devote considerable resources on the implementation of environmental management practices, in an attempt to control for the negative impacts of their operational activities on the natural environment. Therefore, it is essential that we examine the effect of these actions on the financial performance of firms and whether they add costs that are irretrievable, and can only worsen a firm's financial performance, or whether they can enhance financial performance, for example through the adoption of energy efficient technology that reduces overall production costs or through the development of differentiated eco-friendly products for which customers are willing to pay premium prices (Porter and van der Linde,1995; Ruf *et al.*, 2001).

Many researchers have the relationship between environmental management and corporate performance. According to Dangelico and Pontrandolfo (2015), a firm's ability to successfully implement environmental actions, especially those focused on energy efficiency and pollution reduction, has a positive effect on the firm's market performance, measured in terms of access to new markets, increased market share, increased competitive  and  increased customers willingness to pay a premium price for products. On the other hand, a firm's image performance, measured through improved reputation, improved regulatory compliance and better innovation, is found to be positively related to the capabilities of the firm to implement environmental actions focused on the design and development of eco-friendly products and the elimination of hazardous input materials in the production process (Dangelico and Pontrandolfo, 2015).

Furthermore, Gallego-Alvarez *et al*. (2014) in examining the relationship between environmental and financial performance, find that this relationship becomes stronger in times of economic crisis for companies in carbon intensive sectors. Therefore, in order to enhance stakeholder relations and achieve higher economic benefits, the authors suggest that firms should invest in sustainable projects even in the times of economic crisis. Boiral *et al*. (2012) in their study on Canadian manufacturing firms confirm the positive relationship between corporate commitment to reduce GHG emissions and enhanced financial performance. Eccles *et al.* (2013), in examining the relationship between corporate sustainability processes and corporate performance for US companies, find that companies that have voluntarily adopted sustainability policies from 1993 to 2009 exhibit higher corporate performance (both in terms of stock market as well as accounting performance) than firms, with same organizational characteristics, who have not adopted sustainability policies. Additionally, Al-Najjar and Anfimiadou (2012) and Sinkin et al. (2008) also confirm that eco-efficient firms exhibit a higher market value than those lacking environmental strategies. Furthermore, Nakao *et al.* (2007) have shown that a firm's environmental performance has a positive significant impact on its financial performance and vice versa, and estimate that increasing environmental management scores could lead to an increase in a firm's intangible assets in the long-run.

Finally, Lannelongue *et al.* (2015) suggest that, in order to gain a better understanding of the effect of environmental management on financial performance, we should not focus on examining separately the effect of environmental management or environmental performance on financial performance. They find that only when we take into account environmental management productivity, which they define as the ratio between environmental management and environmental performance we can gain a more comprehensive understanding of the relationship between environmental management and financial performance.

However, not all studies find a positive relationship between environmental management and corporate performance. For example, Busch and Hoffmann (2011) find that carbon management is negatively related to financial performance. However, they find that reduced carbon intensity of business activities is positively related to financial performance. Cong and Freedman (2011), also find that there is no relationship between good governance and good pollution performance while they find that there is a positive relationship between pollution disclosure and corporate governance. Finally, Dobler *et al.* (2014) find that there is a negative association between environmental performance and environmental risk and that active risk management does not contribute significantly to environmental performance.

Along those lines, environmental disclosures have also been examined as having a positive significant impact on corporate performance. Prior empirical research has examined the relationship between firms' financial performance and their environmental disclosure practices. Most studies show a positive relationship between financial performance and environmental disclosures (Freedman and Jaggi, 2005; Liu and Anbumzhi, 2009; Nakao *et al.*, 2007; Richardson and Welker, 2001; Brammer and Pavelin, 2006; Clarkson *et al*,.2008; Gallego-Alvarez 2010; Galani *et al*., 2011; Zhang *et al*., 2008). More specifically, firms with higher sustainability scores perform better than firms with lows sustainability scores (Eccles *et al*., 2013). On the other hand, Ghoul et al. (2011) show that firms with better corporate social performance (CSR) scores, especially those associated with environmental policies, have access to financing equity at a lower cost than firms with low CSR scores. Finally, Yadav *et al*. (2015) also confirm that firms with repeated high "green" rankings show significantly higher firm value than firms with either reduced or unchanged rankings across time.

However, the inverse relationship between financial performance and volume of information issued has also been detected by Freedman and Jaggi (1982) and Prado-Lorengo *et al.* (2009). These results suggest that companies which perform more poorly have an incentive to reveal a higher volume of environmental information in order to make themselves more attractive to various stakeholders (Prado-Lorengo *et al.*, 2009). However the majority of the above studies have also shown that the relationship between environmental disclosures and financial performance, at conventional levels of significance, is deemed insignificant suggesting that corporate disclosure practices are not strongly affected by financial performance (Bewli and Li 2000).

This study explores the relationship between climate change strategy, climate change risk management, carbon accounting and corporate performance. Although a very large number of studies exist today on the determinants of CSR reporting or environmental reporting (Fifka, 2013), as well as on the relationship between environmental management, environmental performance and corporate performance, fewer studies have addressed climate change management issues and their relationship to environmental performance and corporate performance. Most times climate change related issues are included in the general environmental reporting section of CSR reports. However, since climate change is now considered to be a major source of business risk, examining the effect of climate change management on corporate performance could offer us results that are of particular interest to both managers and policy makers.

As we have discussed in previous sections of this study, we are going to examine three different aspects of climate change management: strategy, risk management and carbon accounting. Based on the literature review, we developed a set of critical factors for Climate Change Strategy (Table 7), Climate Change Risk management (Table 8) and Carbon Accounting (Table 9). Using the above critical factors, we developed three questionnaires, which were sent to three different target groups. Respondents were asked to rate each critical factor under a seven-point Likert scale, to indicate the difficulty level of implementing the respective climate change practice. The questionnaires are presented in Appendix A, Appendix B and Appendix C. After our data was collected, they were assessed for validity and reliability by using exploratory factor analysis. The methodology used is extensively discussed in the next section.

Based on the results of the factor analysis eight corporate indexes for measuring the level of commitment (or management effort) regarding the implementation of climate change strategies, the identification and assessment of climate change risks and the adoption of carbon accounting practices, were developed. Three indexes are related to climate change strategy, three to risk climate change risk management and two to carbon accounting:

1. Climate Change Strategy

    a. *Climate Change Organizational Management Strategies*. This index refers to organizing, target setting and process and product development dimensions regarding climate change. It measures the management effort in implementing strategies regarding Climate Change Governance in terms of management commitment to climate change monitoring. It also includes strategies referring to the integration of climate change risk management into core business activities and the attainment of carbon reduction targets.
    b. *Carbon Reduction Technology Strategies.* This index measures the management effort in implementing technologies that reduce carbon emissions either through increased energy efficiency or through control of GHG emissions.
    c. *Carbon Compensation Strategies.* This index measures a company's commitment regarding its participation in carbon trading schemes and $CO_2$ emission offsetting projects.

2. Climate Change Risk Management

    a. *Regulation-induced Risk Management.* This index measures the management effort devoted in identifying impacts from climate change regulation and uncertainty in market signals, calculating the financial implications of these impacts, identifying management methods to address potential impacts and calculating the cost of the management methods identified. Climate change regulation includes both command-control regulation as well as market-based regulation.
    b. *Reputation - induced Risk Management.* As above, this index assesses a corporation's level of commitment regarding the management of reputational risks and risks related to changing consumer behavior.
    c. *Physical Risk Management*. This index includes management effort regarding risks related to the physical impacts of climate change, which include extreme weather events and changes in temperature and precipitation extremes.

3. Carbon Accounting

   a. *Core Business Carbon Accounting and Reporting.* This index assesses the level of a company's commitment regarding the implementation of carbon accounting practices related to the calculation of direct and indirect emissions, the verification of these emissions and the reporting of these emissions to mandatory GHG reporting programs.

   b. *Advanced Carbon Accounting Practices*. This index measures the management effort devoted into carbon accounting practices which, according to climate change experts, are more difficult to implement than the practices included in the previous index. This includes calculation of scope 3 emissions and the implementation of internal price of carbon schemes.

Taking as a reference the position of the authors cited above, we are going to examine the relationship between the indexes described above and corporate financial performance. Thus we pose the following working hypotheses:

$H_{1a}$: A company's level of commitment regarding Climate Change Organizational Management Strategies is positively related to its financial performance.

$H_{1b}$: A company's level of commitment regarding Carbon Reduction Technology Strategies is positively related to its financial performance.

$H_{1c}$: A company's level of commitment regarding Carbon Compensation Strategies is positively related to its financial performance.

$H_{2a}$: A company's level of commitment regarding Regulation-induced Risk Management is positively related to its financial performance.

$H_{2b}$: A company's level of commitment regarding Reputation - induced Risk Management is positively related to its financial performance.

$H_{2c}$: A company's level of commitment regarding Physical Risk Management is positively related to its financial performance.

$H_{3a}$: A company's level of commitment regarding Core Business Carbon Accounting and Reporting is positively related to its financial performance.

$H_{3b}$: A company's level of commitment regarding Advanced Carbon Accounting Practices is positively related to its financial performance.

## 4.2 GHGs emissions and corporate performance

Regarding the effect of GHGs emissions on corporate performance, the results obtained in previous research are not unanimous. More specifically, Wang *et al.* (2014) find a significant positive relationship between GHGs and corporate performance. These results are in contrast with the claim that firms with better environmental performance exhibit better corporate performance, since a high GHGs intensity of corporate activities implies a low environmental performance. Nevertheless, the authors interpret the above results by taking into account the structure of the Australian economy, which consists mainly of resource-intensive industries. Along those lines, Gallego-Alvarez (2012) also finds a significant negative relationship between CO2 reductions and firm performance, which can be explained, given the fact that during the time of the research, the economic crisis caused large companies to reduce their investments on environmental performance in order to improve their financial performance.

On the contrary, Nishitani and Kokubu (2012) show that GHG emission reduction enhances firm value. However, this stands only for firms, for which strong market disciple, imposed by stockholders or investors, forces them to reduce GHG emissions. Furthermore, Lannelongue *et al*. (2015) find a significant positive relationship between CO2 reductions and corporate performance. Moreover, Boiral *et al.* (2012) also find a positive relationship between commitment to reduce GHGs and financial performance. Finally, Busch and Hoffman (2011) show that a high carbon intensity of corporate activities negatively affects a firm’s corporate performance. Taking as a reference the above authors, we pose the following hypothesis:

$H_4$: A company’s level of commitment to reduce GHG emissions is positively related to its financial performance.

Figure 7 present the conceptual framework of our study. In the following section we are going to present our research methodology regarding the development of our climate change corporate indexes. Then we will examine the validity of our hypotheses.

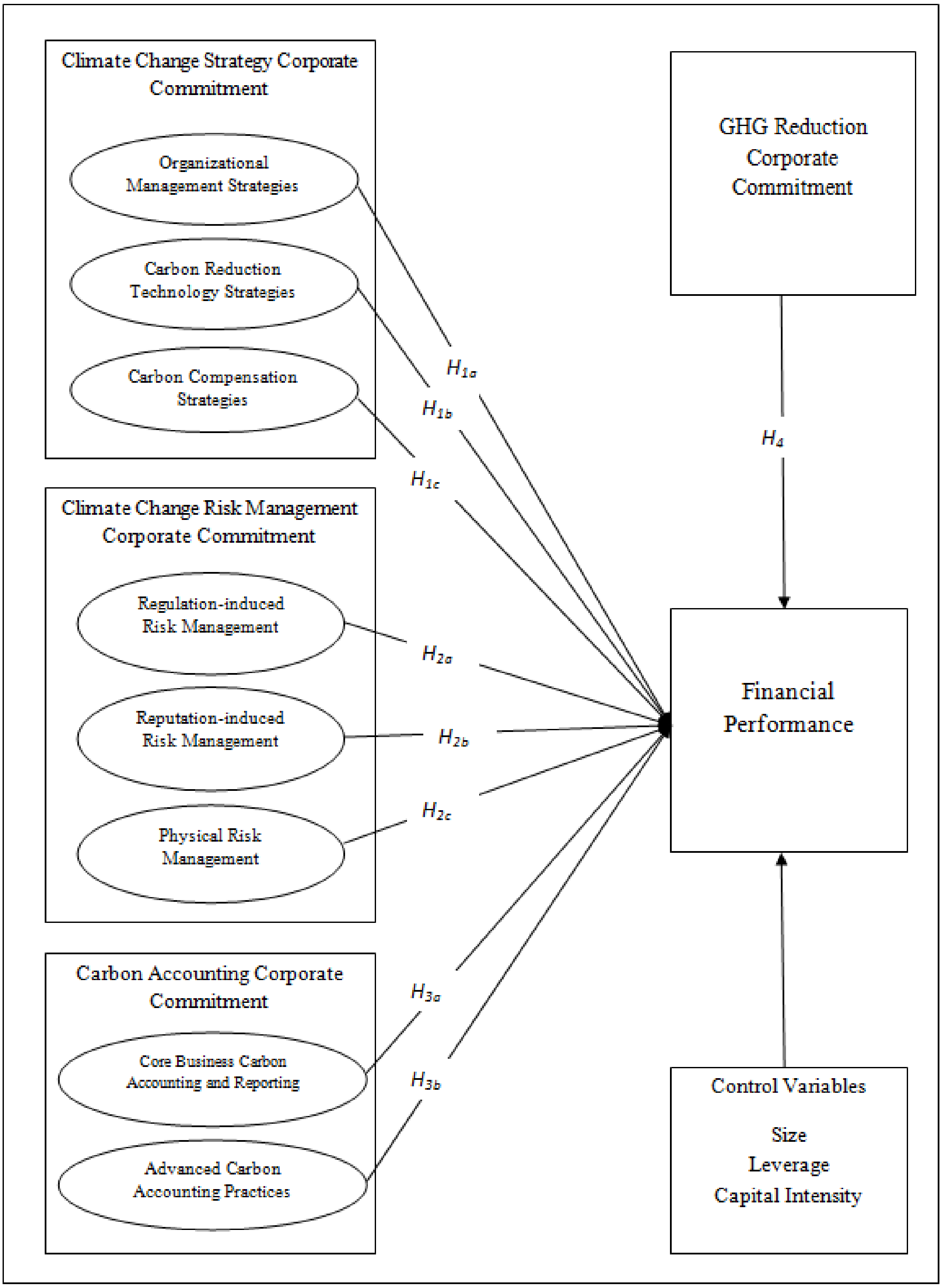



**Figure 7: Conceptual Research Framework**

# 5 METHODOLOGY

The aim of this research is to examine the relationship between corporate commitment regarding climate change strategy, climate change risk management, carbon accounting, GHG reduction and corporate financial performance. For this reason we have developed eight corporate indexes for measuring the level of commitment (i.e. management effort) a firm shows regarding the implementation of climate change strategies, in the identification and assessment of climate change risks and the adoption of carbon accounting practices. Three indexes are related to climate change strategy, three to risk climate change risk management and two to carbon accounting.

In order to measure the level of corporate commitment regarding climate change practices we decided to weight the corporate indexes according to the level of difficulty in implementing the climate change practice included in each respective index. In order to assign proper weighs to our indexes we developed and validated critical factors of climate change strategy, climate change risk management and carbon accounting by using respective survey instruments. Below, we describe the survey instruments used to collect data regarding the climate change practices of firms in climate change strategy, climate change risk management and carbon accounting. Then we will conduct validity and reliability assessment of the survey instruments. According to the results of this process, we will develop the respective climate change indexes and assign relevant weights according to the mean average values of the variables included in each index.

After this procedure is completed, we will test the index in two different business sectors: the Oil and Gas sector and the Banking sector. The reason we selected these two different sectors is because of the nature of their corporate activities. The oil and gas industry is perhaps the most carbon intensive business sector and is therefore directly affected by the adverse effects of climate change, in terms of climate change regulation or corporate reputation etc. On the other hand, the Banking sector, as its main role is the provision of services, is not directly influenced by climate change. However, as we have discussed in previous section of this study, regardless of whether they are directly or indirectly affected by climate change, all companies will eventually have to develop and implement climate change management corporate practices that will either help them mitigate the costs of climate change to their business activities or help them gain competitive advantages against other companies in their respective business sector. The aim of this research therefore, besides examining the effect of climate change management on financial performance, is to prove that enhanced climate change management is equally important for companies belonging to phenomenally diverse business sectors regarding their dependence to the adverse effects of climate change.  The oil and gas companies and the banks that will we assessed are those belonging to the Financial Times 500 Global database. We will examine the climate change practices of these firms for the years 2012-2015.

The assessment of the selected companies will be conducted through a predefined scoring methodology that is described in this section of the study. After the extracting the relevant scores for its company, we will create eight variables in accordance with the indexes developed that will measure the level of corporate commitment regarding *Climate Change Organizational Management Strategies, Carbon Reduction Technology Strategies, Carbon Compensation Strategies, Regulation-induced Risk Management, Reputation - induced Risk Management, Physical Risk Management, Core Business Carbon Accounting and Reporting* and *Advanced Carbon Accounting Practices.* We will then examine the relationship between the above indexes and corporate financial performance.

## 5.1 Development of survey instruments

Based on the literature review, we developed a set of critical factors for Climate Change Strategy (Table 7), Climate Change Risk management (Table 8) and Carbon Accounting (Table 9). For Climate Change Strategy, five critical factors were identified: *Climate Change Governance, Climate Change Risk Management Integration, Carbon Reduction Targets, Carbon Reduction Strategies and Carbon Compensation Strategies*. A total of 23 items were developed under these factors. For Climate Change Risk Management, five critical factors were identified: *Regulation Risk Management, Physical Risk Management, Reputational Risk Management, Competitive Risk Management, Legal Risk Management*. A total of 32 items were developed under the above factors. Finally, for Carbon Accounting, we identified three critical factors, *Internal Price of Carbon, Identification and Calculation of Carbon Emissions and Reporting and Verification of Carbon Emissions*. A total of 13 items were developed under these factors.

Using the above critical factors, we developed three questionnaires, which were sent to three different target groups. Respondents were asked to rate each critical factor under a seven-point Likert scale (1=Very Easy ... 7=Very Difficult), to indicate the difficulty level of implementing the respective climate change practice described in Table 7, Table 8 and Table 9. The questionnaires are presented in Appendix A, Appendix B and Appendix C.

## Table 7: Climate Change Critical Factors

| Critical Factors | Item Description | Item Code |
|---|---|---|
| Climate Change Governance | The Board of Directors (or a committee of the Board) is accountable for climate change performance | STRATEGY_ITEM_01 |
| | Company management has clear responsibilities for achieving climate change goals | STRATEGY_ITEM_02 |
| | Executive compensation is linked to climate change performance | STRATEGY_ITEM_03 |
| Climate Change Risk Management Integration | Climate change risk management processes are integrated into core business risk management processes | STRATEGY_ITEM_04 |
| | Climate change risks and opportunities are identified at asset level | STRATEGY_ITEM_05 |
| | Climate change risks and opportunities are identified at company level | STRATEGY_ITEM_06 |
| | Company has processes that allow the prioritization of risks and opportunities related to climate change | STRATEGY_ITEM_07 |
| Carbon Reduction Targets | Company has short-term absolute $CO_2$ emission reduction targets. | STRATEGY_ITEM_08 |
| | Company has short-term $CO_2$ emission intensity reduction targets | STRATEGY_ITEM_09 |
| | Company has long-term absolute $CO_2$ emission reduction targets. | STRATEGY_ITEM_10 |
| | Company has long-term $CO_2$ emission intensity reduction targets | STRATEGY_ITEM_11 |
| Carbon Reduction Strategies | Fossil fuel switching, from coal to natural gas. | STRATEGY_ITEM_12 |
| | Increased boiler efficiency, by implementing the best available technology. | STRATEGY_ITEM_13 |
| | Usage of Combined Heat and Power Technology (cogeneration). | STRATEGY_ITEM_14 |
| | Energy source switching, from fossil fuels to renewable energy sources. | STRATEGY_ITEM_15 |
| | Capture and Storage of $CO_2$. | STRATEGY_ITEM_16 |
| | Replacement of carbon-based products by non-carbon based products. | STRATEGY_ITEM_17 |
| | Implementation of end-use energy efficiency processes (e.g. turning down heating and cooling during non-working hours, reduce non-necessary travel). | STRATEGY_ITEM_18 |
| | Optimization of current business processes in order to reduce $CO_2$ emissions. | STRATEGY_ITEM_19 |
| | Control of non-$CO_2$ gas emissions (e.g. CH4, H2O). | STRATEGY_ITEM_20 |
| Carbon Compensation Strategies | Participating in emissions trading schemes. | STRATEGY_ITEM_21 |
| | Creating project-based carbon credits. | STRATEGY_ITEM_22 |
| | Purchasing carbon credits. | STRATEGY_ITEM_23 |

## Table 8: Risk Management Critical Factors

| Critical Factors | | Item Description | Item Code |
|---|---|---|---|
| **Regulation Risk Management** | **Command and Control Climate Change Regulation** (process and product standards, performance and technology standards) | Identify impacts from command and control regulation. | RISK_ITEM_01 |
| | | Calculate financial implications from command and control regulation. | RISK_ITEM_02 |
| | | Identify management methods in order to address impacts from command and control regulation. | RISK_ITEM_03 |
| | | Calculate the cost of management methods needed to address impacts from command and control regulation. | RISK_ITEM_04 |
| | **Market-based Regulation** (carbon taxes, emissions trading schemes, fuel tariffs etc.) | Identify impacts from market-based regulation. | RISK_ITEM_05 |
| | | Calculate financial implications from market-based regulation. | RISK_ITEM_06 |
| | | Identify management methods in order to address impacts from market-based regulation. | RISK_ITEM_07 |
| | | Calculate the cost of management methods needed to address impacts from market-based regulation. | RISK_ITEM_08 |
| **Physical Risk Management** | **Extreme Weather Events** (extreme storms and floods, hurricanes, typhoons etc.) | Identify impacts from extreme weather events. | RISK_ITEM_09 |
| | | Calculate financial implications from extreme weather events. | RISK_ITEM_10 |
| | | Identify management methods in order to address impacts from extreme weather events. | RISK_ITEM_11 |
| | | Calculate the cost of management methods needed to address impacts from extreme weather events. | RISK_ITEM_12 |
| | **Changes in Temperature and Precipitation extremes** (reduced water supplies, droughts, heat waves etc.) | Identify impacts from changes in temperature and precipitation extremes. | RISK_ITEM_13 |
| | | Calculate financial implications from changes in temperature and precipitation extremes. | RISK_ITEM_14 |
| | | Identify management methods in order to address impacts from changes in temperature and precipitation extremes. | RISK_ITEM_15 |
| | | Calculate the cost of management methods needed to address impacts from changes in temperature and precipitation extremes. | RISK_ITEM_16 |

| Critical Factors | | Item Description | Item Code |
|---|---|---|---|
| **Reputational Risk Management** | **Reputational Risks** | Identify potential impacts from negative reputation, related to climate change. | RISK_ITEM_17 |
| | | Calculate potential financial implications from negative reputation, related to climate change. | RISK_ITEM_18 |
| | | Identify management methods in order to address impacts from negative reputation, related to climate change. | RISK_ITEM_19 |
| | | Calculate the cost of management methods needed to address impacts from negative reputation, related to climate change. | RISK_ITEM_20 |
| **Competetive Risk Management** | **Uncertainty in Market signals** | Identify potential impacts from climate change competitive risks regarding uncertainty in market signals. | RISK_ITEM_21 |
| | | Calculate potential financial implications from climate change competitive risks regarding uncertainty in market signals. | RISK_ITEM_22 |
| | | Identify management methods in order to address climate change competitive risks regarding uncertainty in market signals. | RISK_ITEM_23 |
| | | Calculate the cost of management methods needed to address climate change competitive risks regarding uncertainty in market signals. | RISK_ITEM_24 |
| | **Changing Consumer Behavior** | Identify potential impacts from climate change competitive risks related to changing consumer behavior. | RISK_ITEM_25 |
| | | Calculate potential financial implications from climate change competitive risks related to changing consumer behavior. | RISK_ITEM_26 |
| | | Identify management methods in order to address climate change competitive risks related to changing consumer behavior. | RISK_ITEM_27 |
| | | Calculate the cost of management methods needed to address climate change competitive risks related to changing consumer behavior. | RISK_ITEM_28 |
| **Legal Risk Management** | **Legal Risks** | Identify potential impacts from climate change legal risks. | RISK_ITEM_29 |
| | | Calculate potential financial implications from climate change legal risks. | RISK_ITEM_30 |
| | | Identify management methods in order to address climate change legal risks. | RISK_ITEM_31 |
| | | Calculate the cost of management methods needed to address climate change legal risks. | RISK_ITEM_32 |

**Table 9: Carbon Accounting Critical Factors**

| Critical Factors | Item Description | Item Code |
|---|---|---|
| **Internal Price of Carbon** | Develop an internal price of carbon scheme. | ACCOUNT_ITEM_01 |
| | Calculate internal price of carbon. | ACCOUNT_ITEM_02 |
| **Identification and Calculation of Carbon Emissions** | Calculate scope1 emissions. | ACCOUNT_ITEM_03 |
| | Calculate scope2 emissions. | ACCOUNT_ITEM_04 |
| | Calculate scope3 emissions. | ACCOUNT_ITEM_05 |
| | Calculate amount of emissions avoided by CO2 saving projects. | ACCOUNT_ITEM_06 |
| | Set an emissions baseline year. | ACCOUNT_ITEM_07 |
| | Use an established methodology to calculate emissions. | ACCOUNT_ITEM_08 |
| **Reporting and Verification of Carbon Emissions** | Have $CO_2$ emissions verified through an internal auditing process. | ACCOUNT_ITEM_09 |
| | Have $CO_2$ emissions verified through an independent external auditing process. | ACCOUNT_ITEM_10 |
| | Achieve Reasonable Assurance Verification. | ACCOUNT_ITEM_11 |
| | Report $CO_2$ emissions to voluntary GHG reporting programs. | ACCOUNT_ITEM_12 |
| | Report $CO_2$ emissions to mandatory GHG reporting programs. | ACCOUNT_ITEM_13 |

## 5.1.1 Data Collection

Data collection involved sending out the questionnaire to climate change experts in three different fields: strategy, risk management and accounting. For the questionnaires used to develop critical factors regarding climate change practices, the target sample included climate change experts who are either currently employed in companies included in the Financial Times Global 500 (FT 500) list or work as external partners with these companies.

The reason why we selected climate change experts who are employed by large multinational companies or work with them is 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 companies to have an enhanced experience on implementing climate change corporate practices and provide a more reliable assessment of the difficulty in the implementation of corporate climate change practices. Furthermore, in the second part of the research, we aim to develop a scoring methodology which we are going to use in order to assess the management effort made by firms to implement climate change strategies, to assess climate change risks and to adopt carbon accounting and reporting practices. The scoring methodology that will be used will be based on the development of weighted corporate indexes that are going measure the management effort devoted by firms on implementing climate change strategies, on managing climate change risks and adopting carbon accounting and reporting practices. The firms that will be assessed are the largest firms, according to the FT500, in the oil and gas industry and in the banking sector.

For that reason, we consider it more appropriate for the development of our corporate climate change indexes to use weights that we have developed based on the expertise of people who are employed or work with companies of this type of calibration. Target respondents were identified via LinkedIn and sent *one* of the three questionnaires (strategy, risk management or accounting) according to their expertise. Expertise was determined according to the target respondent's skills. In order to be included in the target sample, each respondent had to have the following skills in their profile:

For Climate Change strategy:

> 1st skill: Climate Change
> 2nd skill (at least one the following): Strategy, Management, Strategic Management, Business Strategy.

For Climate Change Risk Management:

> 1st skill: Climate Change
> 2nd skill (at least one the following): Risk Management, Risk Assessment, Environmental Risk Management, Environmental Risk Assessment, Environmental Impact Assessment.

For Carbon Accounting:

1st skill: Climate Change

2nd skill (at least one the following): Accounting, Climate Change Reporting, Environmental Reporting, Carbon Accounting.

Finally, for the skills mentioned above, target respondents had to have at least 30 endorsements from other members of the LinkedIn Network in order to be included in the target population of the research.

The questionnaires were sent via the LinkedIn InMail messaging service. A total of 332 questionnaires were sent regarding climate change strategy, 320 for climate change risk management and 193 for carbon accounting. 188 complete questionnaires were received for climate change strategy, 168 for climate change risk management and 103 for carbon accounting, representing response rates of 56,62%, 52,50% and 53,36% respectively. 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 the 15th of October 2015 and completed on the 23rd of March 2016. The descriptive statistics of the final samples are presented on Table 10 for climate change strategy, Table 11 for Climate Change Risk Management and Table 12 for Carbon Accounting and Reporting.

**Table 10: Climate Change Strategy: Descriptive statistics of the final sample**

| Gender | Response Percent | Response Count |
|---|---|---|
| Male | 83,80% | 158 |
| Female | 16,20% | 30 |
| Total | 100,00% | 188 |
| | | |
| Age | Response Percent | Response Count |
| 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 | Response Percent | Response Count |
| Less than high school degree | 0,00% | 0 |
| High school degree or equivalent | 0,00% | 0 |
| Some college but no degree | 0,00% | 0 |
| Associate degree | 0,00% | 0 |
| Bachelor degree | 18,90% | 36 |
| Graduate degree | 81,10% | 152 |
| Total | 100,00% | 188 |

| Job Description | Response Percent | Response Count |
|---|---|---|
| Engineering | 2,70% | 5 |
| Finance/Accounting | 0,00% | 0 |
| Human Resources | 0,00% | 0 |
| Legal | 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 | Response Percent | Response Count |
|---|---|---|
| Owner/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 | Response Percent | Response Count |
|---|---|---|
| Aerospace & defence | 1,20% | 2 |
| Automobiles & parts | 2,90% | 5 |
| Banks | 11,20% | 21 |
| Beverages | 1,50% | 3 |
| Chemicals | 5,50% | 10 |
| Construction & materials | 6,50% | 12 |
| Electricity | 9,50% | 18 |
| Electronic & electrical equipment | 1,50% | 3 |
| Financial services | 6,50% | 12 |
| Fixed line telecommunications | 2,90% | 5 |
| Food & drug retailers | 1,20% | 2 |
| Food producers | 1,30% | 2 |
| Gas, water & multiutilities | 6,50% | 12 |
| General industrials | 3,00% | 6 |
| General retailers | 2,00% | 4 |
| Health care equipment & services | 0,50% | 1 |
| Household goods & home construction | 0,50% | 1 |
| Industrial engineering | 1,00% | 2 |
| Industrial metals & mining | 1,60% | 3 |
| Industrial transportation | 0,80% | 2 |
| Leisure goods | 0,80% | 2 |
| Life insurance | 0,50% | 1 |
| Media | 1,20% | 2 |
| Mining | 2,90% | 5 |
| Mobile telecommunications | 1,20% | 2 |
| Nonlife insurance | 2,90% | 5 |
| Oil & gas producers | 10,10% | 19 |
| Oil equipment & services | 4,50% | 8 |
| Personal goods | 1,00% | 2 |
| Pharmaceuticals & biotechnology | 0,50% | 1 |
| Real estate investment & services | 0,80% | 2 |
| Real estate investment trusts | 1,00% | 2 |

| | | |
|---|---|---|
| Software & computer services | 0,40% | 1 |
| Support services | 0,50% | 1 |
| Technology hardware & equipment | 0,00% | 0 |
| Tobacco | 0,50% | 1 |
| Travel & leisure | 1,80% | 3 |
| Other | 1,80% | 3 |
| Total | 100,00% | 188 |
| | | |
| Experience in climate change related issues | Response Percent | Response Count |
| 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 11: Risk Management: Descriptive statistics of the final sample.**

| Gender | Response Percent | Response Count |
|---|---|---|
| Male | 54,50% | 92 |
| Female | 45,50% | 76 |
| Total | 100,00% | 168 |
| | | |
| Age | Response Percent | Response Count |
| 18 - 29 | 26,20% | 44 |
| 30 - 44 | 30,40% | 51 |
| 45 - 59 | 30,40% | 51 |
| 60+ | 13,00% | 22 |
| Total | 100,00% | 168 |
| | | |
| Level of Education | Response Percent | Response Count |
| Less than high school degree | 0,00% | 0 |
| High school degree or equivalent | 0,00% | 0 |
| Some college but no degree | 0,00% | 0 |
| Associate degree | 0,00% | 0 |
| Bachelor degree | 4,30% | 7 |
| Graduate degree | 95,70% | 161 |
| Total | 100,00% | 168 |
| | | |
| Job Description | Response Percent | Response Count |
| Engineering | 4,30% | 7 |
| Finance/Accounting | 3,80% | 6 |
| Human Resources | 0,00% | 0 |
| Legal | 0,80% | 1 |
| Management | 25,20% | 42 |
| Manufacturing | 1,40% | 2 |
| Project Management | 8,70% | 15 |
| Research | 4,30% | 7 |
| Risk Management | 28,80% | 48 |
| Sales / Marketing | 0,00% | 0 |
| Strategy/Planning | 13,00% | 22 |
| Other | 9,70% | 16 |
| Total | 100,00% | 168 |
| | | |
| Job Level | Response Percent | Response Count |
| Owner/Executive/C-Level | 11,20% | 19 |
| Senior Management | 34,80% | 58 |

| | | |
|---|---|---|
| Middle Management | 27,10% | 46 |
| Intermediate | 18,60% | 31 |
| Entry Level | 8,30% | 14 |
| Other | 0,00% | 0 |
| Total | 100,00% | 168 |

| Industry Sector | Response Percent | Response Count |
|---|---|---|
| Aerospace & defence | 0,50% | 1 |
| Automobiles & parts | 1,20% | 2 |
| Banks | 3,60% | 6 |
| Beverages | 1,20% | 2 |
| Chemicals | 0,80% | 1 |
| Construction & materials | 3,30% | 6 |
| Electricity | 10,30% | 17 |
| Electronic & electrical equipment | 0,50% | 1 |
| Financial services | 10,90% | 18 |
| Fixed line telecommunications | 1,50% | 3 |
| Food & drug retailers | 1,20% | 2 |
| Food producers | 3,50% | 6 |
| Gas, water & multiutilities | 6,50% | 11 |
| General industrials | 1,80% | 3 |
| General retailers | 0,50% | 1 |
| Health care equipment & services | 0,50% | 1 |
| Household goods & home construction | 1,20% | 2 |
| Industrial engineering | 1,50% | 3 |
| Industrial metals & mining | 1,20% | 2 |
| Industrial transportation | 2,50% | 4 |
| Leisure goods | 0,50% | 1 |
| Life insurance | 0,50% | 1 |
| Media | 0,00% | 0 |
| Mining | 5,00% | 8 |
| Mobile telecommunications | 1,50% | 3 |
| Nonlife insurance | 3,50% | 6 |
| Oil & gas producers | 19,70% | 33 |
| Oil equipment & services | 2,80% | 5 |
| Personal goods | 0,50% | 1 |
| Pharmaceuticals & biotechnology | 0,50% | 1 |
| Real estate investment & services | 2,50% | 4 |
| Real estate investment trusts | 4,30% | 7 |
| Software & computer services | 0,00% | 0 |
| Support services | 1,50% | 3 |
| Technology hardware & equipment | 0,00% | 0 |
| Tobacco | 0,00% | 0 |
| Travel & leisure | 0,50% | 1 |
| Other | 2,50% | 4 |
| Total | 100,00% | 168 |

| Experience in climate change related issues | Response Percent | Response Count |
|---|---|---|
| Less than 1 year | 0,00% | 0 |
| At least 1 year but less than 3 years | 8,70% | 15 |
| At least 3 years but less than 5 years | 17,40% | 29 |
| At least 5 years but less than 10 years | 34,80% | 58 |
| 10 years or more | 39,10% | 66 |
| Total | 100,00% | 168 |

**Table 12: Carbon Accounting: Descriptive statistics of the final sample**

| Gender | Response Percent | Response Count |
|---|---|---|
| Male | 53,00% | 55 |
| Female | 47,00% | 48 |
| Total | 100,00% | 103 |
| | | |
| Age | Response Percent | Response Count |
| 18 - 29 | 16,70% | 17 |
| 30 - 44 | 50,00% | 52 |
| 45 - 59 | 33,30% | 34 |
| 60+ | 0,00% | 0 |
| Total | 100,00% | 103 |
| | | |
| Level of Education | Response Percent | Response Count |
| Less than high school degree | 0,00% | 0 |
| High school degree or equivalent | 0,00% | 0 |
| Some college but no degree | 0,00% | 0 |
| Associate degree | 0,00% | 0 |
| Bachelor degree | 39,10% | 40 |
| Graduate degree | 60,90% | 63 |
| Total | 100,00% | 103 |
| | | |
| Job Description | Response Percent | Response Count |
| Engineering | 8,30% | 9 |
| Finance/Accounting | 14,10% | 15 |
| Human Resources | 0,00% | 0 |
| Legal | 1,00% | 1 |
| Management | 12,30% | 13 |
| Manufacturing | 0,00% | 0 |
| Project Management | 19,70% | 20 |
| Research | 7,20% | 7 |
| Risk Management | 5,20% | 5 |
| Sales / Marketing | 0,00% | 0 |
| Strategy/Planning | 16,70% | 17 |
| Other (please specify) | 15,50% | 16 |
| Total | 100,00% | 103 |
| | | |
| Job Level | Response Percent | Response Count |
| Owner/Executive/C-Level | 10,70% | 11 |
| Senior Management | 20,80% | 21 |
| Middle Management | 30,70% | 32 |
| Intermediate | 29,50% | 30 |
| Entry Level | 8,30% | 9 |
| Other (please specify) | 0,00% | 0 |
| Total | 100,00% | 103 |
| | | |
| Industry Sector | Response Percent | Response Count |
| Aerospace & defence | 0,00% | 0 |
| Automobiles & parts | 4,80% | 5 |
| Banks | 13,20% | 14 |
| Beverages | 0,00% | 0 |
| Chemicals | 0,00% | 0 |
| Construction & materials | 4,80% | 5 |
| Electricity | 4,90% | 5 |
| Electronic & electrical equipment | 0,00% | 0 |
| Financial services | 14,50% | 15 |

| | | |
|---|---|---|
| Fixed line telecommunications | 0,00% | 0 |
| Food & drug retailers | 0,00% | 0 |
| Food producers | 0,00% | 0 |
| Gas, water & multiutilities | 6,80% | 7 |
| General industrials | 0,00% | 0 |
| General retailers | 0,00% | 0 |
| Health care equipment & services | 0,00% | 0 |
| Household goods & home construction | 4,80% | 5 |
| Industrial engineering | 0,00% | 0 |
| Industrial metals & mining | 1,80% | 2 |
| Industrial transportation | 4,80% | 5 |
| Leisure goods | 0,00% | 0 |
| Life insurance | 0,00% | 0 |
| Media | 0,00% | 0 |
| Mining | 0,00% | 0 |
| Mobile telecommunications | 0,00% | 0 |
| Nonlife insurance | 2,80% | 3 |
| Oil & gas producers | 15,50% | 16 |
| Oil equipment & services | 3,50% | 4 |
| Personal goods | 0,00% | 0 |
| Pharmaceuticals & biotechnology | 0,00% | 0 |
| Real estate investment & services | 1,00% | 1 |
| Real estate investment trusts | 2,00% | 2 |
| Software & computer services | 1,80% | 2 |
| Support services | 3,20% | 3 |
| Technology hardware & equipment | 0,00% | 0 |
| Tobacco | 0,00% | 0 |
| Travel & leisure | 0,00% | 0 |
| Other | 9,80% | 10 |
| Total | 100,00% | 103 |

| Experience in climate change related issues | Response Percent | Response Count |
|---|---|---|
| Less than 1 year | 1,20% | 1 |
| At least 1 year but less than 3 years | 5,20% | 5 |
| At least 3 years but less than 5 years | 10,20% | 11 |
| At least 5 years but less than 10 years | 54,20% | 56 |
| 10 years or more | 29,20% | 30 |
| Total | 100,00% | 103 |

### 5.1.2 Data Descriptive Statistics

The descriptive statistics of our critical climate change strategy factors are presented in Table 13. As we can observe, the skewness and kurtosis values are among the range of +/- 1 which indicate that are data are close to a normal distribution. Furthermore, regarding the climate change governance factors, we see that STRATEGY_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. Regarding, the climate change risk management factor items, these has been assess generally at the same level of difficultly by our survey respondents. As far as carbon reduction targets 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 of $CO_2$ has by far the highest mean difficulty than all the other factors, 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 carbon compensation strategies, participation in ETS and creation of project-based carbon credit have higher mean difficulty values than purchasing carbon credits.

**Table 13: Climate Change Strategy Descriptive Statistics**

| Item Code | Mean | Median | Skewness Statistic | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|
| STRATEGY_ITEM_01 | 4,22 | 4,00 | -0,160 | 0,177 | -0,732 | 0,353 |
| STRATEGY_ITEM_02 | 3,99 | 4,00 | 0,246 | 0,177 | -0,947 | 0,353 |
| STRATEGY_ITEM_03 | 4,99 | 5,00 | -0,482 | 0,177 | -0,900 | 0,353 |
| STRATEGY_ITEM_04 | 4,12 | 4,00 | 0,111 | 0,177 | -0,853 | 0,353 |
| STRATEGY_ITEM_05 | 3,62 | 3,00 | 0,580 | 0,177 | -0,513 | 0,353 |
| STRATEGY_ITEM_06 | 3,76 | 4,00 | 0,337 | 0,177 | -0,755 | 0,353 |
| STRATEGY_ITEM_07 | 4,03 | 4,00 | 0,196 | 0,177 | -0,880 | 0,353 |
| STRATEGY_ITEM_08 | 4,80 | 5,00 | -0,090 | 0,177 | -0,617 | 0,353 |
| STRATEGY_ITEM_09 | 4,34 | 4,00 | 0,253 | 0,177 | -0,813 | 0,353 |
| STRATEGY_ITEM_10 | 4,87 | 5,00 | -0,471 | 0,177 | -0,817 | 0,353 |
| STRATEGY_ITEM_11 | 4,47 | 5,00 | -0,261 | 0,177 | -0,908 | 0,353 |
| STRATEGY_ITEM_12 | 3,66 | 4,00 | 0,201 | 0,177 | -0,247 | 0,353 |
| STRATEGY_ITEM_13 | 3,11 | 3,00 | 0,761 | 0,177 | 0,074 | 0,353 |
| STRATEGY_ITEM_14 | 3,64 | 4,00 | 0,227 | 0,177 | -0,642 | 0,353 |
| STRATEGY_ITEM_15 | 3,76 | 4,00 | 0,071 | 0,177 | -0,973 | 0,353 |
| STRATEGY_ITEM_16 | 6,37 | 7,00 | -0,964 | 0,177 | 0,212 | 0,353 |
| STRATEGY_ITEM_17 | 4,64 | 5,00 | -0,204 | 0,177 | -0,507 | 0,353 |
| STRATEGY_ITEM_18 | 2,85 | 2,00 | 0,846 | 0,177 | -0,001 | 0,353 |
| STRATEGY_ITEM_19 | 3,13 | 3,00 | 0,422 | 0,177 | -0,609 | 0,353 |
| STRATEGY_ITEM_20 | 4,04 | 4,00 | 0,100 | 0,177 | -0,967 | 0,353 |
| STRATEGY_ITEM_21 | 4,63 | 5,00 | -0,555 | 0,177 | -0,237 | 0,353 |
| STRATEGY_ITEM_22 | 4,82 | 5,00 | -0,599 | 0,177 | 0,326 | 0,353 |
| STRATEGY_ITEM_23 | 3,38 | 3,00 | 0,394 | 0,177 | 0,111 | 0,353 |

The descriptive statistics of our critical factors related to climate change risk management are presented in Table 14. As we can observe, the skewness and kurtosis values are also among the range of +/- 1 which indicate that are data are close to a normal distribution. Regarding the risk factor related to regulation risk management we can observe that the items corresponding to command and control regulation generally present higher mean difficulty values that items included in the market based regulation factor. This result can be explained if we take into account the fact that command and control regulation is more difficult to comply with, since it does not offer any sort of means of compensating for GHG emissions as it is with market based regulation, where companies can buy carbon credits in ETS market.

Furthermore, we can observe that physical risk management related to changes in temperature and precipitation extremes present higher mean difficulty values than physical risk management related to extreme weather events. This can be explained perhaps by the fact that traditionally companies were using insurance mechanisms to protect against extreme weather events, therefore they do not assess it as especially difficult since it something that it is being implemented for many years. On the other hand, changes in precipitation extremes, reduced water supplies, droughts or extreme heat waves are physical risks that have more recently begun to affect operational activities. Therefore, it is expected to receive high mean average values.

Moreover, we can observe high mean difficulty values for reputational risk management as well as for competition risk management, which is to be expected since these types of risks are very difficult to measure and since they are susceptible to sudden changes, especially for reputational risks and changing consumer behavior. Finally, regarding legal risk, we can see that the factors that receive the higher mean difficulty values are those associated with the costs of identifying potential financial implications and the costs of implementing management methods to address litigation risks. This can be explained by the high degree of uncertainty regarding the cost of having to deal with lawsuits for issues, such as climate change, for which there is no clear legislation in place.

**Table 14: Climate Change Risk Management Descriptive Statistics**

| Item Code | Mean | Median | Skewness Statistic | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|
| RISK_ITEM_01 | 4,54 | 5 | -0,466 | 0,187 | -0,84 | 0,373 |
| RISK_ITEM_02 | 4,77 | 5 | -0,185 | 0,187 | -0,887 | 0,373 |
| RISK_ITEM_03 | 4,10 | 4 | 0,038 | 0,187 | -0,773 | 0,373 |
| RISK_ITEM_04 | 4,51 | 4 | -0,065 | 0,187 | -0,854 | 0,373 |
| RISK_ITEM_05 | 3,76 | 3 | 0,57 | 0,187 | -0,17 | 0,373 |
| RISK_ITEM_06 | 3,96 | 4 | 0,332 | 0,187 | -0,896 | 0,373 |
| RISK_ITEM_07 | 3,60 | 3 | 0,547 | 0,187 | -0,535 | 0,373 |
| RISK_ITEM_08 | 3,90 | 4 | -0,005 | 0,187 | -0,836 | 0,373 |
| RISK_ITEM_09 | 4,02 | 4 | -0,232 | 0,187 | -0,932 | 0,373 |
| RISK_ITEM_10 | 4,70 | 5 | -0,363 | 0,187 | -0,856 | 0,373 |
| RISK_ITEM_11 | 4,00 | 4 | -0,113 | 0,187 | -0,897 | 0,373 |
| RISK_ITEM_12 | 4,35 | 4 | -0,167 | 0,187 | -0,962 | 0,373 |
| RISK_ITEM_13 | 4,35 | 4 | -0,288 | 0,187 | -0,951 | 0,373 |
| RISK_ITEM_14 | 4,97 | 5,5 | -0,689 | 0,187 | -0,75 | 0,373 |
| RISK_ITEM_15 | 3,98 | 4 | 0,395 | 0,187 | -0,816 | 0,373 |
| RISK_ITEM_16 | 4,51 | 5 | -0,337 | 0,187 | -0,822 | 0,373 |
| RISK_ITEM_17 | 4,60 | 5 | -0,563 | 0,187 | -0,68 | 0,373 |
| RISK_ITEM_18 | 5,70 | 6 | -0,895 | 0,187 | 0,308 | 0,373 |
| RISK_ITEM_19 | 4,57 | 5 | -0,358 | 0,187 | -0,929 | 0,373 |
| RISK_ITEM_20 | 4,81 | 5 | -0,522 | 0,187 | -0,824 | 0,373 |
| RISK_ITEM_21 | 4,83 | 5 | -0,363 | 0,187 | -0,998 | 0,373 |
| RISK_ITEM_22 | 5,19 | 5 | -0,202 | 0,187 | -0,79 | 0,373 |
| RISK_ITEM_23 | 4,89 | 5 | -0,322 | 0,187 | -0,97 | 0,373 |
| RISK_ITEM_24 | 4,92 | 5,5 | -0,382 | 0,187 | -0,959 | 0,373 |
| RISK_ITEM_25 | 4,24 | 4 | -0,052 | 0,187 | -0,866 | 0,373 |
| RISK_ITEM_26 | 5,29 | 5 | -0,582 | 0,187 | 0,188 | 0,373 |
| RISK_ITEM_27 | 4,10 | 4 | 0,423 | 0,187 | -0,564 | 0,373 |
| RISK_ITEM_28 | 5,07 | 5,5 | -0,376 | 0,187 | -0,967 | 0,373 |
| RISK_ITEM_29 | 4,34 | 4 | -0,081 | 0,187 | -0,955 | 0,373 |
| RISK_ITEM_30 | 4,71 | 5 | -0,306 | 0,187 | -0,859 | 0,373 |
| RISK_ITEM_31 | 4,02 | 4 | 0,187 | 0,187 | -0,928 | 0,373 |
| RISK_ITEM_32 | 4,70 | 5 | -0,644 | 0,187 | -0,73 | 0,373 |

The descriptive statistics of our critical carbon accounting factors are presented in Table 15. As we can observe, the skewness and kurtosis values are among the range of +/- 1 which indicate that are data are close to a normal distribution. Furthermore, regarding the carbon accounting critical factors, we see that items

ACCOUNT_ITEM_01 and ACCOUNT_ITEM_02 corresponding to the development of internal price of carbon scheme, and ACCOUNT_ITEM_03, which corresponds to the calculation of Scope 3 emissions present the highest mean difficulty values. This can be explained by the fact that in relation to the other critical carbon accounting factors, internal price of carbon requires extensive corporate resources and high coordination among all business sectors of a company. Additionally, scope 3 emissions are the most difficult to calculate since they are related to the supply chain of the company which makes its tracking down more difficult than scope 1 and scope 2 emissions.

**Table 15: Carbon Accounting Descriptive Statistics**

| Item Code | Mean | Median | Skewness Statistic | Std. Error of Skewness | Kurtosis | Std. Error of Kurtosis |
|---|---|---|---|---|---|---|
| ACCOUNT_ITEM_01 | 4,90 | 5,00 | -,586 | ,246 | -,592 | ,488 |
| ACCOUNT_ITEM_02 | 4,42 | 4,00 | ,098 | ,246 | -,975 | ,488 |
| ACCOUNT_ITEM_03 | 2,41 | 2,00 | ,626 | ,246 | -,784 | ,488 |
| ACCOUNT_ITEM_04 | 2,44 | 2,00 | ,861 | ,246 | -,310 | ,488 |
| ACCOUNT_ITEM_05 | 4,95 | 5,00 | -,205 | ,246 | -,794 | ,488 |
| ACCOUNT_ITEM_06 | 3,34 | 3,00 | -,195 | ,246 | -,553 | ,488 |
| ACCOUNT_ITEM_07 | 3,02 | 3,00 | ,478 | ,246 | -,144 | ,488 |
| ACCOUNT_ITEM_08 | 2,44 | 2,00 | ,652 | ,246 | ,203 | ,488 |
| ACCOUNT_ITEM_09 | 3,21 | 3,00 | ,784 | ,246 | ,425 | ,488 |
| ACCOUNT_ITEM_10 | 3,27 | 3,00 | ,272 | ,246 | -,800 | ,488 |
| ACCOUNT_ITEM_11 | 3,51 | 4,00 | -,020 | ,246 | -,956 | ,488 |
| ACCOUNT_ITEM_12 | 3,08 | 3,00 | ,436 | ,246 | -,498 | ,488 |
| ACCOUNT_ITEM_13 | 3,08 | 3,00 | ,482 | ,246 | -,451 | ,488 |

### 5.1.3 Validity and Reliability Assessment of the Questionnaires

As we discussed above, the aim of this research is to examine the relationship between climate change strategy, climate change risk management, carbon accounting and corporate financial performance. For this reason we will develop three weighed corporate indexes measuring management effort in the implementation of climate change strategies, in the identification and assessment of climate change risks and the adoption of carbon accounting practices. In order to develop and weight the above climate change indexes, we will use the mean average as a weight for each item included in the index. For that reason we have to ensure that mean average values used form a reliable and valid measurement of the degree of difficulty for each item in the respective index. Therefore, in order to ensure the quality of our mean average values, and subsequently the quality of our weights, we have to measure the quality of our questionnaires.

The quality of a questionnaire is generally measured by conducting validity and reliability analysis. According to Hair et al. (1995) validity is the degree to which a measure accurately represents what it is supposed to. Reliability analysis indicates the extent to which repeating the same survey procedure yields the same results (Carmines and Zeller, 1979).

#### 5.1.3.1 Validity assessment

Three types of validity are generally used in assessing the accuracy of a questionnaire: content validity, criterion validity and construct validity. A measurement construct is considered to have content validity when "there is a general agreement that the measure has items that covers all aspects of the variable being measured" (Wee and Quazi, 2005). It is not based on the calculation of numerical factors but is subjectively judged by the researchers. Regarding this study, since the selection of the initial items in the critical factors of the questionnaire was based on extensive literature review, we consider it to have sufficient content validity. Criterion validity, also known as predictive validity assesses the extent to which a particular construct measure predicts or is related to other construct measures. When using criterion validity, correlations between the constructs and one established criterion are calculated and if these correlations are found to be significant then we can consider the constructs to have criterion-related validity. Finally, a construct measure is considered to have construct validity when it measures the theoretical construct that it was designed to measure. When examining construct validity, we focus on the convergence between the items included in an original construct measure and how these items can be separated and reorganized in new constructs that can accurately measure different theoretical aspects of the original construct (Forza, 2002).

The most common method in examining construct validity is the use of factor analysis (Nunnaly, 1978; Wee and Quazi, 2005; Saraph et al., 1989). Factor analysis is generally used in the field of social sciences in order to interpret self-reporting questionnaires (Williams *et al*, 2010; Byrant et al, 1999). It is generally used to reduce a large number of variables into a smaller set of variables and it explores underlying dimensions between the variables that allow us to interpret the theoretical basis of our variables more accurately (Williams *et al*, 2010). There are two types of factor analysis, exploratory factor analysis and confirmatory factor analysis. Exploratory factor analysis - as its name suggests- is exploratory by nature (Williams *et al*, 2010). That is, the researcher has no previous information on how the variables should be organized and examined. Of course, content validity can help us to broadly define sets of variables, however it cannot be used on its own when we want to develop and validate a "new" theory. On the contrary, confirmatory factor analysis is used to test an established theory and to examine the degree to which it can be applied to different context, for example different target population or in different time frames.

In this research, we are going to use *exploratory* factor analysis since our questionnaires have not been previously validated by other researchers. Thus, exploratory factor analysis will allow us to better understand the structure of our variables and to measure the accuracy of our survey results. Finally, it will help us to reorganize our initial critical factors, and their relevant items, into a new set of factors, which will make the original information obtained more manageable (Field, 2013). Regarding the procedure of conducting exploratory factor analysis, we are going to adopt the one described by Field (2013). First, initial checks will be made regarding the appropriateness of the data for the factor analysis. Then, for the main analysis, the factor extraction and rotation methods will be examined the results of the analysis will be presented. Finally, the factors developed in the previous step will be assessed for reliability by using the internal consistency method. This procedure will be repeated separately for each questionnaire.

Regarding the appropriateness of the data, the following criteria must be met in order to be able to conduct factor analysis:

1. *Sample size*. The size of our sample must be sufficient in order to conduct factor analysis. There are several rules regarding the number of observations needed in order to conduct factor analysis. Hair et al. (1995) suggest that the observations must be at least five times as many as there are variables. Nunnally (1978) recommends that observations must be 10 times the number of initial measurement items included in

the questionnaire. Comrey and Lee (2013) suggest samples sizes: 100 as poor, 300, as good and 1000 or more as excellent. Furthermore, Guadagnoli and Velicer (1988) claim that if a factor has four or more loadings greater than 0.6, then the factor is reliable regardless of the number of observations while MacCallum, Widaman, Zhang, and Hong (1999) find that with all communalities above 0.6, samples less than 100 are adequate. Finally, the adequacy of sampling is determined by Kaiser-Meyer-Olkin 's (KMO) Measure of Sampling Adequacy. The KMO test ranges from 0 to 1, with 0 denoting diffusion in the pattern of correlations between the variable items, thus making factor analysis inappropriate for the analysis of the data and 1 denoting patterns of correlations that are "relative compact", thus allowing factor analysis to produce "distinct and reliable" factors (Field, 2013). More specifically, KMO values around 0.6 are considered mediocre, values around 0.7 middling, and values around 0.8 or more meritorious (Field, 2013).

2. *Correlations between variables*. In order to proceed with the extraction of factors, we must check for correlations between the variables. Correlations have to be high (above 0.3), but not too high ( for example above 0.8). In both cases, the underlying variables must be removed from the analysis since they could potentially reduce the validity of the structure measurements. Correlations can be examined by looking at the correlation matrix of the variables. As mentioned above, correlations must be greater than 0.3, in order for factor analysis to be able to extract reliable factors (Hair et al., 1995). Also, examining the significance of Barllett's test of sphericity can help us assess the overall significance of the correlation matrix i.e. if $p<=0.000$, then Barllett's test is significant, which means that the correlations between variables are overall significantly different from zero (Field, 2013). Finally, assessing multicollinearity between the variables (because the correlations must not be very high), can be conducted by looking at the determinant in the correlation matrix (R-matrix). The determinant must be above 0.00001 in order to denote the absence of multicollinearity between the variables.

Once the above criteria have been met, we can proceed with the extraction of the factors. Regarding the extraction method, there are several ways to extract factors: Principal Component Analysis, Principal Axis Factoring, Image Factoring, Maximum Likelihood, Alpha Factoring and Canonical (Williams *et al*, 2010). However, the most commonly used in academic research are the Principal Component Analysis (PCA) and the Principal Axis Factoring (PAF). In this study, we are going to use PAF. Although, the differences between PCA and PAF are not significant (Williams *et al*, 2010; Thomson, 2004), PAF only can "estimate the underlying factors and it relies on various assumptions for these estimates to be accurate. PCA is concerned only with establishing which linear components exist within the data and how a particular variable might contribute to that component" (Field,2013).

Regarding the number of factors extracted, there are several approaches that can be followed: Kaiser's criteria, the Scree test and the cumulative percent of variance explained by the factors. Regarding Kaiser's criteria, the number of factors extracted can be based on the number of eigenvalues than are above 1. "This criterion is based on the idea that the eigenvalues represent the amount of variation explained by a factor and than an eigenvalue of 1 represents a substantial amount of variation" (Field, 2013). The scree test is a diagram than shows each eigenvalue (Y-axis) against the factor with which it is associated (X-axis). According to the scree test, the number of factors extracted can be determined by the point where the slope of the curve of the diagram changes dramatically (Field, 2013). Finally, regarding the cumulative percent of variance explained, there is no fixed threshold which can determine the number of factors that should be extracted (Williams *et al*, 2010). In social sciences, the explained variance usually varies between 0.5 to 0.6 (Hair et al.,1995).

Finally, after the factors have been extracted we can "calculate the degree to which variables load on these factors" (Field, 2013) or as it is commonly known the "factor loadings". In examining the factors extracted, some of the variables will have higher factor loadings on a specific factor and smaller loadings on other factors. Regarding the value of factor loadings, values of 0.45 or above are considered to be high enough to be included in a factor (Hair et al., 1995). However, the fact that the same variable has factor loadings in different factors often makes the interpretation of the factor analysis result difficult (Field, 2013). For that reason, before extracting the factors, we must decide the rotation methodology that we will use in our analysis. The rotation of the factors helps us to better interpret the results of the factor analysis. Varimax rotation is usually selected when we want the factors to be uncorrelated and Oblique rotation is used when we want our factors to be correlated. In this study, we will use the varimax rotation.

*5.1.3.1.1 Validity assessment for the Climate Change Strategy Questionnaire*

Regarding our sample size (n=188), we adopt Hair's rule for the number of observations to be five times the number of variables in the initial structure. Furthermore, as it is shown in Table 16, the factor loadings of the variables are all above 0.6, which, according to Guadagnoli and Velicer (1988), means that the factors extracted are reliable regardless of sample size. Moreover, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0,869 which indicates high sampling adequacy. Regarding the correlations between the variables, Table 17 shows that the majority of correlations are above 0.3 and at the same time not above 0.6 which means that factor analysis will be able to extract reliable factors. Finally, Barllett's test of sphericity is significant (p<=0.000) and the Determinant is above the critical value of 0.00001 (it is 0.000453 to be precise), which indicate the absence of multicollinearity between the variables.

In Table 16 we can see the results of the factor analysis. Factor loadings for the variable items are above 0.6 which means that the factors created are highly reliable. In Table 22 we can see the factors as they have been constructed after the analysis. In specific, the first factor combines the three initial critical factors, namely, Climate Change Governance, Climate Change Risk Management Integration and Carbon Reduction Targets, as well as two items from the Carbon Reduction Strategies factor, Replacement of carbon - based products by non-carbon based products, Implementation of end-use energy efficiency process and Optimization of current business processes. We can observe that the items included in this factor are highly associated with the managerial dimension of climate change since they include organizing, target setting and process and product development dimensions regarding climate change. Therefore, we are going to name this factor *Climate Change Organizational Management Strategies*. The second factor includes the carbon reduction strategies that are not included in the previous factor. They include the implementation of technologies that reduce carbon emissions either through increased energy efficiency (Items 12 to 15) or through control of GHG emissions (items 16 and 20). We are going to name this factor *Carbon Reduction Technology Strategies*. Finally, the last factor remains the same as the initial critical factor named *Carbon Compensation Strategies*.

**Table 16: Climate Change Strategy Factor Matrix**

| | Factor | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| STRATEGY_ITEM_01 | **0,612** | -0,161 | 0,008 | 0,298 |
| STRATEGY_ITEM_02 | **0,660** | -0,166 | -0,096 | 0,251 |
| STRATEGY_ITEM_03 | **0,608** | -0,129 | -0,024 | 0,129 |
| STRATEGY_ITEM_04 | **0,682** | -0,131 | 0,013 | 0,176 |
| STRATEGY_ITEM_05 | **0,693** | 0,058 | 0,109 | 0,007 |
| STRATEGY_ITEM_06 | **0,639** | -0,161 | -0,208 | 0,165 |
| STRATEGY_ITEM_07 | **0,663** | -0,128 | -0,155 | 0,217 |
| STRATEGY_ITEM_08 | **0,658** | -0,065 | 0,091 | -0,227 |
| STRATEGY_ITEM_09 | **0,663** | -0,086 | -0,130 | -0,023 |
| STRATEGY_ITEM_10 | **0,677** | -0,057 | -0,060 | -0,218 |
| STRATEGY_ITEM_11 | **0,650** | -0,140 | -0,108 | -0,151 |
| STRATEGY_ITEM_12 | 0,250 | **0,727** | 0,026 | 0,058 |
| STRATEGY_ITEM_13 | 0,197 | **0,715** | -0,004 | 0,132 |
| STRATEGY_ITEM_14 | 0,123 | **0,660** | 0,064 | 0,192 |
| STRATEGY_ITEM_15 | 0,218 | **0,660** | 0,060 | 0,042 |
| STRATEGY_ITEM_16 | 0,257 | **0,605** | -0,022 | -0,053 |
| STRATEGY_ITEM_17 | **0,616** | 0,026 | -0,065 | -0,228 |
| STRATEGY_ITEM_18 | **0,693** | 0,125 | -0,148 | -0,156 |
| STRATEGY_ITEM_19 | **0,657** | -0,008 | -0,082 | -0,195 |
| STRATEGY_ITEM_20 | 0,227 | **0,651** | -0,060 | -0,079 |
| STRATEGY_ITEM_21 | 0,254 | -0,141 | **0,678** | 0,020 |
| STRATEGY_ITEM_22 | 0,241 | -0,049 | **0,618** | 0,002 |
| STRATEGY_ITEM_23 | 0,229 | -0,031 | **0,676** | -0,028 |

**Table 17: Climate Change Strategy Correlations**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | STRATEGY_ITEM_01 | 1 | | | | | | | | | | |
| 2 | STRATEGY_ITEM_02 | ,569** | 1 | | | | | | | | | |
| 3 | STRATEGY_ITEM_03 | ,538** | ,482** | 1 | | | | | | | | |
| 4 | STRATEGY_ITEM_04 | ,560** | ,505** | ,481** | 1 | | | | | | | |
| 5 | STRATEGY_ITEM_05 | ,312** | ,397** | ,340** | ,498** | 1 | | | | | | |
| 6 | STRATEGY_ITEM_06 | ,342** | ,530** | ,433** | ,552** | ,463** | 1 | | | | | |
| 7 | STRATEGY_ITEM_07 | ,456** | ,521** | ,396** | ,511** | ,506** | ,530** | 1 | | | | |
| 8 | STRATEGY_ITEM_08 | ,314** | ,381** | ,353** | ,436** | ,429** | ,382** | ,414** | 1 | | | |
| 9 | STRATEGY_ITEM_09 | ,447** | ,457** | ,483** | ,386** | ,524** | ,461** | ,393** | ,449** | 1 | | |
| 10 | STRATEGY_ITEM_10 | ,383** | ,388** | ,448** | ,409** | ,425** | ,422** | ,415** | ,527** | ,465** | 1 | |
| 11 | STRATEGY_ITEM_11 | ,403** | ,347** | ,487** | ,423** | ,495** | ,431** | ,404** | ,468** | ,553** | ,536** | 1 |
| 12 | STRATEGY_ITEM_12 | 0,125 | 0,128 | 0,118 | 0,116 | ,215** | 0,115 | 0,055 | 0,062 | ,146* | 0,096 | 0,069 |
| 13 | STRATEGY_ITEM_13 | 0,127 | 0,138 | 0,125 | 0,13 | ,227** | 0,126 | 0,099 | 0,115 | 0,088 | 0,127 | 0,103 |
| 14 | STRATEGY_ITEM_14 | 0,119 | 0,126 | 0,123 | 0,116 | 0,1 | 0,137 | 0,057 | 0,085 | 0,124 | 0,124 | 0,116 |
| 15 | STRATEGY_ITEM_15 | 0,118 | 0,111 | 0,114 | 0,062 | ,168* | 0,128 | ,152* | ,174* | ,148* | ,197** | 0,106 |
| 16 | STRATEGY_ITEM_16 | 0,125 | 0,103 | 0,129 | 0,119 | ,186* | 0,126 | 0,069 | 0,122 | 0,101 | ,197** | 0,131 |
| 17 | STRATEGY_ITEM_17 | ,354** | ,348** | ,321** | ,442** | ,372** | ,299** | ,372** | ,521** | ,382** | ,488** | ,422** |
| 18 | STRATEGY_ITEM_18 | ,401** | ,465** | ,347** | ,392** | ,419** | ,427** | ,391** | ,469** | ,496** | ,460** | ,420** |
| 19 | STRATEGY_ITEM_19 | ,315** | ,413** | ,348** | ,430** | ,473** | ,443** | ,438** | ,420** | ,363** | ,463** | ,409** |
| 20 | STRATEGY_ITEM_20 | 0,054 | 0,047 | 0,114 | 0,124 | ,216** | 0,135 | 0,106 | 0,087 | 0,068 | 0,133 | 0,123 |
| 21 | STRATEGY_ITEM_21 | ,156* | 0,122 | ,232** | 0,142 | ,224** | 0,14 | ,169* | ,209** | 0,137 | ,226** | 0,071 |
| 22 | STRATEGY_ITEM_22 | ,184* | 0,076 | 0,107 | ,252** | ,169* | 0,132 | 0,125 | 0,122 | 0,087 | 0,081 | ,164* |
| 23 | STRATEGY_ITEM_23 | 0,121 | 0,103 | ,171* | 0,126 | ,230** | 0,083 | 0,115 | ,214** | 0,116 | 0,131 | 0,091 |

| | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | STRATEGY_ITEM_01 | | | | | | | | | | | | |
| 2 | STRATEGY_ITEM_02 | | | | | | | | | | | | |
| 3 | STRATEGY_ITEM_03 | | | | | | | | | | | | |
| 4 | STRATEGY_ITEM_04 | | | | | | | | | | | | |
| 5 | STRATEGY_ITEM_05 | | | | | | | | | | | | |
| 6 | STRATEGY_ITEM_06 | | | | | | | | | | | | |
| 7 | STRATEGY_ITEM_07 | | | | | | | | | | | | |
| 8 | STRATEGY_ITEM_08 | | | | | | | | | | | | |
| 9 | STRATEGY_ITEM_09 | | | | | | | | | | | | |
| 10 | STRATEGY_ITEM_10 | | | | | | | | | | | | |
| 11 | STRATEGY_ITEM_11 | | | | | | | | | | | | |
| 12 | STRATEGY_ITEM_12 | 1 | | | | | | | | | | | |
| 13 | STRATEGY_ITEM_13 | ,547** | 1 | | | | | | | | | | |
| 14 | STRATEGY_ITEM_14 | ,491** | ,489** | 1 | | | | | | | | | |
| 15 | STRATEGY_ITEM_15 | ,566** | ,503** | ,526** | 1 | | | | | | | | |
| 16 | STRATEGY_ITEM_16 | ,445** | ,451** | ,481** | ,513** | 1 | | | | | | | |
| 17 | STRATEGY_ITEM_17 | ,165* | 0,072 | 0,124 | ,179* | ,185* | 1 | | | | | | |
| 18 | STRATEGY_ITEM_18 | ,281** | ,229** | 0,083 | ,288** | ,229** | ,481** | 1 | | | | | |
| 19 | STRATEGY_ITEM_19 | 0,123 | 0,114 | 0,113 | ,189** | ,202** | ,495** | ,602** | 1 | | | | |
| 20 | STRATEGY_ITEM_20 | ,531** | ,484** | ,463** | ,445** | ,463** | ,229** | ,312** | ,179* | 1 | | | |
| 21 | STRATEGY_ITEM_21 | 0,122 | 0,116 | 0,1 | 0,116 | 0,127 | ,174* | ,147* | ,212** | 0,094 | 1 | | |
| 22 | STRATEGY_ITEM_22 | 0,115 | 0,125 | 0,115 | 0,081 | 0,118 | 0,069 | 0,076 | 0,104 | 0,126 | ,500** | 1 | |
| 23 | STRATEGY_ITEM_23 | 0,073 | 0,119 | 0,058 | 0,083 | 0,097 | 0,116 | 0,053 | 0,094 | 0,114 | ,553** | ,470** | 1 |

*5.1.3.1.2 Validity assessment for the Risk Management Questionnaire*

The sample size (n=168) for this questionnaire is also in accordance to Hair's rule. Moreover, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0,843 which indicates high sampling adequacy. Regarding the correlations between the variables, Table 19 shows that the majority of correlations are above 0.3 and at the same time not above 0.6 which means that factor analysis will be able to extract reliable factors. Finally, Barllett's test of sphericity is significant (p<=0.000) and the Determinant value is 0.000271 (> 0.00001) which indicate the absence of multicollinearity between the variables.

In Table 18 we can see the results of the factor analysis. Factor loadings for the variable items are above 0.6 which means that the factors created are highly reliable. In Table 23 we can see the factors as they have been constructed after the analysis. In specific, the first factor consists of the initial Regulation Risk Management factor and the Competition Risk Management factor regarding Uncertainty in Markets Signals. This means that - according to the survey respondents - risk management regarding changing market conditions is considered to be closely related to changes in regulation or that it is highly influenced by changes in regulation. Therefore, we will name this factor *Regulation - induced Risk Management*. On the other hand, changing consumer behavior, which is the other factor in Competition Risk Management, is included in the second factor along with Reputation Risk, which means that risk management regarding changes in consumer preferences is highly affected by the reputation of the company or the sector in which it operates. We will name this variable construct *Reputation - induced Risk Management*. Finally, the third and fourth factor remains the same as the initial critical factors regarding *Physical Risk Management* and *Legal Risk Management* respectively.

**Table 18: Risk Management Factor Matrix**

| | Factor | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| RISK_ITEM_01 | **0,602** | -0,256 | -0,051 | -0,157 | 0,048 |
| RISK_ITEM_02 | **0,635** | -0,279 | -0,138 | -0,081 | 0,110 |
| RISK_ITEM_03 | **0,617** | -0,273 | -0,157 | -0,094 | -0,070 |
| RISK_ITEM_04 | **0,627** | -0,224 | -0,245 | -0,074 | 0,113 |
| RISK_ITEM_05 | **0,684** | -0,256 | -0,225 | -0,050 | -0,096 |
| RISK_ITEM_06 | **0,614** | -0,197 | -0,230 | -0,196 | -0,119 |
| RISK_ITEM_07 | **0,649** | -0,222 | -0,227 | -0,094 | 0,072 |
| RISK_ITEM_08 | **0,724** | -0,068 | -0,135 | 0,034 | 0,159 |
| RISK_ITEM_09 | 0,193 | -0,193 | **0,661** | 0,040 | 0,022 |
| RISK_ITEM_10 | 0,279 | -0,246 | **0,609** | -0,087 | 0,170 |
| RISK_ITEM_11 | 0,298 | -0,134 | **0,693** | 0,124 | -0,193 |
| RISK_ITEM_12 | 0,249 | -0,103 | **0,608** | 0,183 | -0,192 |
| RISK_ITEM_13 | 0,281 | -0,278 | **0,655** | 0,039 | -0,023 |
| RISK_ITEM_14 | 0,262 | -0,346 | **0,624** | -0,097 | 0,274 |
| RISK_ITEM_15 | 0,232 | -0,110 | **0,612** | 0,035 | -0,183 |
| RISK_ITEM_16 | 0,309 | -0,152 | **0,648** | 0,084 | 0,061 |
| RISK_ITEM_17 | 0,216 | **0,629** | 0,174 | 0,032 | 0,173 |
| RISK_ITEM_18 | 0,341 | **0,662** | 0,020 | 0,062 | 0,123 |
| RISK_ITEM_19 | 0,226 | **0,691** | 0,132 | 0,141 | 0,003 |
| RISK_ITEM_20 | 0,264 | **0,607** | 0,171 | 0,024 | 0,221 |
| RISK_ITEM_21 | **0,720** | 0,142 | -0,160 | 0,015 | 0,008 |
| RISK_ITEM_22 | **0,647** | -0,199 | -0,425 | 0,051 | 0,230 |
| RISK_ITEM_23 | **0,749** | 0,123 | -0,071 | -0,042 | -0,296 |
| RISK_ITEM_24 | **0,630** | 0,124 | -0,203 | 0,069 | -0,294 |
| RISK_ITEM_25 | 0,216 | **0,607** | 0,213 | 0,174 | -0,009 |
| RISK_ITEM_26 | 0,266 | **0,640** | 0,011 | 0,053 | 0,108 |
| RISK_ITEM_27 | 0,283 | **0,662** | 0,039 | -0,100 | -0,090 |
| RISK_ITEM_28 | 0,306 | **0,684** | 0,009 | 0,191 | -0,094 |
| RISK_ITEM_29 | 0,070 | -0,085 | -0,192 | **0,631** | -0,065 |
| RISK_ITEM_30 | 0,047 | -0,243 | -0,269 | **0,633** | 0,092 |
| RISK_ITEM_31 | 0,006 | -0,315 | -0,128 | **0,618** | 0,042 |
| RISK_ITEM_32 | 0,058 | -0,238 | -0,011 | **0,625** | 0,052 |

## Table 19: Risk Management Correlations

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | RISK_ITEM_01 | 1 | | | | | | | |
| 2 | RISK_ITEM_02 | ,597** | 1 | | | | | | |
| 3 | RISK_ITEM_03 | ,550** | ,535** | 1 | | | | | |
| 4 | RISK_ITEM_04 | ,522** | ,577** | ,505** | 1 | | | | |
| 5 | RISK_ITEM_05 | ,472** | ,548** | ,561** | ,466** | 1 | | | |
| 6 | RISK_ITEM_06 | ,381** | ,477** | ,483** | ,447** | ,559** | 1 | | |
| 7 | RISK_ITEM_07 | ,476** | ,541** | ,532** | ,561** | ,562** | ,569** | 1 | |
| 8 | RISK_ITEM_08 | ,427** | ,486** | ,469** | ,500** | ,553** | ,528** | ,575** | 1 |
| 9 | RISK_ITEM_09 | ,204** | 0,083 | 0,083 | 0,116 | 0,097 | 0,12 | 0,114 | 0,096 |
| 10 | RISK_ITEM_10 | ,175* | ,190* | ,177* | 0,137 | 0,109 | 0,127 | 0,138 | 0,139 |
| 11 | RISK_ITEM_11 | ,205** | ,170* | 0,103 | 0,112 | 0,071 | 0,115 | 0,089 | 0,095 |
| 12 | RISK_ITEM_12 | 0,124 | 0,121 | 0,116 | 0,126 | 0,113 | 0,148 | 0,138 | 0,078 |
| 13 | RISK_ITEM_13 | 0,131 | ,166* | ,166* | 0,127 | ,197* | 0,131 | 0,062 | 0,133 |
| 14 | RISK_ITEM_14 | ,204** | ,160* | 0,115 | 0,126 | 0,1 | 0,054 | 0,151 | ,203** |
| 15 | RISK_ITEM_15 | ,178* | 0,096 | ,210** | 0,084 | 0,101 | 0,116 | ,156* | 0,139 |
| 16 | RISK_ITEM_16 | ,189* | 0,086 | 0,149 | 0,084 | 0,064 | 0,119 | 0,127 | 0,135 |
| 17 | RISK_ITEM_17 | 0,113 | ,157* | 0,058 | 0,14 | 0,078 | 0,141 | 0,121 | ,156* |
| 18 | RISK_ITEM_18 | 0,126 | 0,072 | 0,114 | 0,104 | 0,119 | 0,116 | 0,07 | ,227** |
| 19 | RISK_ITEM_19 | 0,115 | 0,114 | 0,106 | 0,124 | 0,119 | 0,115 | 0,126 | ,234** |
| 20 | RISK_ITEM_20 | 0,114 | 0,118 | 0,103 | 0,116 | 0,101 | 0,129 | 0,054 | 0,147 |
| 21 | RISK_ITEM_21 | ,367** | ,413** | ,345** | ,391** | ,512** | ,568** | ,572** | ,576** |
| 22 | RISK_ITEM_22 | ,474** | ,500** | ,499** | ,494** | ,505** | ,487** | ,574** | ,585** |
| 23 | RISK_ITEM_23 | ,362** | ,353** | ,543** | ,424** | ,538** | ,457** | ,436** | ,478** |
| 24 | RISK_ITEM_24 | ,366** | ,355** | ,402** | ,490** | ,492** | ,528** | ,319** | ,360** |
| 25 | RISK_ITEM_25 | 0,122 | 0,133 | 0,115 | 0,122 | 0,116 | 0,147 | 0,116 | ,191* |
| 26 | RISK_ITEM_26 | 0,116 | 0,116 | 0,077 | 0,131 | 0,127 | 0,127 | 0,116 | 0,083 |
| 27 | RISK_ITEM_27 | 0,126 | 0,076 | 0,093 | 0,122 | 0,138 | 0,138 | 0,113 | 0,1 |
| 28 | RISK_ITEM_28 | 0,14 | 0,131 | 0,089 | 0,118 | 0,13 | 0,133 | 0,114 | ,252** |
| 29 | RISK_ITEM_29 | 0,115 | 0,115 | 0,085 | 0,148 | 0,096 | 0,114 | 0,062 | 0,121 |
| 30 | RISK_ITEM_30 | 0,138 | 0,139 | 0,101 | 0,112 | 0,125 | 0,091 | 0,129 | 0,148 |
| 31 | RISK_ITEM_31 | 0,116 | 0,139 | 0,069 | 0,075 | 0,098 | 0,14 | 0,063 | 0,129 |
| 32 | RISK_ITEM_32 | 0,102 | 0,142 | 0,114 | 0,143 | 0,097 | 0,124 | 0,135 | 0,126 |

| | | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | RISK_ITEM_01 | | | | | | | | |
| 2 | RISK_ITEM_02 | | | | | | | | |
| 3 | RISK_ITEM_03 | | | | | | | | |
| 4 | RISK_ITEM_04 | | | | | | | | |
| 5 | RISK_ITEM_05 | | | | | | | | |
| 6 | RISK_ITEM_06 | | | | | | | | |
| 7 | RISK_ITEM_07 | | | | | | | | |
| 8 | RISK_ITEM_08 | | | | | | | | |
| 9 | RISK_ITEM_09 | 1 | | | | | | | |
| 10 | RISK_ITEM_10 | ,535** | 1 | | | | | | |
| 11 | RISK_ITEM_11 | ,549** | ,459** | 1 | | | | | |
| 12 | RISK_ITEM_12 | ,380** | ,398** | ,563** | 1 | | | | |
| 13 | RISK_ITEM_13 | ,600** | ,537** | ,598** | ,430** | 1 | | | |
| 14 | RISK_ITEM_14 | ,550** | ,675** | ,416** | ,405** | ,605** | 1 | | |
| 15 | RISK_ITEM_15 | ,458** | ,446** | ,555** | ,553** | ,487** | ,445** | 1 | |
| 16 | RISK_ITEM_16 | ,506** | ,480** | ,556** | ,501** | ,568** | ,537** | ,540** | 1 |
| 17 | RISK_ITEM_17 | 0,119 | 0,115 | 0,097 | 0,072 | 0,116 | 0,113 | ,165* | ,168* |
| 18 | RISK_ITEM_18 | 0,09 | 0,118 | 0,113 | 0,114 | 0,127 | 0,116 | 0,137 | 0,115 |
| 19 | RISK_ITEM_19 | 0,114 | 0,126 | 0,117 | 0,149 | 0,123 | 0,081 | 0,116 | 0,089 |
| 20 | RISK_ITEM_20 | 0,133 | 0,113 | 0,102 | 0,083 | 0,126 | 0,116 | 0,085 | 0,148 |
| 21 | RISK_ITEM_21 | 0,138 | 0,135 | 0,128 | 0,139 | 0,115 | 0,125 | 0,065 | ,175* |
| 22 | RISK_ITEM_22 | 0,096 | 0,084 | 0,115 | 0,121 | 0,065 | 0,132 | 0,091 | 0,115 |
| 23 | RISK_ITEM_23 | 0,127 | 0,117 | ,180* | 0,124 | ,184* | 0,126 | ,262** | ,154* |
| 24 | RISK_ITEM_24 | 0,149 | 0,094 | 0,127 | 0,119 | 0,115 | 0,135 | 0,115 | 0,114 |
| 25 | RISK_ITEM_25 | ,173* | 0,069 | 0,142 | ,175* | 0,12 | 0,126 | ,169* | ,167* |
| 26 | RISK_ITEM_26 | 0,115 | 0,126 | 0,113 | 0,118 | 0,108 | 0,118 | 0,116 | 0,117 |
| 27 | RISK_ITEM_27 | 0,124 | 0,08 | 0,12 | 0,11 | 0,128 | 0,117 | 0,082 | 0,127 |
| 28 | RISK_ITEM_28 | 0,128 | 0,118 | 0,125 | 0,094 | 0,148 | 0,127 | 0,125 | 0,114 |
| 29 | RISK_ITEM_29 | 0,085 | 0,108 | 0,112 | 0,126 | 0,145 | 0,137 | 0,124 | 0,117 |
| 30 | RISK_ITEM_30 | 0,09 | 0,092 | 0,089 | 0,115 | 0,117 | 0,106 | 0,112 | 0,132 |
| 31 | RISK_ITEM_31 | 0,114 | 0,122 | 0,12 | 0,125 | 0,136 | 0,112 | 0,141 | 0,12 |
| 32 | RISK_ITEM_32 | 0,08 | 0,133 | 0,099 | 0,124 | 0,117 | 0,133 | 0,053 | 0,108 |

| | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|
| RISK_ITEM_01 | | | | | | | | |
| RISK_ITEM_02 | | | | | | | | |
| RISK_ITEM_03 | | | | | | | | |
| RISK_ITEM_04 | | | | | | | | |
| RISK_ITEM_05 | | | | | | | | |
| RISK_ITEM_06 | | | | | | | | |
| RISK_ITEM_07 | | | | | | | | |
| RISK_ITEM_08 | | | | | | | | |
| RISK_ITEM_09 | | | | | | | | |
| RISK_ITEM_10 | | | | | | | | |
| RISK_ITEM_11 | | | | | | | | |
| RISK_ITEM_12 | | | | | | | | |
| RISK_ITEM_13 | | | | | | | | |
| RISK_ITEM_14 | | | | | | | | |
| RISK_ITEM_15 | | | | | | | | |
| RISK_ITEM_16 | | | | | | | | |
| RISK_ITEM_17 | 1 | | | | | | | |
| RISK_ITEM_18 | ,563** | 1 | | | | | | |
| RISK_ITEM_19 | ,530** | ,620** | 1 | | | | | |
| RISK_ITEM_20 | ,607** | ,472** | ,536** | 1 | | | | |
| RISK_ITEM_21 | ,169* | ,160* | 0,12 | ,183* | 1 | | | |
| RISK_ITEM_22 | 0,119 | 0,117 | 0,144 | 0,125 | ,541** | 1 | | |
| RISK_ITEM_23 | ,237** | ,318** | ,295** | ,165* | ,568** | ,462** | 1 | |
| RISK_ITEM_24 | 0,131 | ,238** | ,289** | 0,089 | ,499** | ,463** | ,613** | 1 |
| RISK_ITEM_25 | ,496** | ,515** | ,599** | ,456** | ,205** | 0,11 | ,218** | ,204** |
| RISK_ITEM_26 | ,578** | ,574** | ,457** | ,464** | ,221** | 0,129 | ,235** | ,166* |
| RISK_ITEM_27 | ,529** | ,480** | ,478** | ,525** | ,187* | 0,121 | ,290** | ,234** |
| RISK_ITEM_28 | ,453** | ,559** | ,665** | ,457** | ,196* | 0,135 | ,203** | ,230** |
| RISK_ITEM_29 | 0,113 | 0,13 | 0,124 | 0,105 | 0,14 | 0,143 | 0,15 | 0,146 |
| RISK_ITEM_30 | 0,148 | 0,113 | 0,09 | 0,136 | 0,077 | ,242** | 0,114 | 0,089 |
| RISK_ITEM_31 | ,153* | ,195* | 0,116 | 0,104 | 0,131 | ,161* | 0,127 | 0,093 |
| RISK_ITEM_32 | ,155* | 0,062 | 0,115 | 0,116 | 0,041 | 0,143 | 0,112 | 0,102 |

| | | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | RISK_ITEM_01 | | | | | | | | |
| 2 | RISK_ITEM_02 | | | | | | | | |
| 3 | RISK_ITEM_03 | | | | | | | | |
| 4 | RISK_ITEM_04 | | | | | | | | |
| 5 | RISK_ITEM_05 | | | | | | | | |
| 6 | RISK_ITEM_06 | | | | | | | | |
| 7 | RISK_ITEM_07 | | | | | | | | |
| 8 | RISK_ITEM_08 | | | | | | | | |
| 9 | RISK_ITEM_09 | | | | | | | | |
| 10 | RISK_ITEM_10 | | | | | | | | |
| 11 | RISK_ITEM_11 | | | | | | | | |
| 12 | RISK_ITEM_12 | | | | | | | | |
| 13 | RISK_ITEM_13 | | | | | | | | |
| 14 | RISK_ITEM_14 | | | | | | | | |
| 15 | RISK_ITEM_15 | | | | | | | | |
| 16 | RISK_ITEM_16 | | | | | | | | |
| 17 | RISK_ITEM_17 | | | | | | | | |
| 18 | RISK_ITEM_18 | | | | | | | | |
| 19 | RISK_ITEM_19 | | | | | | | | |
| 20 | RISK_ITEM_20 | | | | | | | | |
| 21 | RISK_ITEM_21 | | | | | | | | |
| 22 | RISK_ITEM_22 | | | | | | | | |
| 23 | RISK_ITEM_23 | | | | | | | | |
| 24 | RISK_ITEM_24 | | | | | | | | |
| 25 | RISK_ITEM_25 | 1 | | | | | | | |
| 26 | RISK_ITEM_26 | ,473$^{**}$ | 1 | | | | | | |
| 27 | RISK_ITEM_27 | ,509$^{**}$ | ,483$^{**}$ | 1 | | | | | |
| 28 | RISK_ITEM_28 | ,567$^{**}$ | ,517$^{**}$ | ,519$^{**}$ | 1 | | | | |
| 29 | RISK_ITEM_29 | 0,13 | 0,122 | 0,139 | 0,111 | 1 | | | |
| 30 | RISK_ITEM_30 | 0,093 | 0,126 | ,174$^{*}$ | 0,124 | ,477$^{**}$ | 1 | | |
| 31 | RISK_ITEM_31 | 0,117 | 0,134 | 0,119 | 0,106 | ,436$^{**}$ | ,493$^{**}$ | 1 | |
| 32 | RISK_ITEM_32 | 0,115 | 0,109 | 0,106 | 0,078 | ,402$^{**}$ | ,470$^{**}$ | ,492$^{**}$ | 1 |

#### *5.1.3.1.3 Validity assessment for the Carbon Accounting Questionnaire*

As with the previous questionnaires, the sample size (n=103) for carbon accounting is also in accordance to Hair's rule. Moreover, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0,804 which indicates high sampling adequacy. Regarding the correlations between the variables, Table 21 shows that the majority of correlations are above 0.3 and at the same time not above 0.665 which means that factor analysis will be able to extract reliable factors. Finally, Barllett's test of sphericity is significant (p<=0.000) and the Determinant value is 0.000271 (> 0.00001) which indicate the absence of multicollinearity between the variables.

In Table 20 we can see the results of the factor analysis. Factor loadings for the variable items are above 0.6 which means that the factors created are highly reliable. In Table 24 we can see the factors as they have been constructed after the analysis. In specific, the first variable construct consists of the initial Identification and Calculation of Carbon Emissions Regulation critical factor except from ACCOUNT_ITEM_05, regarding Scope 3 emissions calculation, which is included in the second factor. Furthermore, items 10, 11 and 13 regarding external verification of carbon emissions, reasonable assurance verification and mandatory reporting are also included in the first factor. The second variable structure includes the initial Internal Price of Carbon critical factor and the scope 3 emissions calculation item. If we look at the descriptive statistics of the initial variables (Table 15) we can observe that the variables in the second factor have much higher mean values than the rest of the variables, which means that are generally more difficult to implement than the items included in the first factor. Therefore, we will name the final variable constructs as *Basic Carbon Accounting and Reporting Practices* and *Advanced Carbon Accounting Practices*, for factors one and two respectively. Finally, regarding ACCOUNT_ITEM_09 and ACCOUNT_ITEM_12, since they have low factor loadings in comparison to the other variables, we decided not to include them in the final variable structures.

**Table 20: Carbon Accounting Factor Matrix**

| | Factor | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| ACCOUNT_ITEM_01 | 0,368 | **0,708** | 0,248 |
| ACCOUNT_ITEM_02 | 0,531 | **0,720** | -0,175 |
| ACCOUNT_ITEM_03 | **0,729** | -0,149 | -0,084 |
| ACCOUNT_ITEM_04 | **0,649** | -0,137 | -0,040 |
| ACCOUNT_ITEM_05 | 0,279 | **0,610** | 0,036 |
| ACCOUNT_ITEM_06 | **0,604** | -0,034 | -0,444 |
| ACCOUNT_ITEM_07 | **0,790** | -0,219 | -0,219 |
| ACCOUNT_ITEM_08 | **0,632** | -0,155 | -0,124 |
| ACCOUNT_ITEM_09 | 0,376 | 0,102 | 0,069 |
| ACCOUNT_ITEM_10 | **0,840** | -0,210 | 0,238 |
| ACCOUNT_ITEM_11 | **0,648** | -0,226 | 0,156 |
| ACCOUNT_ITEM_12 | 0,330 | 0,012 | 0,160 |
| ACCOUNT_ITEM_13 | **0,601** | -0,274 | 0,351 |

5.1.3.2 Reliability assessment

Reliability indicates the level of dependency, stability, predictability, consistency and accuracy of a measurement instrument (Kerlinger, 1986). Reliability is estimated with different methods. According to Nunnaly (1978) and Carmines and Zeller (1979) the four most common methods of assessing reliability are the test-retest method, the alternative form method, the split halves method and internal consistency method. In the test-retest method, the same measurement instrument (questionnaire) is sent to the same respondents at two different points of time. If the instrument is reliable then it should yield the same results, i.e. maintain stability over time. The alternative form methodology calculates the correlation between responses obtained with different measurement instruments that measure the same construct, sent to the same respondents are two different time periods. In the split halves methods, the items of the measurement construct are separated into two different groups and are then are then assessed for statistically significant correlations at the same point of time.

**Table 21: Carbon Accounting Correlations**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ACCOUNT_ITEM_01 | 1 | | | | | | | | | | | | |
| 2 | ACCOUNT_ITEM_02 | ,658** | 1 | | | | | | | | | | | |
| 3 | ACCOUNT_ITEM_03 | 0,101 | ,334** | 1 | | | | | | | | | | |
| 4 | ACCOUNT_ITEM_04 | 0,167 | ,276** | ,580** | 1 | | | | | | | | | |
| 5 | ACCOUNT_ITEM_05 | ,648** | ,665** | ,250* | 0,172 | 1 | | | | | | | | |
| 6 | ACCOUNT_ITEM_06 | 0,098 | ,379** | ,411** | ,416** | ,259* | 1 | | | | | | | |
| 7 | ACCOUNT_ITEM_07 | 0,061 | ,290** | ,632** | ,498** | ,279** | ,612** | 1 | | | | | | |
| 8 | ACCOUNT_ITEM_08 | 0,114 | 0,194 | ,516** | ,404** | ,218* | ,453** | ,575** | 1 | | | | | |
| 9 | ACCOUNT_ITEM_09 | 0,156 | ,288** | ,315** | ,235* | ,272** | 0,121 | ,215* | ,294** | 1 | | | | |
| 10 | ACCOUNT_ITEM_10 | ,241* | ,297** | ,633** | ,554** | ,218* | ,422** | ,640** | ,523** | ,268** | 1 | | | |
| 11 | ACCOUNT_ITEM_11 | 0,12 | 0,101 | ,402** | ,526** | ,220* | ,388** | ,494** | ,416** | ,218* | ,667** | 1 | | |
| 12 | ACCOUNT_ITEM_12 | 0,122 | ,204* | 0,163 | 0,106 | 0,141 | 0,129 | ,276** | 0,154 | ,272** | ,335** | ,272** | 1 | |
| 13 | ACCOUNT_ITEM_13 | 0,133 | 0,025 | ,478** | ,398** | 0,166 | 0,194 | ,513** | ,371** | 0,182 | ,643** | ,471** | ,252* | 1 |

The internal consistency method mathematically calculates the reliability of the measurement instrument. “It assesses the equivalence, homogeneity and inter-correlation of the items used in a measure. This means that the items of a measure should hang together as a set and should be capable of independently measuring the same construct.” (Forza, 2002 ). Internal consistency of a structure is measured with the Cronbach alpha coefficient (Cronbach, 1951). Cronbach’s alpha calculates the average inter-item correlation among the items included in the measurement instrument. It is therefore related both to the level of correlation between the items as well as the number of items included in the construct. According to Nunnally (1978), the construct’s Cronbach alpha coefficient should be over 0,800 in order for the construct to yield reliable results. Also, the item-related Cronbach alpha coefficients should be lower than the construct’s total Cronbach alpha. A higher item-related Cronbach alpha coefficient means that if the specific item is removed from the construct, then the reliability of the construct will increase.

In the previous section we assessed the validity of the questionnaires used in order to calculate the weights that will be used in our corporate indexes. In doing so, we employed factor analysis and developed new variable constructs. In this section, the factors developed will be assessed for reliability by using the internal consistency method. Internal consistency for the climate change strategy, risk management and carbon accounting is depicted in Table 22, Table 23 and Table 24 respectively. As we can observe, the item-related Cronbach alpha coefficients of each variable construct are lower than the construct’s total Cronbach alpha. Therefore, we can consider the factors extracted to be reliable.

## Table 22: Climate Change Strategy Internal Consistency

| Item | Critical Factor/Item Description | Cronbach's Alpha Coefficient | | Mean Difficulty | Median Difficulty |
|---|---|---|---|---|---|
| | **Climate Change Organizational Management Strategies** | ,914 | | 4,13 | 4,00 |
| STRATEGY_ITEM_01 | The Board of Directors (or a committee of the Board) is accountable for climate change performance | | ,909 | 4,22 | 4,00 |
| STRATEGY_ITEM_02 | Company management has clear responsibilities for achieving climate change goals | | ,907 | 3,99 | 4,00 |
| STRATEGY_ITEM_03 | Executive compensation is linked to climate change performance | | ,909 | 4,99 | 5,00 |
| STRATEGY_ITEM_04 | Climate change risk management processes are integrated into core business risk management processes | | ,906 | 4,12 | 4,00 |
| STRATEGY_ITEM_05 | Climate change risks and opportunities are identified at asset level | | ,908 | 3,62 | 3,00 |
| STRATEGY_ITEM_06 | Climate change risks and opportunities are identified at company level | | ,907 | 3,76 | 4,00 |
| STRATEGY_ITEM_07 | Company has processes that allow the prioritization of risks and opportunities related to climate change | | ,907 | 4,03 | 4,00 |
| STRATEGY_ITEM_08 | Company has short-term absolute $CO_2$ emission reduction targets. | | ,909 | 4,80 | 5,00 |
| STRATEGY_ITEM_09 | Company has short-term $CO_2$ emission intensity reduction targets | | ,907 | 4,34 | 4,00 |
| STRATEGY_ITEM_10 | Company has long-term absolute $CO_2$ emission reduction targets. | | ,907 | 4,87 | 5,00 |
| STRATEGY_ITEM_11 | Company has long-term $CO_2$ emission intensity reduction targets | | ,908 | 4,47 | 5,00 |
| STRATEGY_ITEM_17 | Replacement of carbon-based products by non-carbon based products. | | ,910 | 4,64 | 5,00 |
| STRATEGY_ITEM_18 | Implementation of end-use energy efficiency processes | | ,908 | 2,85 | 2,00 |
| STRATEGY_ITEM_19 | Optimization of current business processes in order to reduce $CO_2$ emissions. | | ,908 | 3,13 | 3,00 |
| | **Carbon Reduction Technology Strategies** | ,848 | | 4,10 | 4,00 |
| STRATEGY_ITEM_12 | Fossil fuel switching, from coal to natural gas. | | ,807 | 3,66 | 4,00 |
| STRATEGY_ITEM_13 | Increased boiler efficiency, by implementing the best available technology. | | ,815 | 3,11 | 3,00 |
| STRATEGY_ITEM_14 | Usage of Combined Heat and Power Technology (cogeneration). | | ,824 | 3,64 | 4,00 |
| STRATEGY_ITEM_15 | Energy source switching, from fossil fuels to renewable energy sources. | | ,821 | 3,76 | 4,00 |
| STRATEGY_ITEM_16 | Capture and Storage of $CO_2$. | | ,839 | 6,37 | 7,00 |
| STRATEGY_ITEM_20 | Control of non-$CO_2$ gas emissions (e.g. $CH_4$, H2O). | | ,829 | 4,04 | 4,00 |
| | **Carbon Compensation Strategies** | ,796 | | 4,28 | 5,00 |
| STRATEGY_ITEM_21 | Participating in emissions trading schemes. | | ,678 | 4,63 | 5,00 |
| STRATEGY_ITEM_22 | Creating project-based carbon credits. | | ,737 | 4,82 | 5,00 |
| STRATEGY_ITEM_23 | Purchasing carbon credits. | | ,742 | 3,38 | 3,00 |

## Table 23: Risk Management Internal Consistency

| Item | Critical Factor/Item Description | Cronbach's Alpha Coefficient | Mean Difficulty | Median Difficulty |
|---|---|---|---|---|
| | **Regulation-induced Risk Management** | 0,921 | 4,42 | 4,5 |
| RISK_ITEM_01 | Identify impacts from command and control regulation. | 0,916 | 4,54 | 5 |
| RISK_ITEM_02 | Calculate financial implications from command and control regulation. | 0,914 | 4,77 | 5 |
| RISK_ITEM_03 | Identify management methods in order to address impacts from command and control regulation. | 0,914 | 4,1 | 4 |
| RISK_ITEM_04 | Calculate the cost of management methods needed to address impacts from command and control regulation. | 0,914 | 4,51 | 4 |
| RISK_ITEM_05 | Identify impacts from market-based regulation. | 0,911 | 3,76 | 3 |
| RISK_ITEM_06 | Calculate financial implications from market-based regulation. | 0,913 | 3,96 | 4 |
| RISK_ITEM_07 | Identify management methods in order to address impacts from market-based regulation. | 0,912 | 3,6 | 3 |
| RISK_ITEM_08 | Calculate the cost of management methods needed to address impacts from market-based regulation. | 0,913 | 3,9 | 4 |
| RISK_ITEM_21 | Identify potential impacts from climate change competitive risks regarding uncertainty in market signals. | 0,915 | 4,83 | 5 |
| RISK_ITEM_22 | Calculate potential financial implications from climate change competitive risks regarding uncertainty in market signals. | 0,913 | 5,19 | 5 |
| RISK_ITEM_23 | Identify management methods in order to address climate change competitive risks regarding uncertainty in market signals. | 0,915 | 4,89 | 5 |
| RISK_ITEM_24 | Calculate the cost of management methods needed to address climate change competitive risks regarding uncertainty in market signals. | 0,917 | 4,92 | 5,5 |
| | **Legal Risk Management** | 0,774 | | |
| RISK_ITEM_29 | Identify potential impacts from climate change legal risks. | 0,737 | 4,34 | 4 |
| RISK_ITEM_30 | Calculate potential financial implications from climate change legal risks. | 0,704 | 4,71 | 5 |
| RISK_ITEM_31 | Identify management methods in order to address climate change legal risks. | 0,709 | 4,02 | 4 |
| RISK_ITEM_32 | Calculate the cost of management methods needed to address climate change legal risks. | 0,726 | 4,7 | 5 |

| Item | Critical Factor/Item Description | Cronbach's Alpha Coefficient | Mean Difficulty | Median Difficulty |
|---|---|---|---|---|
| | **Reputation-induced Risk Management** | 0,894 | 4,79 | 5 |
| RISK_ITEM_17 | Identify potential impacts from negative reputation, related to climate change. | 0,880 | 4,6 | 5 |
| RISK_ITEM_18 | Calculate potential financial implications from negative reputation, related to climate change. | 0,880 | 5,7 | 6 |
| RISK_ITEM_19 | Identify management methods in order to address impacts from negative reputation, related to climate change. | 0,876 | 4,57 | 5 |
| RISK_ITEM_20 | Calculate the cost of management methods needed to address impacts from negative reputation, related to climate change. | 0,882 | 4,81 | 5 |
| RISK_ITEM_25 | Identify potential impacts from climate change competitive risks related to changing consumer behavior. | 0,882 | 4,24 | 4 |
| RISK_ITEM_26 | Calculate potential financial implications from climate change competitive risks related to changing consumer behavior. | 0,883 | 5,29 | 5 |
| RISK_ITEM_27 | Identify management methods in order to address climate change competitive risks related to changing consumer behavior. | 0,883 | 4,1 | 4 |
| RISK_ITEM_28 | Calculate the cost of management methods needed to address climate change competitive risks related to changing consumer behavior. | 0,879 | 5,07 | 5,5 |
| | **Physical Risk Management** | 0,895 | 4,36 | 4 |
| RISK_ITEM_09 | Identify impacts from extreme weather events. | 0,881 | 4,02 | 4 |
| RISK_ITEM_10 | Calculate financial implications from extreme weather events. | 0,882 | 4,7 | 5 |
| RISK_ITEM_11 | Identify management methods in order to address impacts from extreme weather events. | 0,877 | 4 | 4 |
| RISK_ITEM_12 | Calculate the cost of management methods needed to address impacts from extreme weather events. | 0,886 | 4,35 | 4 |
| RISK_ITEM_13 | Identify impacts from changes in temperature and precipitation extremes. | 0,876 | 4,35 | 4 |
| RISK_ITEM_14 | Calculate financial implications from changes in temperature and precipitation extremes. | 0,881 | 4,97 | 5,5 |
| RISK_ITEM_15 | Identify management methods in order to address impacts from changes in temperature and precipitation extremes. | 0,883 | 3,98 | 4 |
| RISK_ITEM_16 | Calculate the cost of management methods needed to address impacts from changes in temperature and precipitation extremes. | 0,879 | 4,51 | 5 |

## Table 24: Carbon Accounting Internal Consistency

| Item | Critical Factor/Item Description | Cronbach's Alpha Coefficient | | Mean Difficulty | Median Difficulty |
|---|---|---|---|---|---|
| | **Core Business Carbon Accounting and Reporting** | ,885 | | 2,95 | 3,00 |
| ACCOUNT_ITEM_03 | Calculate scope1 emissions. | | ,866 | 2,43 | 2,00 |
| ACCOUNT_ITEM_04 | Calculate scope2 emissions. | | ,872 | 2,46 | 2,00 |
| ACCOUNT_ITEM_06 | Calculate amount of emissions avoided by $CO_2$ saving projects. | | ,882 | 3,35 | 3,00 |
| ACCOUNT_ITEM_07 | Set an emissions baseline year. | | ,861 | 3,02 | 3,00 |
| ACCOUNT_ITEM_08 | Use an established methodology to calculate emissions. | | ,875 | 2,45 | 2,00 |
| ACCOUNT_ITEM_10 | Have $CO_2$ emissions verified through an independent external auditing process. | | ,855 | 3,30 | 3,00 |
| ACCOUNT_ITEM_11 | Achive Reasonable Assurance Verification. | | ,873 | 3,51 | 4,00 |
| ACCOUNT_ITEM_13 | Report $CO_2$ emissions to mandatory GHG reporting programs. | | ,878 | 3,09 | 3,00 |
| | **Advanced Carbon Accounting Practices** | ,847 | | 4,75 | 5,00 |
| ACCOUNT_ITEM_01 | Develop an internal price of carbon scheme. | | ,795 | 4,91 | 5,00 |
| ACCOUNT_ITEM_02 | Calculate internal price of carbon. | | ,773 | 4,00 | 4,00 |
| ACCOUNT_ITEM_05 | Calculate scope3 emissions. | | ,791 | 5,00 | 5,00 |

## 5.2 Development of the Climate Change Indexes

Based on the factor analysis results we are going to develop eight corporate climate change indexes that measure a company's level of commitment regarding climate change strategy, climate change risk management and carbon accounting. More specifically we will develop three indexes related to climate change strategy management: *Climate Change Organizational Management Strategies, Carbon Reduction Technology Strategies* and *Carbon Compensation Strategies.* Three indexes related to climate change risk management: *Regulation-induced Risk Management, Reputation - induced Risk Management* and *Physical Risk Management* and two indexes related to Carbon Accounting: *Core Business Carbon Accounting and Reporting* and *Advanced Carbon Accounting Practices.*

In order to measure the level of commitment of each company related to the aspects of climate change management described above we are going to use the mean average values of the items included in each index as weights. The result will be the development of weighted corporate climate change indexes that will accurately and reliably measure a company's level of commitment regarding specific climate change practices. The companies that will be assessed will be Oil and Gas Companies and Banks included in the Financial Times Global 500 data set for the years 2012-2015. The assessment was based on the CDP climate change reports of the companies. As we have discussed in previous section of this study, the CDP is a global not-for-profit organization, which provides a global disclosure system through which thousands of firms around the world report, manage and share environmental information. Furthermore it holds the largest and most comprehensive collection globally of primary corporate climate change information (CDP, 2015). Reports were assess for the years 2012-2015.

In the following section we will describe the scoring methodology used in measuring the level of commitment of each company for each respective index.

### 5.2.1 Scoring Methodology

The scoring methodology used in this study was based on a two – step procedure described below. 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, 1996; Krippendorff, 1980; Weber, 1990). Content analysis enables researchers to sift through large volumes of data with relative ease in a systematic fashion (GAO, 1996). It can be a useful technique for allowing 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 environmental management and environmental disclosures (Freedman and Jaggi, 2005; Clarkson *et al.*, 2008; Brammer and Pavelin, 2008; Prado-Lorenzo *et al*., 2009; Tagesson et al., 2009; Gallego-Alvarez, 2010; Haque and Deegan, 2010; Galani et al., 2011; Martínez-Ferrero *et al*., 2013). We will also apply this methodology in order to analyze information provided in the CDP reports of Oil and Gas Companies and Banks 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.

For example, figure 8 is a snapshot of the CDP report of HESS CORPORATION, one of the largest oil and gas produces in the U.S. In this case items related to climate change market- based regulation will receive the value of 1 for ″Identify impacts from market-based regulation″, ″Calculate financial implications from market-based regulation″, ″Identify management methods in order to address impacts from market-based regulation″, ″Calculate the cost of management methods needed to address impacts from market-based regulation″. In another example, figure 9 is a snapshot of the CDP report of TOTAL, the largest oil producer in France. In this case items related to climate change market- based regulation will receive the value of 1 for ″Identify impacts from market-based regulation″, and ″Identify management methods in order to address impacts from market-based regulation″, and 0 for ″Calculate financial implications from market-based regulation″ and ″Calculate the cost of management methods needed to address impacts from market-based regulation″.

| Risk driver | Description | Potential impact | Timeframe | Direct/ Indirect | Likelihood | Magnitude of impact | Estimated financial implications | Management method | Cost of management |
|---|---|---|---|---|---|---|---|---|---|
| Cap and trade schemes | Hess' Denmark operations are subject to the European Union Emissions Trading Scheme (EU ETS). Under Phase III, Hess makes annual purchases of allowances to make up the gap between free allowances allocated and the verified greenhouse gas (GHG) emissions. During Phase III the gap between the annual number of free allowances allocated to Hess (EUAs) and actual GHG emissions is expected to widen. This means that we will need to purchase more allowances which will add to routine operational costs. | Increased operational cost | 1 to 3 years | Direct | Virtually certain | Low | Our cost to purchase additional allowances was approximately US$1million. This is estimated based on an EU ETS price of $6-7 per EUA. | 2014 Summary: Hess' Denmark operations banked free allowances under EU ETS Phase II. In order to meet our 2014 obligations, we carried over surplus allowances from 2013 and applied these, as well as a portion of our 2014 free allowances, toward our 2014 obligations. We also received allowances from our partners and utilized a third-party to purchase additional EUAs. 2015 Goals: To meet the full obligations in 2015 we will purchase quotas on the spot market. | There is minimal to no cost for managing the purchase of allowances we need to meet our EU ETS obligations as the cost of using a third party to purchase allowances on our behalf is already included in the price we pay for the EUAs. Annual third party verification of GHG emissions is part of the EU ETS and costs $20,000-25,000. This annual cost is likely to occur for the duration of the EU ETS. |

## Figure 8: CDP Snap Shot of Hess Corporation

| Risk driver | Description | Potential impact | Timeframe | Direct/ Indirect | Likelihood | Magnitude of impact | Estimated financial implications | Management method | Cost of management |
|---|---|---|---|---|---|---|---|---|---|
| Carbon taxes | Absence of regional carbon tax systems outside the EU. Risk of carbon leakage for the Petrochemicals and Refining sectors in case the list of exposed sectors receiving free allocations is changed in 2019. | Other: lower competitiveness | 3 to 6 years | Direct | Unlikely | High | Possible increase of production costs for certain products. | Close monitoring of the company's exposure to CO2 quotas deficit. Close monitoring of carbon leakage threshold criteria. | Included in running operational costs. |

## Figure 9: CDP Snap Shot of Total Corporation

After content analysis was conducted for all the sample companies for the years 2012-2015, the data were weighted with the respective mean average value. The reason why we decided to weight the content analysis data is based on the fact that not all climate change practices have the same level of difficulty to be implemented. For example, identifying the impact of market – based regulation has a mean difficulty value of 4.54 which is lower than the mean difficulty value of calculation the financial implications of market-based regulation (4.77). Therefore, in order to gain a better understanding of the level of corporate commitment regarding climate change practices, we will weigh the data obtained by the content analysis according to the mean average values.

In Table 25 and Table 26 and we provide an example, which explains the reason why we decided to weigh the results of content analysis. Table 25 and Table 26 measure the level of corporate commitment for regulation-induced risk management. As we can see, each company has different management practices. Company A focused on the Identification of Impacts and Management Solutions for all three types of regulation risks, while Company B does not take into account Command and Control regulation risks, but focuses on identifying impact and management solutions as well as calculating the cost for these items. If we were to employ simple content analysis, then corporate level of commitment for both companies would be the same ie. 8. However, when we apply weights to the content analysis data then we observe that the level of corporate commitment for company B (37.75) is higher than that of company A (33.58).

**Table 25: Corporate commitment for regulation-induced risk management (A)**

| Company A | | | | Total Score |
|---|---|---|---|---|
| Market-based Regulation | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 1 | 0 | 1 | 0 | 2 |
| 4,54 | 4,77 | 4,10 | 4,51 | |
| 4,54 | 0 | 4,1 | 0 | 8,64 |
| Command and Control Climate Change Regulation | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 1 | 1 | 1 | 1 | 4 |
| 3,76 | 3,96 | 3,6 | 3,9 | |
| 3,76 | 3,96 | 3,6 | 3,9 | 15,22 |
| Uncertainty in Market signals | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 1 | 0 | 1 | 0 | 2 |
| 4,83 | 5,19 | 4,89 | 4,92 | |
| 4,83 | 0 | 4,89 | 0 | 9,72 |
| Total Unweighted Regulation - Induced Risk Management score | | | | 8 |
| Total Weighted Regulation - Induced Risk Management score | | | | 33,58 |

**Table 26: Corporate commitment for regulation-induced risk management (B)**

| Company B | | | | Total Score |
|---|---|---|---|---|
| Market-based Regulation | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 1 | 1 | 1 | 1 | 4 |
| 4,54 | 4,77 | 4,10 | 4,51 | |
| 4,54 | 4,77 | 4,1 | 4,51 | 17,92 |
| Command and Control Climate Change Regulation | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 0 | 0 | 0 | 0 | 0 |
| 3,76 | 3,96 | 3,6 | 3,9 | |
| 0 | 0 | 0 | 0 | 0 |
| Uncertainty in Market signals | | | | |
| Identify impacts | Calculate financial implications | Identify management methods | Calculate the cost of management methods | |
| 1 | 1 | 1 | 1 | 4 |
| 4,83 | 5,19 | 4,89 | 4,92 | |
| 4,83 | 5,19 | 4,89 | 4,92 | 19,83 |
| Total Unweighted Regulation - Induced Risk Management score | | | | 8 |
| Total Weighted Regulation - Induced Risk Management score | | | | 37,75 |

### 5.2.2 Scoring Methodology for the Banking Sector

At this point we would like to clarify a bit on the scoring methodology used when assessing the climate change practices of companies belonging to the banking sector. Since the banking sector is a services sector, we did not assess climate change practices that are directly related to a bank's operational activities. What we mean is, for example, regarding the ‘’Energy source switching, from fossil fuels to renewable energy sources’’, what we did assess was whether the bank invests on renewable energy sources or encourage its clients to invest in these types of carbon reduction technologies, such as combined heat and power or expand its business to the natural gas industry. Direct emissions reduction strategies from a bank's operational activities are not included in the Carbon Reduction Technologies Strategies rather in the Organization Management Strategies Index under the items: Implementation of end-use energy efficiency processes and Optimization of current business processes in order to reduce $CO_2$ emissions. Therefore, the Banking strategies for reducing $CO_2$ emissions were focus on developing and expanding green banking activities, which basically means promoting on-line banking services to reduce paper consumption or the reducing unnecessary traveling by using online communication media or by installing energy efficient equipment for lighting premises etc. Therefore, as we also going to see in Table 27 and Table 28, the maximum score for banks regarding carbon reduction strategies is very low in comparison to this of oil and gas companies.

Moreover, regarding Carbon Compensation Strategies, which include emissions trading and creating or purchasing project-based carbon credits, a score would be given when the bank either facilitated the buy and selling of carbon credits for its clients or when it took into its financial assessment of a company potential liabilities which could arise due to the lack of compliance to the requirements of emissions permits. This also the same, regarding regulation-induced risk management. Corporate commitment regarding regulation risk management did involved the direct effect of climate change regulation on the bank itself, as banks do not belong in carbon intensive sectors, but rather the indirect effects through increased compliance costs for their customers, which could potential alter their risk assessment profile, for example in loan granting etc. Physical Risk Management has also to do with the risk profile of a bank's clients and how vulnerable their business is to the natural adverse effects of climate change. So basically, a high score for a bank in the Physical Risk Management Index would mean that the bank devotes a considerable amount of resources in identifying and assessing climate change physical risks related to their clients' nature of business activities. Moreover, regarding a bank's level of corporate commitment related to reputation-induced climate change risks, this is defined in the strict borders of the bank as a company and how it is viewed by the public, for example whether it invests on carbon-friendly technologies etc. Finally, for carbon accounting, the scores produces are also strictly related to the activities of the bank and not its clients.

### 5.2.3 Analysis of the scoring results

Building on the above, we are going to use the weighted content analysis methodology in order to assess the corporate commitment of our sample companies. Table 27 presents the descriptive statistics for the oil and gas companies and Table 28 presents the descriptive statistics for the banks, for all the climate change indexes. According to above descriptive statistics, the level of corporate commitment regarding climate change practices varies to a great extent between companies in both sectors. Regarding carbon reduction technology strategies, we can observe that the level of corporate commitment for companies that belong to the oil and gas sector is much higher than that for the companies that belong to the banking sector. This is also the same for regulation-induced climate change risk management, carbon compensation strategies and advanced carbon accounting practices. These results can be easily explained if we take into account the fact that oil and gas companies are directly affected by climate change regulation since they belong to the highest carbon intensity business sector, which explains the regulation-induced climate change risk management effect. Also the fact that in certain countries, such as the European Union, participation in carbon trading schemes (which is included in the carbon compensation index) is mandatory, also explains the high level of corporate commitment regarding carbon compensation strategies.

In accordance with the above, corporate commitment regarding advanced carbon accounting practices is also much higher for the oil and gas companies. This particular climate change index, measures the level of commitment of a company to account for CO2 emissions across its value chain (Scope 3 emissions) as well as its ability to develop and implement internal price of carbon schemes. Therefore, since oil and gas companies are directly affected by climate change regulation and since the purpose of climate change regulation is to put a price on carbon emissions, it is essential for companies in the oil and gas sector to incorporate the cost of carbon emissions in their business activities.

**Table 27: Descriptive Statistics of Oil and Gas Companies**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Climate Change Organizational Management Strategies | 110 | 57,15 | 12,52 | 33,21 | 76,78 |
| Carbon Reduction Technology Strategies | 110 | 31,83 | 18,49 | 0,00 | 85,18 |
| Carbon Compensation Strategies | 110 | 51,96 | 28,93 | 0,00 | 100,00 |
| Regulation-induced Risk Management | 110 | 41,62 | 15,85 | 0,00 | 91,00 |
| Reputation - induced Risk Management | 110 | 40,97 | 26,38 | 0,00 | 87,46 |
| Physical Risk Management | 110 | 52,32 | 24,02 | 0,00 | 100,00 |
| Core Business Carbon Accounting and Reporting | 110 | 73,96 | 14,55 | 16,37 | 100,00 |
| Advanced Carbon Accounting Practices | 110 | 58,78 | 22,49 | 34,60 | 99,87 |

**Table 28: Descriptive Statistics of Banks**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Climate Change Organizational Management Strategies | 165 | 59,73 | 13,93 | 24,10 | 92,00 |
| Carbon Reduction Technology Strategies | 165 | 13,88 | 6,60 | 0,00 | 41,20 |
| Carbon Compensation Strategies | 165 | 23,15 | 23,58 | 0,00 | 100,00 |
| Regulation-induced Risk Management | 165 | 30,26 | 14,64 | 0,00 | 66,20 |
| Reputation - induced Risk Management | 165 | 39,15 | 19,96 | 0,00 | 86,80 |
| Physical Risk Management | 165 | 46,65 | 23,03 | 0,00 | 100,00 |
| Core Business Carbon Accounting and Reporting | 165 | 80,11 | 13,98 | 26,70 | 100,00 |
| Advanced Carbon Accounting Practices | 165 | 44,30 | 20,17 | 0,00 | 99,90 |

## 5.3 Testing of Research Hypotheses

### 5.3.1 Data Description and Sample Selection

In order to measure the level of corporate commitment regarding climate change strategy, climate change risk management and carbon accounting we used the scores obtained with the methodology described above. Regarding Carbon Reduction emissions we used data published by the Carbon Disclosure Project (CDP). The CDP is a global not-for-profit organization, which provides a global disclosure system through which thousands of firms around the world report, manage and share environmental information. Furthermore it holds the largest and most comprehensive collection globally of primary corporate climate change information (CDP, 2015).

For the purpose of this study, we obtained the GHG emissions from the CDP's data on emissions. Both scope 1 and scope 2 emissions were used in this study. Scope 1 GHG emissions are those who come directly from sources that are owned or controlled by the reporting firm. Scope 2 GHG emissions are a consequence of the activities of the reporting firm, but occur at sources owned or controlled by another firm (CDP, 2014).

In order to test our two hypotheses we have selected, as the target population, firms in the Financial Times Global 500 data set. The economic sectors selected to undertake this research were Oil and Gas Companies and Banks. A sample of 275 firms was chosen and data was selected for the years 2012-2015. Firms were selected on the basis of having both a disclosure score rating and providing data on their emissions according to the CDP. Accounting data were selected from the financial and annual reports of our sample firms.

#### 5.3.1.1 Dependent Variables

Firm financial performance is the depended variable in our regression model. In previous research both accounting measures, such as Return on Assets (ROA) and Return on Equity (ROE) (Gallego-Alvarez, 2012; Lannelonge *et al*., 2015; Eccles *et al*, 2013; Busch and Hoffman, 2011), as well as market performance measures such as Tobin's q (Nishitani and Kokubu, 2012; Busch and Hoffman, 2011; Wang *et al*., 2014), share/stock price ratio (Al-Najjar and Anfimiadou, 2012) and standardized cumulative abnormal returns (Yadav *et a*l., 2015) have been used to measure the corporate performance of a firm. Freedman and Jaggi (2005), Brammer and Pavelin

(2006), Gallego-Alvarez (2010) and Bewli and Li (2000) have used return on assets (ROA) as a financial indicator. Liu and Anbumzhi (2009) and Zhang *et al*. (2008) have used Return on Equity (ROE) as a financial performance indicator in analyzing environmental disclosure practices of 175 large Chinese listed companies and the Chinese chemical industry respectively. Galani *et al*. (2011) and Richardson and Welker (2001) have also used ROE as a financial performance indicators while Prado-Lorengo *et al*. (2009) has used both ROA and ROE. King and Lenox (2001) used Tobin's q, which represents the firm's market valuation over the replacement value of its assets. They calculated this variable by dividing the sum of firm equity values, book value of long-term debt and net current liabilities by the book value of total assets. Clarkson *et al.* (2008) and Nakao *et al*. (2007) used both ROA and Tobin's q as measures for financial performance in examining the disclosure practices of US high polluting industries and Japanese listed firms respectively.

Following the research of both Busch and Hoffman, (2011), Clarkson *et al*. (2008) and Nakao *et al*., (2007), we are going to use two accounting measures, ROA and ROE, and one market performance measure, Tobin's q, to examine a firm's corporate performance. We will use ROA and ROE because they are the most commonly used measure regarding the efficiency of tangible assets (Busch and Hoffman, 2011). Additionally, Tobin's q is considered as an indicator of intangible assets (Busch and Hoffman, 2011), since it reflects market expectations, reputational effects and financial risks (Wang *et al*., 2014; Busch and Hoffman, 2011). We define ROA as the net profits of a firm divided by its total assets, ROE as the Stakeholder's Equity divided by total assets and Tobin's q as the sum of market value, book value of long-term debt and net current liabilities divided by the book value of total assets.

#### 5.3.1.2 Independent Variables

In this study, we are going to use nine different independent variables, the climate change corporate commitment indexes as they have been described in previous sections of this study and carbon reduction variation. Previous research has examined different measures for environmental performance. Nakao *et al*., (2007) use an environmental management score published in the Nikkei Environmental Management Survey report, while Eccles *et al*., (2013) use disclosure scores calculated by Bloomberg and Thomson Reuters. In our research we are going to use the climate change indexes developed for the purposes of this study.

Regarding carbon reduction variation, Wang *et al*., (2014) have used the logarithm of total emissions. Nishitani and Kokubu, (2012) have used net sales divided by total carbon emissions while Lannelongue *et al*., (2015) have used total carbon emissions divided by sales. Furthermore, Gallego-Alvarez, (2012) has used carbon emission variation between years to measure the environmental performance of firms. Finally, Busch and Hoffman (2011) have used the natural logarithm of carbon intensity (carbon emissions divided by sales), divided by median of the sample firms. In our study, we will also use emission variation between years to measure the climate change performance of firms.

#### 5.3.1.3 Control Variables

In our study we are going to use size, leverage and capital intensity as control variables. Size has been used several times as an independent or control variable in previous research on environmental disclosures (Freedman and Jaggi, 2005; Liu and Anbumzhi, 2009; Moneva and Cuellar, 2009; Brammer and Pavelin, 2006; Clarkson *et al.*,2008; Cong and Freedman, 2011; Cormier *et al*. 2005; Prado-Lorengo *et al.*, 2009; Gallego-Alvarez, 2010; Galani *et al*., 2011; Zhang *et al.*, 2008). Most of the studies mentioned above have used total revenue (Prado-lorengo *et al.*, 2009; Galani *et al.* ,2011), natural logarithm of revenue (Cong and Freedman, 2011; Gallego-Alvarez 2010), natural logarithm of firm assets (Yadav *et al*., 2015; Wang *et al*., 2014; Ghoul *et al*., 2011; Freedman and Jaggi, 2005; Liu and Anbumzhi, 2009; Brammer and Pavelin, 2006; Clarkson *et al*.,2008; King and Lenox, 2001; Cormier *et al*., 2005; Zhang et al. 2008), number of employees (Nishitani and Kokubu, 2012; Lannelongue *et al*., 2015) and market value (Busch and Hoffman, 2011) as measures to represent firm size. In this study we also will use the natural log of total firm assets obtained from online published financials reports for the years 2012-2015.

With regard to measuring a firm’s leverage, Busch and Hoffman, (2011) have used long-term debt to total assets, Ghoul *et al.*, (2011), Gallego-Alvarez (2012), Freedman and Jaggi (2005), Gallego-Alvarez (2010) and Andrikopoulos and Kriklani (2013) have used a debt/ equity ratio, while Wang *et al.*, (2014), Al-Najjar and Anfimiadou, (2012) Brammer and Pavelin (2008), Stanny and Ely (2008) and Clarkson *et al*. (2008) have used a debt/asset ratio. In this study, we will also use a debt/asset ratio. Regarding capital intensity, Wang *et al.*, (2014) have used a capital expenditure to sales ratio, and

Nakao *et al*. (2007) have used sales to total assets ratio as a proxy variable for capital intensity. Following Nakao et al. (2007), sales to total assets ratio as a proxy variable for capital intensity.

### 5.3.2 Regression analysis

Multiple regression analysis was conducted in order to test the relationship between corporate commitment regarding climate change strategy, climate change risk management, carbon accounting, GHG reduction and corporate financial performance. In this study, three financial performance indexes, ROA, ROE and Tobin's q were used as dependent variables. *Climate Change Organizational Management Strategies, Carbon Reduction Technology Strategies*, *Carbon Compensation Strategies, Regulation-induced Risk Management, Reputation - induced Risk Management, Physical Risk Management, Core Business Carbon Accounting and Reporting* and *Advanced Carbon Accounting Practice,* each measured with its respective score and *GHG Reduction*, measured by percentage of $CO_2$ emissions variation between years (scope 1 and scope 2 emissions where used) where used as independent variables. *Firm Size*, calculated as the natural logarithm of total assets, *Leverage,* expressed as the ratio of debt to total assets and *Capital Intensity*, represented by the ratio sales to total assets were used as control variables.

Our models can be written as:

ROA = f (ORG_MGM, Z) + $e_i$ (S1)
ROA = f (TECH_MGM, Z) + $e_i$ (S2)
ROA = f (CONP_MGM, Z) + $e_i$ (S3)
ROA = f (ORG_MGM, TECH_MGM, CONP_MGM, Z) + $e_i$ (S4)
ROE = f (ORG_MGM, Z) + $e_i$ (S5)
ROE = f (TECH_MGM, Z) + $e_i$ (S6)
ROE = f (CONP_MGM, Z) + $e_i$ (S7)
ROE = f (ORG_MGM, TECH_MGM, CONP_MGM, Z) + $e_i$ (S8)
TOBIN = f (ORG_MGM, Z) + $e_i$ (S9)
TOBIN = f (TECH_MGM, Z) + $e_i$ (S10)
TOBIN = f (CONP_MGM, Z) + $e_i$ (S11)
TOBIN = f (ORG_MGM, TECH_MGM, CONP_MGM, Z) + $e_i$ (S12)

ROA = f (REG_RISK, Z) + $e_i$ (R1)
ROA = f (REP_RISK, Z) + $e_i$ (R2)

$$ROA = f\ (PHYS\_RISK, Z) + e_i \quad (R3)$$
$$ROA = f\ (REG\_RISK, REP\_RISK, PHYS\_RISK, Z) + e_i \quad (R4)$$
$$ROE = f\ (REG\_RISK, Z) + e_i \quad (R5)$$
$$ROE = f\ (REP\_RISK, Z) + e_i \quad (R6)$$
$$ROE = f\ (PHYS\_RISK, Z) + e_i \quad (R7)$$
$$ROE = f\ (REG\_RISK, REP\_RISK, PHYS\_RISK, Z) + e_i \quad (R8)$$
$$TOBIN = f\ (REG\_RISK, Z) + e_i \quad (R9)$$
$$TOBIN = f\ (REP\_RISK, Z) + e_i \quad (R10)$$
$$TOBIN = f\ (PHYS\_RISK, Z) + e_i \quad (R11)$$
$$TOBIN = f\ (REG\_RISK, REP\_RISK, PHYS\_RISK, Z) + e_i \quad (R12)$$

$$ROA = f\ (ACC\_REP, Z) + e_i \quad (A1)$$
$$ROA = f\ (ADV\_ACC, Z) + e_i \quad (A2)$$
$$ROA = f\ (ACC\_REP, ADV\_ACC, Z) + e_i \quad (A3)$$
$$ROE = f\ (ACC\_REP, Z) + e_i \quad (A4)$$
$$ROE = f\ (ADV\_ACC, Z) + e_i \quad (A5)$$
$$ROE = f\ (ACC\_REP, ADV\_ACC, Z) + e_i \quad (A6)$$
$$ROE = f\ (ACC\_REP, Z) + e_i \quad (A7)$$
$$ROE = f\ (ADV\_ACC, Z) + e_i \quad (A8)$$
$$ROE = f\ (ACC\_REP, ADV\_ACC, Z) + e_i \quad (A9)$$

$$ROA = f\ (CARB\_RED, Z) + e_i \quad (C1)$$
$$ROE = f\ (CARB\_RED, Z) + e_i \quad (C2)$$
$$TOBIN = f\ (CARB\_RED, Z) + e_i \quad (C3)$$

Where

ORG_MGM = Climate Change Organizational Management Strategies

TECH_MGM = Carbon Reduction Technology Strategies

CONP_MGM = Carbon Compensation Strategies

REG_RISK = Regulation-induced Risk Management

REP_RISK = Reputation - induced Risk Management

PHYS_RISK = Physical Risk Management

ACC_REP = Core Business Carbon Accounting and Reporting

ADV_ACC = Advanced Carbon Accounting Practices

CARB_RED = Carbon Reduction

ROA = Return on Assets

ROE = Return on Equity

TOBIN = Tobin’s Q

Z is a vector that contains the variables: firm size (SIZE), leverage (LEV), capital intensity (CAP_INT) and

$e_i$ is the mean-zero disturbance term.

### 5.3.2.1 Hypotheses Testing for the Oil and Gas Sector

In this section we are going to test our hypotheses for companies that operate in the oil and gas sector. As we have discussed in previous section, data were taken for the years 2012-2015. In analyzing our data, we are going to separate our initial sample into two different samples, one including data for the years 2012-2013 and the other for the years 2014-2015. The reason we decided to separately examine the relationship between financial performance and our climate change indexes for the two different time periods is because we want to examine whether there are differences in the level of corporate commitment, regarding climate change practices of firms, and whether the relationship between climate change corporate commitment and financial performance has changed between the two different time periods.

#### *5.3.2.1.1 Results and Analysis for the years 2012-2013*

##### *5.3.2.1.1.1 Descriptive Statistics and Bivariate Results*

Table 29 presents the descriptive statistics of the depended and independent variables. The minimum, maximum, mean and standard deviation values are reported. As we can see, the companies issue an average of 57,62 out of the 100 regarding the level of organizational management corporate commitment, while the highest mean average values are observed for the carbon accounting indexes, 76,90 for carbon accounting and reporting and 58,47 for advanced carbon accounting practices. Furthermore, a high variation is depicted, for carbon reduction technologies and carbon compensation management strategies ranging from 0,00 to 68.77 and 0,00 to 100.00 respectively. Finally, Reputation and Physical Risk Management also exhibit a high degree of variation ranging from 0,00 to 87,46 and 12,47 to 100,00 respectively.

**Table 29: Descriptive Statistics for the oil and gas sector (2012-2013)**

| N=55 | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| ROA | 0,07 | 0,04 | -0,04 | 0,13 |
| ROE | 0,44 | 0,14 | 0,10 | 0,70 |
| TOBIN | 1,42 | 0,24 | 0,94 | 2,02 |
| ORG_MGM | 57,62 | 12,25 | 33,21 | 76,78 |
| TECH_MGM | 32,04 | 18,03 | 0,00 | 68,77 |
| COMP_MGM | 51,67 | 23,32 | 0,00 | 100,00 |
| REG_RISK | 40,86 | 14,55 | 16,30 | 91,00 |
| REP_RISK | 44,64 | 25,93 | 0,00 | 87,46 |
| PHYS_RISK | 51,60 | 20,58 | 12,47 | 100,00 |
| ACC_REP | 76,90 | 12,79 | 35,64 | 100,00 |
| ADV_ACC | 58,47 | 23,54 | 34,60 | 100,00 |
| CARB_RED | 0,011 | 0,121 | -0,307 | 0,537 |
| SIZE | 10,98 | 0,87 | 9,71 | 12,78 |
| LEV | 0,20 | 0,11 | 0,02 | 0,54 |
| CAP_INT | 0,71 | 0,38 | 0,14 | 1,51 |

The Pearson's correlation matrix for the regression variable is presented in Table 31 It is worth mentioning that the correlations between carbon reductions and ROE and Tobin's q are very high. Correlations are also very high for all financial performance indicators and organizational management strategies, carbon reduction strategies and climate change risk management corporate commitment indexes. On the other hand, there is no significant correlation between the carbon reductions and ROA and Carbon Compensation Strategies with the financial performance indicators.

*5.3.2.1.1.2 Regression Analysis*

In order to estimate the regression model, several statistical assumptions of the regression analysis were used. Regarding normality, we applied the Kolmogorov–Smirnov test which showed us that the variables generally follow a normal distribution (Table 30). However, for some of the variables that do not show normal distribution, according to Gallego-Alvarez (2012) and Lumley *et al.* (2002), the absence of a normal distribution does not reduce the validity of the model. In order to alleviate heteroscedasticity problems, we transformed some of our variables into a logarithm. Regarding autocorrelation, we conducted the Durbin-Watson's test. Our models exhibit values around 2 (Table 32, Table 34, Table 36 and Table 38) which reflects the absence of autocorrelation in the residuals. Finally, in the case of multicollinearity, the values obtained in tolerance have to be high (0< tolerance<1) and the values obtained in the variance-inflation factors (VIF) have to be low (VIF<10). Our model presents tolerances between 0,579 and 0,954, and VIFs between 1,069 and 1,330, indicating the absence of multicollinearity (Table 33, Table 35, Table 37, Table 38).

**Table 30: Kolmogorov-Smirnov Test for the oil and gas sector (2012-2013)**

| | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|
| ROA | 0,511 | 0,956 |
| ROE | 1,029 | 0,24 |
| TOBIN | 0,764 | 0,603 |
| ORG_MGM | 1,211 | 0,106 |
| TECH_MGM | 1,721 | 0,005 |
| COMP_MGM | 1,398 | 0,04 |
| REG_RISK | 1,019 | 0,25 |
| REP_RISK | 1,389 | 0,042 |
| PHYS_RISK | 1,148 | 0,143 |
| ACC_REP | 1,924 | 0,001 |
| ADV_ACC | 2,084 | 0,000 |
| CARB_RED | 0,798 | 0,547 |

a. Test distribution is Normal.

b. Calculated from data.

**Table 31: Correlations for the oil and gas sector for the years 2012-2013**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ROA | 1,000 | | | | | | | | | | | | | | |
| 2 | ROE | ,569** | 1,000 | | | | | | | | | | | | | |
| 3 | TOBIN | ,492** | ,399** | 1,000 | | | | | | | | | | | | |
| 4 | ORG_MGM | ,503** | ,480** | ,507** | 1,000 | | | | | | | | | | | |
| 5 | TECH_MGM | ,566** | ,435** | ,506** | ,430** | 1,000 | | | | | | | | | | |
| 6 | COMP_MGM | -0,010 | 0,013 | 0,087 | ,320* | -0,042 | 1,000 | | | | | | | | | |
| 7 | REG_RISK | ,423** | ,412** | ,407** | ,481** | ,499** | 0,115 | 1,000 | | | | | | | | |
| 8 | REP_RISK | ,690** | ,434** | ,560** | ,460** | ,438** | 0,233 | ,283* | 1,000 | | | | | | | |
| 9 | PHYS_RISK | ,467** | 0,249 | ,365** | ,284* | ,309* | 0,012 | ,407** | ,317* | 1,000 | | | | | | |
| 10 | ACC_REP | ,323* | ,332* | ,459** | ,651** | ,321* | ,603** | ,349** | ,388** | ,359** | 1,000 | | | | | |
| 11 | ADV_ACC | ,355** | 0,161 | 0,256 | ,307* | 0,124 | 0,068 | 0,036 | 0,254 | 0,017 | 0,093 | 1,000 | | | | |
| 12 | CARB_RED | 0,178 | ,346** | ,557** | 0,198 | 0,260 | 0,117 | 0,218 | ,343* | 0,221 | ,290* | 0,081 | 1,000 | | | |
| 13 | SIZE | -0,080 | -,315* | 0,000 | 0,002 | -0,041 | ,416** | -0,120 | 0,081 | -0,010 | 0,257 | 0,153 | 0,123 | 1,000 | | |
| 14 | LEV | -,547** | -,445** | -0,069 | -0,219 | -,346** | 0,127 | -,308* | -,301* | -0,166 | -0,048 | -0,149 | -0,105 | 0,088 | 1,000 | |
| 15 | CAP_INT | ,424** | 0,170 | 0,199 | 0,201 | 0,204 | 0,170 | 0,233 | 0,176 | 0,181 | ,344* | ,315* | 0,056 | ,284* | -,362** | 1,000 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**Table 32: Strategy Regression statistics for the oil and gas sector (2012-2013)**

| | Model S1 | Model S2 | Model S3 | Model S4 | Model S5 | Model S6 | Model S7 | Model S8 | Model S9 | Model S10 | Model S11 | Model S12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| ORG_MGM | 0,376*** | | | 0,264** | 0,408*** | | | 0,293** | 0,500*** | | | 0,401*** |
| TECH_MGM | | 0,399*** | | 0,293*** | | 0,305** | | 0,188* | | 0,528*** | | 0,378*** |
| COMP_MGM | | | 0,146 | 0,010 | | | 0,212 | 0,108 | | | 0,098 | -0,102 |
| SIZE | -0,163 | -0,126 | -0,196 | -0,139 | -0,242* | -0,213** | -0,407*** | -0,283** | -0,119 | -0,069 | -0,139 | -0,060 |
| LEV | -0,359*** | -0,304*** | -0,438*** | -0,292*** | -0,329*** | -0,308** | -0,400*** | -0,327*** | 0,109 | 0,182 | 0,015 | 0,215 |
| CAP_INT | 0,301** | 0,296** | 0,328** | 0,273** | 0,091 | 0,104 | 0,107 | 0,045 | 0,198 | 0,192 | 0,250 | 0,176 |
| R Square | 0,509 | 0,515 | 0,395 | 0,573 | 0,396 | 0,320 | 0,323 | 0,467 | 0,283 | 0,292 | 0,058 | 0,402 |
| F | 12,971*** | 13,266*** | 8,171*** | 10,726*** | 8,190*** | 5,893*** | 6,993*** | 7,018*** | 4,936*** | 5,155*** | ,766 | 5,374*** |
| Durbin -Watson | 2,213 | 2,164 | 2,116 | 2,199 | 2,235 | 2,148 | 2,118 | 2,202 | 1,848 | 1,874 | 1,797 | 1,899 |

*p<0.10 **p<0.05 ***p<0.01

**Table 33: Strategy Multicollinearity Diagnostics for the oil and gas sector (2012-2013)**

| | MODEL S1 | | MODEL S2 | | MODEL S3 | | MODEL S4 | | MODEL S5 | | MODEL S6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | 0,935 | 1,069 | | | | | 0,667 | 1,5 | 0,935 | 1,069 | | |
| TECH_MGM | | | 0,868 | 1,153 | | | 0,736 | 1,359 | | | 0,868 | 1,153 |
| COMP_MGM | | | | | 0,879 | 1,137 | 0,729 | 1,372 | | | | |
| SIZE | 0,715 | 1,399 | 0,71 | 1,408 | 0,684 | 1,461 | 0,676 | 1,48 | 0,715 | 1,399 | 0,71 | 1,408 |
| LEV | 0,816 | 1,225 | 0,771 | 1,296 | 0,829 | 1,206 | 0,752 | 1,33 | 0,816 | 1,225 | 0,771 | 1,296 |
| CAP_INT | 0,614 | 1,628 | 0,613 | 1,631 | 0,61 | 1,64 | 0,602 | 1,66 | 0,614 | 1,628 | 0,613 | 1,631 |
| | MODEL S7 | | MODEL S8 | | MODEL S9 | | MODEL S10 | | MODEL S11 | | MODEL S12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | | | 0,667 | 1,5 | 0,935 | 1,069 | | | | | 0,667 | 1,5 |
| TECH_MGM | | | 0,736 | 1,359 | | | 0,868 | 1,153 | | | 0,736 | 1,359 |
| COMP_MGM | 0,879 | 1,137 | 0,729 | 1,372 | | | | | 0,879 | 1,137 | 0,729 | 1,372 |
| SIZE | 0,684 | 1,461 | 0,676 | 1,48 | 0,715 | 1,399 | 0,71 | 1,408 | 0,684 | 1,461 | 0,676 | 1,48 |
| LEV | 0,829 | 1,206 | 0,752 | 1,33 | 0,816 | 1,225 | 0,771 | 1,296 | 0,829 | 1,206 | 0,752 | 1,33 |
| CAP_INT | 0,61 | 1,64 | 0,602 | 1,66 | 0,614 | 1,628 | 0,613 | 1,631 | 0,61 | 1,64 | 0,602 | 1,66 |

**Table 34: Risk Management Regression statistics for the oil and gas sector (2012-2013)**

| | Model R1 | Model R2 | Model R3 | Model R4 | Model R5 | Model R6 | Model R7 | Model R8 | Model R9 | Model R10 | Model R11 | Model R12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| REG_RISK | 0,234* | | | 0,042 | 0,280** | | | 0,205 | 0,400*** | | | 0,241* |
| REP_RISK | | 0,580*** | | 0,512*** | | 0,354*** | | 0,304** | | 0,596*** | | 0,510*** |
| PHYS_RISK | | | 0,355*** | 0,200** | | | 0,174 | 0,018 | | | 0,340** | 0,117 |
| SIZE | -0,120 | -0,222** | -0,143 | -0,197** | -0,190 | -0,277** | -0,232 | -0,235* | -0,045 | -0,179 | -0,099 | -0,121 |
| LEV | -0,370*** | -0,254*** | -0,385*** | -0,243*** | -0,335** | -0,295** | -0,380*** | -0,261** | 0,115 | 0,199 | 0,061 | 0,240* |
| CAP_INT | 0,296** | 0,343*** | 0,293** | 0,300*** | 0,080 | 0,141 | 0,118 | 0,090 | 0,170 | 0,256* | 0,210 | 0,181 |
| R Square | 0,424 | 0,679 | 0,497 | 0,720 | 0,308 | 0,353 | 0,268 | 0,390 | 0,188 | 0,368 | 0,160 | 0,444 |
| F | 9,203*** | 26,398*** | 12,360*** | 20,573*** | 5,563*** | 6,806*** | 4,586*** | 5,107*** | 2,896** | 7,292*** | 2,380* | 6,384*** |
| Durbin - Watson | 2,389 | 2,431 | 2,401 | 2,587 | 2,207 | 2,154 | 2,118 | 2,215 | 1,600 | 1,866 | 1,697 | 1,846 |

*p<0.10 **p<0.05 ***p<0.01

**Table 35: Risk Management Multicollinearity Diagnostics oil and gas sector (2012-2013)**

| | MODEL R1 | | MODEL R2 | | MODEL R3 | | MODEL R4 | | MODEL R5 | | MODEL R6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | ,874 | 1,145 | | | | | ,662 | 1,511 | ,874 | 1,145 | | |
| REP_RISK | | | ,771 | 1,296 | | | ,570 | 1,754 | | | ,771 | 1,296 |
| PHYS_RISK | | | | | ,869 | 1,150 | ,520 | 1,925 | | | | |
| SIZE | ,876 | 1,142 | ,861 | 1,162 | ,848 | 1,179 | ,828 | 1,207 | ,876 | 1,142 | ,861 | 1,162 |
| LEV | ,837 | 1,195 | ,856 | 1,168 | ,851 | 1,175 | ,837 | 1,195 | ,837 | 1,195 | ,856 | 1,168 |
| CAP_INT | ,763 | 1,311 | ,657 | 1,522 | ,756 | 1,323 | ,650 | 1,539 | ,763 | 1,311 | ,657 | 1,522 |
| | MODEL R7 | | MODEL R8 | | MODEL R9 | | MODEL R10 | | MODEL R11 | | MODEL R12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | | | ,736 | 1,358 | ,874 | 1,145 | | | | | ,662 | 1,511 |
| REP_RISK | | | ,811 | 1,233 | | | ,771 | 1,296 | | | ,570 | 1,754 |
| PHYS_RISK | ,869 | 1,150 | ,785 | 1,274 | | | | | ,869 | 1,150 | ,520 | 1,925 |
| SIZE | ,848 | 1,179 | ,685 | 1,460 | ,876 | 1,142 | ,861 | 1,162 | ,848 | 1,179 | ,828 | 1,207 |
| LEV | ,851 | 1,175 | ,756 | 1,323 | ,837 | 1,195 | ,856 | 1,168 | ,851 | 1,175 | ,837 | 1,195 |
| CAP_INT | ,756 | 1,323 | ,593 | 1,685 | ,763 | 1,311 | ,657 | 1,522 | ,756 | 1,323 | ,650 | 1,539 |

**Table 36: Carbon Accounting Regression statistics for the oil and gas sector (2012-2013)**

| | Model A1 | Model A2 | Model A3 | Model A4 | Model A5 | Model A6 | Model A7 | Model A8 | Model A9 |
|---|---|---|---|---|---|---|---|---|---|
| | | ROA | | | ROE | | | TOBIN | |
| ACC_REP | 0,273** | | 0,277** | 0,397*** | | 0,396*** | 0,475*** | | 0,472*** |
| ADV_ACC | | 0,240** | 0,247** | | 0,229* | 0,227* | | 0,455*** | 0,452*** |
| SIZE | -0,21 | -0,265** | -0,313** | -0,311** | -0,307** | -0,378*** | -0,201* | -0,249* | -0,333** |
| LEV | -0,438*** | -0,376*** | -0,392*** | -0,421*** | -0,368*** | -0,391*** | -0,002 | 0,085 | 0,058 |
| CAP_INT | 0,278** | 0,294** | 0,221* | 0,038 | 0,109 | 0,001 | 0,137 | 0,192 | 0,063 |
| | | | | | | | | | |
| R Square | 0,44 | 0,478 | 0,54 | 0,374 | 0,282 | 0,416 | 0,242 | 0,216 | 0,407 |
| F | 9,822*** | 11,444*** | 11,524*** | 7,473*** | 4,912*** | 6,971*** | 3,989*** | 3,445** | 6,712*** |
| Durbin - Watson | 2,37 | 2,41 | 2,248 | 2,184 | 2,214 | 2,151 | 1,866 | 1,876 | 1,914 |

*p<0.10 **p<0.05 ***p<0.01

**Table 37: Carbon Accounting MulticollinearityDiagnostics oil and gas sector(2012-2013)**

| | MODEL A1 | | MODEL A2 | | MODEL A3 | | MODEL A4 | | MODEL A5 | | MODEL A6 | | MODEL A7 | | MODEL A8 | | MODEL A9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ACC_REP | ,851 | 1,174 | | | ,851 | 1,174 | ,851 | 1,174 | | | ,851 | 1,174 | ,851 | 1,174 | | | ,851 | 1,174 |
| ADV_ACC | | | ,804 | 1,244 | ,804 | 1,244 | | | ,804 | 1,244 | ,804 | 1,244 | | | ,804 | 1,244 | ,804 | 1,244 |
| SIZE | ,696 | 1,437 | ,664 | 1,505 | ,648 | 1,542 | ,696 | 1,437 | ,664 | 1,505 | ,648 | 1,542 | ,696 | 1,437 | ,664 | 1,505 | ,648 | 1,542 |
| LEV | ,834 | 1,198 | ,822 | 1,216 | ,820 | 1,220 | ,834 | 1,198 | ,822 | 1,216 | ,820 | 1,220 | ,834 | 1,198 | ,822 | 1,216 | ,820 | 1,220 |
| CAP_INT | ,590 | 1,696 | ,609 | 1,641 | ,579 | 1,728 | ,590 | 1,696 | ,609 | 1,641 | ,579 | 1,728 | ,590 | 1,696 | ,609 | 1,641 | ,579 | 1,728 |

**Table 38: Carbon Reductions Regression statistics for the oil and gas sector (2012-2013)**

| | ROA | | | ROE | | | TOBIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | MODEL C1 | | | MODEL C2 | | | MODEL C3 | | |
| | | Tolerance | VIF | | Tolerance | VIF | | Tolerance | VIF |
| CARB_RED | 0,135 | 0,971 | 1,03 | 0,349*** | 0,971 | 1,03 | 0,571*** | 0,971 | 1,03 |
| SIZE | -0,149 | 0,862 | 1,161 | -0,367*** | 0,862 | 1,161 | -0,146 | 0,862 | 1,161 |
| LEV | -0,406*** | 0,818 | 1,223 | -0,327*** | 0,818 | 1,223 | 0,091 | 0,818 | 1,223 |
| CAP_INT | 0,312** | 0,768 | 1,302 | 0,136 | 0,768 | 1,302 | 0,241* | 0,768 | 1,302 |
| R Square | 0,391 | | | 0,405 | | | 0,36 | | |
| F | 8,0155*** | | | 8,521*** | | | 7,035*** | | |
| Durbin -Watson | 2,222 | | | 2,313 | | | 1,949 | | |

*p<0.10 **p<0.05 ***p<0.01

Regarding the explanatory power of our models, the $R^2$ have values ranging from 0,283 to 0,515 for a confidence level of 99% ($p < 0.01$). The explanatory power of our models is similar to other studies. Specifically, Lannelonge *et al*. (2015), Gallego-Alvarez *et al*. (2012), and Busch and Hoffman (2011), obtain values between 0.16 and 0,43 for the $R^2$ while Wang *et al.* (2014), Nishitani and Kokubu (2012) and Nakao *et al*. (2007) obtain $R^2$ values of 0,411, 0,104 and 0,411 respectively.

The results obtained from the estimation of our proposed models using the ordinary least squares methodology are presented in Table 32, Table 34, Table 36 and Table 38. The models estimated determine the relationship between financial performance, climate change strategy, climate change risk management, carbon accounting and GHG reduction of business activities. Specifically, a positive but no significant relationship was found between carbon reductions and ROA while a positive and significant relationship is found between ROE and Tobin's Q. This allows as to partly accept hypotheses $H_4$. Moreover, a positive and significant relationship is detected between organizational management strategies, carbon reduction technology strategies and financial performance measured by both ROA, ROE and Tobin's q while a positive but no significant relationship is observed between carbon compensation strategies and the financial performance measures. This result causes us to accept hypotheses $H_{1a}$ and $H_{1b}$ and to reject hypothesis $H_{1c}$.

Regarding the relationship between corporate commitment in climate change risk management, a positive and significant relationship is detected between all the risk management indexes and the financial performance measures, with the exception of physical risk management and ROE, where no significant relationship is detected. Furthermore, the strongest relationship is detected between reputation risk management and financial performance. Additionally, all risk management indexes have the strongest connection to the Tobin's Q index. Based on the above, we accept hypotheses $H_{2a}$ and $H_{2b}$ and partly accept hypothesis $H_{2c}$. Finally, regarding the carbon accounting indexes, they are positively and significantly related to the financial performance indexes, with the strongest relationship detected between the Tobin's Q index. This causes as to accept both hypotheses $H_{3a}$ and $H_{3b}$.

*5.3.2.1.2 Results and Analysis for the years 2014-2015*

*5.3.2.1.2.1 Descriptive Statistics and Bivariate Results*

Table 39 presents the descriptive statistics of the depended and independent variables. The minimum, maximum, mean and standard deviation values are reported. As we can see, the companies issue an average of 56,90 out of the 100 regarding the level of organizational management corporate commitment and 31,90 regarding carbon reduction technology management. Moreover, a high variation is depicted for carbon reduction, carbon compensation management strategies and advanced carbon accounting practices ranging from 0,00 to 85,18 , 0,00 to 100.00 and 34,6 to 100,00 respectively. Reputation and Physical Risk Management also exhibit a high degree of variation ranging from 0,00 to 86,78 and 00,00 to 100,00 respectively.

**Table 39: Descriptive Statistics for the oil and gas sector (2014-2015)**

| N=55 | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| ROA | ,05 | ,05 | -,08 | ,19 |
| ROE | ,41 | ,16 | ,10 | ,67 |
| TOBIN | 1,36 | ,27 | ,89 | 2,10 |
| ORG_MGM | 56,90 | 12,88 | 33,21 | 76,78 |
| TECH_MGM | 31,90 | 19,16 | ,00 | 85,18 |
| COMP_MGM | 51,13 | 33,58 | ,00 | 100,00 |
| REG_RISK | 42,75 | 17,11 | ,00 | 90,21 |
| REP_RISK | 37,32 | 26,80 | ,00 | 86,78 |
| PHYS_RISK | 53,17 | 27,44 | ,00 | 100,00 |
| ACC_REP | 71,04 | 15,79 | 16,37 | 100,00 |
| ADV_ACC | 58,90 | 21,76 | 34,60 | 100,00 |
| CARB_RED | ,04 | ,13 | -,19 | ,43 |
| SIZE | 11,19 | ,88 | 9,89 | 12,97 |
| LEV | ,21 | ,09 | ,00 | ,48 |
| CAP_INT | ,64 | ,31 | ,16 | 1,36 |

The Pearson's correlation matrix for the regression variable is presented in Table 40 It is worth mentioning that the correlations between carbon reduction and Tobin's q are very high. Correlations are also very high for organizational management strategies, ROA and ROE and for carbon technology reduction strategies and Tobin's q. Regarding the climate change risk management indexes, the highest correlations are detected between physical risk management, ROA and Tobin' q while there is also a strong correlation between core business accounting and reporting and ROA.

**Table 40: Correlations for the oil and gas sector for the years 2014-2015**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ROA | 1 | | | | | | | | | | | | | | |
| 2 | ROE | ,704** | 1 | | | | | | | | | | | | | |
| 3 | TOBIN | ,773** | ,547** | 1 | | | | | | | | | | | | |
| 4 | ORG_MGM | ,678** | ,633** | ,571** | 1 | | | | | | | | | | | |
| 5 | TECH_MGM | ,541** | ,495** | ,626** | ,420** | 1 | | | | | | | | | | |
| 6 | COMP_MGM | ,534** | ,435** | ,399** | ,415** | ,271* | 1 | | | | | | | | | |
| 7 | REG_RISK | ,512** | ,563** | ,582** | ,463** | ,459** | ,367** | 1 | | | | | | | | |
| 8 | REP_RISK | ,580** | ,588** | ,567** | ,553** | ,379** | ,373** | ,361** | 1 | | | | | | | |
| 9 | PHYS_RISK | ,623** | ,500** | ,624** | ,597** | ,350** | ,377** | ,554** | ,575** | 1 | | | | | | |
| 10 | ACC_REP | ,677** | ,599** | ,584** | ,611** | ,594** | ,274* | ,511** | ,462** | ,501** | 1 | | | | | |
| 11 | ADV_ACC | ,395** | ,398** | ,366** | ,435** | ,334* | ,323* | ,274* | ,379** | ,331* | ,233 | 1 | | | | |
| 12 | CARB_RED | ,546** | ,583** | ,618** | ,356** | ,390** | ,342* | ,410** | ,501** | ,480** | ,386** | ,280* | 1 | | | |
| 13 | SIZE | -,341* | -,311* | -,330* | -,108 | -,102 | ,007 | -,158 | -,120 | -,217 | -,203 | ,159 | -,129 | 1 | | |
| 14 | LEV | -,443** | -,525** | -,227 | -,407** | -,215 | -,219 | -,244 | -,218 | -,186 | -,399** | -,391** | -,202 | -,003 | 1 | |
| 15 | CAP_INT | ,395** | ,504** | ,269* | ,463** | ,328* | ,314* | ,228 | ,412** | ,208 | ,354** | ,278* | ,300* | ,265 | -,363** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*5.3.2.1.2.2 Regression Analysis*

In order to estimate the regression model, several statistical assumptions of the regression analysis were used. Regarding normality, we applied the Kolmogorov–Smirnov test which showed us that the variables generally follow a normal distribution (Table 41). However, for some of the variables that do not show normal distribution, according to Gallego-Alvarez (2012) and Lumley *et al.* (2002), the absence of a normal distribution does not reduce the validity of the model. In order to alleviate heteroscedasticity problems, we transformed some of our variables into a logarithm. Regarding autocorrelation, we conducted the Durbin-Watson's test. Our models exhibit values around 2 (Table 42, Table 44, Table 46 and Table 48), which reflects the absence of autocorrelation in the residuals. Finally, in the case of multicollinearity, the values obtained in tolerance have to be high (0< tolerance<1) and the values obtained in the variance-inflation factors (VIF) have to be low (VIF<10). Our model presents tolerances between 0,674 and 0,915, and VIFs between 1,092 and 1,527, indicating the absence of multicollinearity(Table 43, Table 45, Table 47, Table 48).

**Table 41: Kolmogorov-Smirnov Test for the oil and gas sector (2014-2015)**

| | **Kolmogorov-Smirnov Z** | **Asymp. Sig. (2-tailed)** |
|---|---|---|
| ROA | 0,844 | 0,474 |
| ROE | 0,814 | 0,521 |
| TOBIN | 0,734 | 0,653 |
| ORG_MGM | 0,936 | 0,344 |
| TECH_MGM | 1,318 | 0,062 |
| COMP_MGM | 1,074 | 0,199 |
| REG_RISK | 1,109 | 0,171 |
| REP_RISK | 1,004 | 0,266 |
| PHYS_RISK | 1,081 | 0,193 |
| ACC_REP | 1,88 | 0,002 |
| ADV_ACC | 1,888 | 0,002 |
| CARB_RED | 0,932 | 0,351 |

a. Test distribution is Normal.

b. Calculated from data.

**Table 42: Strategy Regression statistics for the oil and gas sector (2014-2015)**

| | Model S1 | Model S2 | Model S3 | Model S4 | Model S5 | Model S6 | Model S7 | Model S8 | Model S9 | Model S10 | Model S11 | Model S12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| ORG_MGM | 0,475*** | | | 0,315*** | 0,318*** | | | 0,215* | 0,482*** | | | 0,298** |
| TECH_MGM | | 0,351*** | | 0,230** | | 0,251** | | 0,174* | | 0,530*** | | 0,431*** |
| COMP_MGM | | | 0,390*** | 0,271* | | | 0,234*** | 0,151 | | | 0,308** | 0,161 |
| SIZE | -0,342*** | -0,380*** | -0,421*** | -0,314*** | -0,372*** | -0,394*** | -0,426*** | -0,350*** | -0,313** | -0,317*** | -0,399*** | -0,259*** |
| LEV | -0,177* | -0,265** | -0,252** | -0,165* | -0,265*** | -0,323*** | -0,319*** | -0,258*** | 0,017 | -0,057 | -0,069 | 0,028 |
| CAP_INT | 0,201* | 0,284** | 0,292*** | 0,111 | 0,358*** | 0,408*** | 0,427*** | 0,298*** | 0,134 | 0,159 | 0,252* | 0,017 |
| R Square | 0,598 | 0,550 | 0,580 | 0,709 | 0,637 | 0,623 | 0,618 | 0,684 | 0,411 | 0,492 | 0,338 | 0,589 |
| F | 18,200*** | 14,977*** | 16,897*** | 19,071*** | 21,526*** | 20,214*** | 19,783*** | 16,925*** | 8,538*** | 11,863*** | 6,253*** | 11,205*** |
| Durbin - Watson | 1,646 | 1,807 | 1,981 | 1,620 | 2,336 | 2,137 | 2,273 | 2,264 | 1,969 | 1,786 | 1,936 | 1,902 |

*p<0.10 **p<0.05 ***p<0.01

**Table 43: Strategy MulticollinearityDiagnostics oil and gas sector(2014-2015)**

| | MODEL S1 | | MODEL S2 | | MODEL S3 | | MODEL S4 | | MODEL S5 | | MODEL S6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | ,674 | 1,484 | | | | | ,583 | 1,715 | ,674 | 1,484 | | |
| TECH_MGM | | | ,847 | 1,180 | | | ,780 | 1,282 | | | ,847 | 1,180 |
| COMP_MGM | | | | | ,884 | 1,131 | ,801 | 1,249 | | | | |
| SIZE | ,862 | 1,161 | ,884 | 1,131 | ,915 | 1,092 | ,846 | 1,182 | ,862 | 1,161 | ,884 | 1,131 |
| LEV | ,794 | 1,259 | ,852 | 1,174 | ,848 | 1,179 | ,794 | 1,260 | ,794 | 1,259 | ,852 | 1,174 |
| CAP_INT | ,655 | 1,527 | ,717 | 1,394 | ,742 | 1,348 | ,622 | 1,607 | ,655 | 1,527 | ,717 | 1,394 |
| | MODEL S7 | | MODEL S8 | | MODEL S9 | | MODEL S10 | | MODEL S11 | | MODEL S12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | | | ,583 | 1,715 | ,674 | 1,484 | | | | | ,583 | 1,715 |
| TECH_MGM | | | ,780 | 1,282 | | | ,847 | 1,180 | | | ,780 | 1,282 |
| COMP_MGM | ,884 | 1,131 | ,801 | 1,249 | | | | | ,884 | 1,131 | ,801 | 1,249 |
| SIZE | ,915 | 1,092 | ,846 | 1,182 | ,862 | 1,161 | ,884 | 1,131 | ,915 | 1,092 | ,846 | 1,182 |
| LEV | ,848 | 1,179 | ,794 | 1,260 | ,794 | 1,259 | ,852 | 1,174 | ,848 | 1,179 | ,794 | 1,260 |
| CAP_INT | ,742 | 1,348 | ,622 | 1,607 | ,655 | 1,527 | ,717 | 1,394 | ,742 | 1,348 | ,622 | 1,607 |

**Table 44: Risk Management Regression statistics for the oil and gas sector (2014-2015)**

| | Model R1 | Model R2 | Model R3 | Model R4 | Model R5 | Model R6 | Model R7 | Model R8 | Model R9 | Model R10 | Model R11 | Model R12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| REG_RISK | 0,315*** | | | 0,128 | 0,337*** | | | 0,268*** | 0,471*** | | | 0,292** |
| REP_RISK | | 0,330*** | | 0,190 | | 0,381*** | | 0,246** | | 0,457*** | | 0,245* |
| PHYS_RISK | | | 0,444*** | 0,289** | | | 0,272*** | 0,021 | | | 0,509*** | 0,247* |
| SIZE | -0,380*** | -0,357*** | -0,323*** | -0,293*** | -0,369*** | -0,363*** | -0,366*** | -0,318*** | -0,317*** | -0,310** | -0,276** | -0,227* |
| LEV | -0,245** | -0,276** | -0,254** | -0,238** | -0,291*** | -0,328*** | -0,319*** | -0,287*** | -0,027 | -0,079 | -0,054 | -0,019 |
| CAP_INT | 0,334*** | 0,231* | 0,295*** | 0,218** | 0,418*** | 0,344*** | 0,428*** | 0,316*** | 0,234* | 0,133 | 0,215* | 0,102 |
| R Square | 0,532 | 0,558 | 0,617 | 0,648 | 0,669 | 0,653 | 0,634 | 0,716 | 0,448 | 0,416 | 0,480 | 0,571 |
| F | 13,916*** | 15,435*** | 19,729*** | 14,446*** | 24,717*** | 23,070*** | 21,192*** | 19,773*** | 9,957*** | 8,712*** | 11,295*** | 10,405*** |
| Durbin - Watson | 1,947 | 1,895 | 1,846 | 1,956 | 2,025 | 2,223 | 1,994 | 1,995 | 1,761 | 1,949 | 2,013 | 1,954 |

*p<0.10 **p<0.05 ***p<0.01

**Table 45: Risk Management MulticollinearityDiagnostics oil and gas sector(2014-2015)**

| | MODEL R1 | | MODEL R2 | | MODEL R3 | | MODEL R4 | | MODEL R5 | | MODEL R6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | ,874 | 1,145 | | | | | ,662 | 1,511 | ,874 | 1,145 | | |
| REP_RISK | | | ,771 | 1,296 | | | ,570 | 1,754 | | | ,771 | 1,296 |
| PHYS_RISK | | | | | ,869 | 1,150 | ,520 | 1,925 | | | | |
| SIZE | ,876 | 1,142 | ,861 | 1,162 | ,848 | 1,179 | ,828 | 1,207 | ,876 | 1,142 | ,861 | 1,162 |
| LEV | ,837 | 1,195 | ,856 | 1,168 | ,851 | 1,175 | ,837 | 1,195 | ,837 | 1,195 | ,856 | 1,168 |
| CAP_INT | ,763 | 1,311 | ,657 | 1,522 | ,756 | 1,323 | ,650 | 1,539 | ,763 | 1,311 | ,657 | 1,522 |
| | MODEL R7 | | MODEL R8 | | MODEL R9 | | MODEL R10 | | MODEL R11 | | MODEL R12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | | | ,736 | 1,358 | ,874 | 1,145 | | | | | ,662 | 1,511 |
| REP_RISK | | | ,811 | 1,233 | | | ,771 | 1,296 | | | ,570 | 1,754 |
| PHYS_RISK | ,869 | 1,150 | ,785 | 1,274 | | | | | ,869 | 1,150 | ,520 | 1,925 |
| SIZE | ,848 | 1,179 | ,685 | 1,460 | ,876 | 1,142 | ,861 | 1,162 | ,848 | 1,179 | ,828 | 1,207 |
| LEV | ,851 | 1,175 | ,756 | 1,323 | ,837 | 1,195 | ,856 | 1,168 | ,851 | 1,175 | ,837 | 1,195 |
| CAP_INT | ,756 | 1,323 | ,593 | 1,685 | ,763 | 1,311 | ,657 | 1,522 | ,756 | 1,323 | ,650 | 1,539 |

**Table 46: Carbon Accounting Regression statistics for the oil and gas sector (2014-2015)**

| | Model A1 | Model A2 | Model A3 | Model A4 | Model A5 | Model A6 | Model A7 | Model A8 | Model A9 |
|---|---|---|---|---|---|---|---|---|---|
| | | ROA | | | ROE | | | TOBIN | |
| PHYS_RISK | | | | | | | | | |
| ACC_REP | 0,413*** | | 0,426*** | 0,274** | | 0,241** | 0,346*** | | 0,436*** |
| ADV_ACC | | 0,288*** | 0,306*** | | 0,271*** | 0,245*** | | 0,366*** | 0,324*** |
| SIZE | -0,406*** | -0,490*** | -0,449*** | -0,423*** | -0,482*** | -0,462*** | -0,384*** | -0,462*** | -0,427*** |
| LEV | -0,177* | -0,212* | -0,083 | -0,291*** | -0,266*** | -0,205** | -0,003 | -0,018 | 0,090 |
| CAP_INT | 0,309*** | 0,367*** | 0,265*** | 0,451*** | 0,459*** | 0,411*** | 0,261* | 0,302** | 0,216* |
| | | | | | | | | | |
| R Square | 0,584 | 0,515 | 0,662 | ,623 | 0,630 | 0,671 | 0,352 | 0,363 | 0,497 |
| F | 17,217*** | 12,988*** | 18,841*** | 18,235*** | 20,885*** | 18,890*** | 6,651*** | 5,916*** | 7,261*** |
| Durbin -Watson | 2,070 | 1,742 | 1,923 | 2,175 | 2,153 | 2,099 | 1,960 | 1,897 | 2,035 |

*p<0.10 **p<0.05 ***p<0.01

## Table 47: Carbon Accounting MulticollinearityDiagnostics oil and gas sector(2014-2015)

| | MODEL A1 | | MODEL A2 | | MODEL A3 | | MODEL A4 | | MODEL A5 | | MODEL A6 | | MODEL A7 | | MODEL A8 | | MODEL A9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ACC_REP | 0,815 | 1,227 | | | 0,814 | 1,229 | 0,815 | 1,227 | | | 0,814 | 1,229 | 0,815 | 1,227 | | | 0,814 | 1,229 |
| ADV_ACC | | | 0,835 | 1,197 | 0,834 | 1,199 | | | 0,835 | 1,197 | 0,834 | 1,199 | | | 0,835 | 1,197 | 0,834 | 1,199 |
| SIZE | 0,909 | 1,1 | 0,9 | 1,112 | 0,89 | 1,123 | 0,909 | 1,1 | 0,9 | 1,112 | 0,89 | 1,123 | 0,909 | 1,1 | 0,9 | 1,112 | 0,89 | 1,123 |
| LEV | 0,789 | 1,268 | 0,789 | 1,268 | 0,725 | 1,38 | 0,789 | 1,268 | 0,789 | 1,268 | 0,725 | 1,38 | 0,789 | 1,268 | 0,789 | 1,268 | 0,725 | 1,38 |
| CAP_INT | 0,758 | 1,319 | 0,785 | 1,274 | 0,744 | 1,344 | 0,758 | 1,319 | 0,785 | 1,274 | 0,744 | 1,344 | 0,758 | 1,319 | 0,785 | 1,274 | 0,744 | 1,344 |

## Table 48: Carbon Reductions Regression statistics for the oil and gas sector (2014-2015)

| | ROA | | | ROE | | | TOBIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | MODEL C1 | | | MODEL C2 | | | MODEL C3 | | |
| | | Tolerance | VIF | | Tolerance | VIF | | Tolerance | VIF |
| CARB_RED | 0,357*** | 0,857 | 1,166 | 0,358*** | 0,857 | 1,166 | 0,513*** | 0,857 | 1,166 |
| SIZE | -0,371*** | 0,876 | 1,141 | -0,365*** | 0,876 | 1,141 | -0,309*** | 0,876 | 1,141 |
| LEV | -0,267** | 0,853 | 1,173 | -0,315*** | 0,853 | 1,173 | -0,061 | 0,853 | 1,173 |
| CAP_INT | 0,289** | 0,726 | 1,377 | 0,378*** | 0,726 | 1,377 | 0,174 | 0,726 | 1,377 |
| R Square | 0,555 | | | 0,68 | | | 0,481 | | |
| F | 15,272*** | | | 25,976*** | | | 11,334 | | |
| Durbin -Watson | 1,99 | | | 1,97 | | | 1,84 | | |

*p<0.10 **p<0.05 ***p<0.01

Regarding the explanatory power of our models, the $R^2$ have values ranging from 0,338 to 0,680 for a confidence level of 99% ($p < 0.01$). The explanatory power of our models generally very high compared to other similar studies. For example, Lannelonge *et al*. (2015), Gallego-Alvarez (2012), and Busch and Hoffman (2011), obtain values between 0.16 and 0,43 for the $R^2$ while Wang et al. (2014), Nishitani and Kokubu (2012) and Nakao *et al*. (2007) obtain $R^2$ values of 0,411, 0,104 and 0,411 respectively.

The results obtained from the estimation of our proposed models using the ordinary least squares methodology are presented in Table 42, Table 44, Table 46 and Table 48. The models estimated determine the relationship between financial performance, climate change strategy, climate change risk management, carbon accounting and GHG reduction of business activities. Contrary to the results in the time period 2012-2013, a positive and significant relationship is found between carbon reductions and ROA while a positive and significant relationship is also detected between carbon reductions, ROE and Tobin's Q. This allows as to accept hypotheses $H_4$ . Moreover, a positive and significant relationship is detected between organizational management strategies, carbon reduction technology strategies and financial performance measured by both ROA, ROE and Tobin's q . In contrast to the previous time period a positive but significant relationship is observed between carbon compensation strategies and the financial performance measures. However, this relationship is much weaker compared to corporate commitment regarding organizational management and carbon reduction technology strategies. This result causes us to accept hypotheses $H_{1a}$ and $H_{1b}$ and to partly accept hypothesis $H_{1c}$.

Regarding the relationship between corporate commitment in climate change risk management, a positive and significant relationship is detected between all the risk management indexes and the financial performance measures. Physical risk management has the strongest influence related to the other risk management indexes in terms of ROA, while regulation and reputational risk management influence financial performance to a higher degree than physical risk management. Moreover, regarding Tobin's q all types of risk management contribute equally to enhanced financial performance. Based on the above, we accept all hypotheses $H_{2a}$ and $H_{2b}$ and $H_{2c}$. Finally, regarding the carbon accounting indexes, they are positively and significantly related to the financial performance indexes, with the strongest relationship detected for the Tobin's Q index. This allows as to accept both hypotheses $H_{3a}$ and $H_{3b}$.

5.3.2.2 Hypotheses Testing for the Banking Sector

In this section we are going to test our hypotheses for companies that operate in the banking sector. As we have discussed in previous section, data were taken for the years 2012-2015. In analyzing our data, we are also going to separate our initial sample into two different samples, as we did with the oil and gas companies. Therefore, the first sample will include data for the years 2012-2013 and the other for the years 2014-2015.

*5.3.2.2.1 Results and Analysis for the years 2012-2013*

*5.3.2.2.1.1 Descriptive Statistics and Bivariate Results*

Table 49 presents the descriptive statistics of the depended and independent variables. The minimum, maximum, mean and standard deviation values are reported. As we can see, the companies issue an average of 55,68 out of the 100 regarding the level of organizational management corporate commitment and 13,62 regarding carbon reduction technology management. Moreover, a very high mean average value is observed for core business carbon accounting and reporting. Additionally, a high variation is depicted for carbon compensation management strategies and advance carbon accounting practices ranging from 0,00 to 100.00.

**Table 49: Descriptive Statistics for the banking sector (2012-2013)**

| N=81 | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| ROA | 0,00 | 0,00 | -0,01 | 0,02 |
| ROE | 0,06 | 0,02 | 0,02 | 0,13 |
| TOBIN | 0,98 | 0,05 | 0,86 | 1,10 |
| ORG_MGM | 55,68 | 13,55 | 24,10 | 83,60 |
| TECH_MGM | 13,62 | 6,89 | 0,00 | 31,70 |
| COMP_MGM | 29,38 | 24,24 | 0,00 | 100,00 |
| REG_RISK | 27,40 | 15,17 | 0,00 | 66,20 |
| REP_RISK | 32,41 | 15,20 | 0,00 | 86,20 |
| PHYS_RISK | 42,84 | 21,98 | 0,00 | 85,70 |
| ACC_REP | 80,69 | 15,68 | 26,70 | 100,00 |
| ADV_ACC | 43,88 | 21,68 | 0,00 | 100,00 |
| CARB_RED | 0,05 | 0,09 | -0,22 | 0,33 |
| SIZE | 13,75 | 0,72 | 12,50 | 14,84 |
| LEV | 0,25 | 0,12 | 0,01 | 0,49 |
| CAP_INT | 0,04 | 0,02 | 0,01 | 0,07 |

The Pearson's correlation matrix for the regression variable is presented in Table 51 As we can observe, correlations between carbon reductions the financial performance indexes are not very high, while there is a very high correlation between the risk management indexes and the financial performance indexes. Furthermore, it is worth mentioning that among the climate change strategy indexes, the highest correlations are detected between organizational management and ROA and carbon reduction technology strategies and Tobin's q. Finally, high correlations are detected between both carbon accounting indexes and ROA and Tobin's q. On the other hand, no significant correlations are detected  between the carbon accounting indexes and ROE.

*5.3.2.2.1.2 Regression Analysis*

In order to estimate the regression model, several statistical assumptions of the regression analysis were used. Regarding normality, we applied the Kolmogorov–Smirnov test which showed us that the variables generally follow a normal distribution (Table50). However, for some of the variables that do not show normal distribution, according to Gallego-Alvarez (2012) and Lumley *et al*. (2002), the absence of a normal distribution does not reduce the validity of the model. Regarding autocorrelation, we conducted the Durbin-Watson's test. Our models exhibit values around 2 (Table 52, Table 54, Table 56, Table 58), which reflects the absence of autocorrelation in the residuals. Finally, in the case of multicollinearity, the values obtained in tolerance have to be high (0< tolerance<1) and the values obtained in the variance-inflation factors (VIF) have to be low (VIF<10). Our model presents tolerances between 0,549 and 0,932, and VIFs between 1,051 and 1,823, indicating the absence of multicollinearity(Table 53, Table 55, Table 57, Table 58).

**Table 50: Kolmogorov-Smirnov Test for the banking sector (2012-2013)**

| | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|
| ROA | 0,634 | 0,817 |
| ROE | 1,228 | 0,098 |
| TOBIN | 1,04 | 0,23 |
| ORG_MGM | 1,789 | 0,003 |
| TECH_MGM | 3,925 | 0 |
| COMP_MGM | 2,139 | 0 |
| REG_RISK | 1,021 | 0,248 |
| REP_RISK | 2,076 | 0 |
| PHYS_RISK | 1,793 | 0,003 |
| ACC_REP | 1,871 | 0,002 |
| ADV_ACC | 2,88 | 0 |
| CARB_RED | 0,715 | 0,685 |
| SIZE | 0,911 | 0,378 |
| LEV | 0,528 | 0,943 |
| CAP_INT | 1,142 | 0,147 |

a. Test distribution is Normal.

b. Calculated from data.

**Table 51: Correlations for the banking sector for the years 2012-2013**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ROA | 1,000 | | | | | | | | | | | | | | |
| 2 | ROE | ,562** | 1,000 | | | | | | | | | | | | | |
| 3 | TOBIN | ,543** | ,397** | 1,000 | | | | | | | | | | | | |
| 4 | ORG_MGM | ,404** | ,352** | ,354** | 1,000 | | | | | | | | | | | |
| 5 | TECH_MGM | ,377** | ,359** | ,442** | ,373** | 1,000 | | | | | | | | | | |
| 6 | COMP_MGM | ,307** | ,354** | 0,204 | 0,097 | 0,074 | 1,000 | | | | | | | | | |
| 7 | REG_RISK | ,513** | ,562** | ,254* | ,502** | ,420** | ,366** | 1,000 | | | | | | | | |
| 8 | REP_RISK | ,433** | ,431** | ,470** | ,315** | ,236* | 0,125 | ,338** | 1,000 | | | | | | | |
| 9 | PHYS_RISK | ,644** | ,525** | ,502** | ,526** | ,338** | ,265* | ,530** | ,356** | 1,000 | | | | | | |
| 10 | ACC_REP | ,346** | 0,198 | ,415** | ,383** | ,226* | 0,111 | 0,207 | 0,208 | ,310** | 1,000 | | | | | |
| 11 | ADV_ACC | ,333** | 0,104 | ,251* | ,491** | 0,151 | 0,146 | ,261* | ,317** | ,361** | ,346** | 1,000 | | | | |
| 12 | CARB_RED | ,232* | 0,072 | ,253* | 0,040 | 0,112 | 0,126 | 0,165 | 0,065 | 0,128 | -0,068 | 0,093 | 1,000 | | | |
| 13 | SIZE | -,426** | -0,130 | -0,162 | 0,020 | -0,018 | 0,216 | 0,081 | 0,004 | -,300** | -0,104 | -0,029 | 0,030 | 1,000 | | |
| 14 | LEV | -,313** | -,258* | -,404** | 0,017 | -0,007 | -0,097 | 0,036 | -,262* | -0,193 | -0,172 | -0,128 | 0,056 | 0,096 | 1,000 | |
| 15 | CAP_INT | ,524** | ,598** | ,282* | ,316** | 0,209 | 0,191 | ,315** | ,292** | ,392** | 0,211 | ,257* | 0,207 | -,341** | -,234* | 1,000 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**Table 52: Strategy Regression statistics for the banking sector (2012-2013)**

| | Model S1 | Model S2 | Model S3 | Model S4 | Model S5 | Model S6 | Model S7 | Model S8 | Model S9 | Model S10 | Model S11 | Model S12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| ORG_MGM | 0,333*** | | | 0,270*** | 0,186* | | | 0,117 | 0,350*** | | | 0,241** |
| TECH_MGM | | 0,305*** | | 0,226*** | | 0,247*** | | 0,210** | | 0,367*** | | 0,251*** |
| COMP_MGM | | | 0,249** | 0,268*** | | | 0,240** | 0,236** | | | 0,187* | 0,207** |
| SIZE | -0,323*** | -0,293*** | -0,373*** | -0,432*** | 0,058 | 0,070 | 0,090 | 0,076 | -0,117 | -0,092 | -0,140 | -0,203 |
| LEV | -0,227** | -0,209** | -0,205** | -0,241*** | -0,143 | -0,136 | -0,123 | -0,144 | -0,389*** | -0,375*** | -0,363*** | -0,402*** |
| CAP_INT | 0,255** | 0,310*** | 0,360*** | 0,199** | 0,524*** | 0,538*** | 0,602*** | 0,507*** | 0,039 | 0,074 | 0,157 | -0,022 |
| CARB_RED | | | | | | | | | | | | |
| R Square | 0,477 | 0,469 | 0,434 | 0,583 | 0,409 | 0,436 | 0,429 | 0,495 | 0,312 | 0,374 | 0,235 | 0,454 |
| F | 17,356*** | 16,777*** | 14,577*** | 17,222*** | 13,144*** | 14,701*** | 14,258*** | 12,090 | 8,602*** | 11,372*** | 5,830*** | 10,234*** |
| Durbin -Watson | 2,148 | 2,117 | 1,986 | 2,186 | 2,075 | 2,021 | 1,910 | 1,976 | 1,986 | 2,199 | 2,197 | 2,144 |

*p<0.10 **p<0.05 ***p<0.01

**Table 53: Strategy Multicollinearity Diagnostics the banking sector (2012-2013)**

| | MODEL S1 | | MODEL S2 | | MODEL S3 | | MODEL S4 | | MODEL S5 | | MODEL S6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | ,873 | 1,145 | | | | | ,780 | 1,282 | ,873 | 1,145 | | |
| TECH_MGM | | | ,951 | 1,051 | | | ,851 | 1,175 | | | ,951 | 1,051 |
| COMP_MGM | | | | | ,884 | 1,131 | ,859 | 1,164 | | | | |
| SIZE | ,866 | 1,155 | ,881 | 1,136 | ,764 | 1,309 | ,747 | 1,339 | ,866 | 1,155 | ,881 | 1,136 |
| LEV | ,936 | 1,069 | ,943 | 1,061 | ,943 | 1,060 | ,934 | 1,071 | ,936 | 1,069 | ,943 | 1,061 |
| CAP_INT | ,736 | 1,358 | ,802 | 1,247 | ,835 | 1,197 | ,721 | 1,387 | ,736 | 1,358 | ,802 | 1,247 |
| | MODEL S7 | | MODEL S8 | | MODEL S9 | | MODEL S10 | | MODEL S11 | | MODEL S12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | | | ,780 | 1,282 | ,873 | 1,145 | | | | | ,780 | 1,282 |
| TECH_MGM | | | ,851 | 1,175 | | | ,951 | 1,051 | | | ,851 | 1,175 |
| COMP_MGM | ,861 | 1,161 | ,859 | 1,164 | | | | | ,861 | 1,161 | ,859 | 1,164 |
| SIZE | ,764 | 1,309 | ,747 | 1,339 | ,866 | 1,155 | ,881 | 1,136 | ,764 | 1,309 | ,747 | 1,339 |
| LEV | ,943 | 1,060 | ,934 | 1,071 | ,936 | 1,069 | ,943 | 1,061 | ,943 | 1,060 | ,934 | 1,071 |
| CAP_INT | ,835 | 1,197 | ,721 | 1,387 | ,736 | 1,358 | ,802 | 1,247 | ,835 | 1,197 | ,721 | 1,387 |

**Table 54 Risk Management Regression statistics for the banking sector (2012-2013)**

| | Model R1 | Model R2 | Model R3 | Model R4 | Model R5 | Model R6 | Model R7 | Model R8 | Model R9 | Model R10 | Model R11 | Model R12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| REG_RISK | 0,496*** | | | 0,327*** | 0,437*** | | | 0,324*** | 0,256** | | | -0,014 |
| REP_RISK | | 0,313*** | | 0,154* | | 0,259*** | | 0,126 | | 0,378*** | | 0,284*** |
| PHYS_RISK | | | 0,425*** | 0,232** | | | 0,363*** | 0,142 | | | 0,428*** | 0,351*** |
| SIZE | -0,380*** | -0,313*** | -0,189** | -0,320*** | -0,006 | 0,054 | 0,152* | 0,028 | -0,121 | -0,113 | 0,012 | -0,033 |
| LEV | -0,252*** | -0,131 | -0,148* | -0,177** | -0,175** | -0,072 | -0,088 | -0,121 | -0,385*** | -0,278*** | -0,312*** | -0,259*** |
| CAP_INT | 0,178** | 0,294*** | 0,243*** | 0,133 | 0,416*** | 0,523*** | 0,487*** | 0,383*** | 0,069 | 0,067 | 0,045 | -0,006 |
| R Square | 0,590 | 0,465 | 0,553 | 0,647 | 0,541 | 0,436 | 0,484 | 0,569 | 0,260 | 0,328 | 0,352 | 0,415 |
| F | 27,302*** | 16,515*** | 23,496*** | 22,597*** | 22,370*** | 14,706*** | 17,841*** | 16,268*** | 6,676*** | 9,263*** | 10,333*** | 8,757*** |
| Durbin - Watson | 1,979 | 1,899 | 2,043 | 1,878 | 2,121 | 1,998 | 1,898 | 2,054 | 2,281 | 2,099 | 2,082 | 2,039 |

*p<0.10 **p<0.05 ***p<0.01

**Table 55: Risk Management MulticollinearityDiagnostics the banking sector(2012-2013)**

| | MODEL R1 | | MODEL R2 | | MODEL R3 | | MODEL R4 | | MODEL R5 | | MODEL R6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | ,849 | 1,178 | | | | | ,579 | 1,728 | ,849 | 1,178 | | |
| REP_RISK | | | ,862 | 1,160 | | | ,769 | 1,300 | | | ,862 | 1,160 |
| PHYS_RISK | | | | | ,805 | 1,242 | ,549 | 1,823 | | | | |
| SIZE | ,844 | 1,184 | ,870 | 1,149 | ,851 | 1,175 | ,735 | 1,360 | ,844 | 1,184 | ,870 | 1,149 |
| LEV | ,932 | 1,073 | ,902 | 1,108 | ,933 | 1,072 | ,850 | 1,177 | ,932 | 1,073 | ,902 | 1,108 |
| CAP_INT | ,721 | 1,388 | ,781 | 1,281 | ,768 | 1,301 | ,700 | 1,429 | ,721 | 1,388 | ,781 | 1,281 |
| | MODEL R7 | | MODEL R8 | | MODEL R9 | | MODEL R10 | | MODEL R11 | | MODEL R12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | | | ,579 | 1,728 | ,849 | 1,178 | | | | | ,579 | 1,728 |
| REP_RISK | | | ,769 | 1,300 | | | ,862 | 1,160 | | | ,769 | 1,300 |
| PHYS_RISK | ,805 | 1,242 | ,549 | 1,823 | | | | | ,805 | 1,242 | ,549 | 1,823 |
| SIZE | ,851 | 1,175 | ,735 | 1,360 | ,844 | 1,184 | ,870 | 1,149 | ,851 | 1,175 | ,735 | 1,360 |
| LEV | ,933 | 1,072 | ,850 | 1,177 | ,932 | 1,073 | ,902 | 1,108 | ,933 | 1,072 | ,850 | 1,177 |
| CAP_INT | ,768 | 1,301 | ,700 | 1,429 | ,721 | 1,388 | ,781 | 1,281 | ,768 | 1,301 | ,700 | 1,429 |

**Table 56: Carbon Accounting Regression statistics for the bankimg sector (2012-2013)**

| | Model A1 | Model A2 | Model A3 | Model A4 | Model A5 | Model A6 | Model A7 | Model A8 | Model A9 |
|---|---|---|---|---|---|---|---|---|---|
| | | ROA | | | ROE | | | TOBIN | |
| ACC_REP | 0,215** | | 0,164* | 0,062 | | 0,092 | 0,329*** | | 0,306*** |
| ADV_ACC | | 0,218** | 0,166* | | -0,067 | -0,096 | | 0,171 | 0,076 |
| SIZE | -0,268*** | -0,290*** | -0,281*** | 0,087 | 0,090 | 0,095 | -0,056 | -0,079 | -0,062 |
| LEV | -0,168* | -0,180** | -0,163* | -0,118 | -0,131 | -0,121 | -0,314*** | -0,344*** | -0,311*** |
| CAP_INT | 0,347*** | 0,326*** | 0,312*** | 0,586*** | 0,615*** | 0,607*** | 0,119 | 0,130 | 0,103 |
| R Square | 0,424 | 0,424 | 0,447 | 0,382 | 0,383 | 0,390 | 0,307 | 0,232 | 0,311 |
| F | 13,979*** | 13,999*** | 12,136*** | 11,750*** | 11,777*** | 9,586*** | 8,401*** | 5,724*** | 6,785*** |
| Durbin -Watson | 2,128 | 2,159 | 2,144 | 2,014 | 2,034 | 1,984 | 2,193 | 2,235 | 2,183 |

*p<0.10 **p<0.05 ***p<0.01

**Table 57: Carbon Accounting MulticollinearityDiagnostics banking sector(2012-2013)**

| | MODEL A1 | | MODEL A2 | | MODEL A3 | | MODEL A4 | | MODEL A5 | | MODEL A6 | | MODEL A7 | | MODEL A8 | | MODEL A9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ACC_REP | 0,939 | 1,066 | | | 0,851 | 1,176 | 0,939 | 1,066 | | | 0,851 | 1,176 | 0,939 | 1,066 | | | 0,851 | 1,176 |
| ADV_ACC | | | 0,925 | 1,081 | 0,838 | 1,193 | | | 0,925 | 1,081 | 0,838 | 1,193 | | | 0,925 | 1,081 | 0,838 | 1,193 |
| SIZE | 0,882 | 1,133 | 0,880 | 1,137 | 0,877 | 1,141 | 0,882 | 1,133 | 0,880 | 1,137 | 0,877 | 1,141 | 0,882 | 1,133 | 0,880 | 1,137 | 0,877 | 1,141 |
| LEV | 0,929 | 1,076 | 0,940 | 1,064 | 0,928 | 1,078 | 0,929 | 1,076 | 0,940 | 1,064 | 0,928 | 1,078 | 0,929 | 1,076 | 0,940 | 1,064 | 0,928 | 1,078 |
| CAP_INT | 0,822 | 1,217 | 0,793 | 1,261 | 0,787 | 1,270 | 0,822 | 1,217 | 0,793 | 1,261 | 0,787 | 1,270 | 0,822 | 1,217 | 0,793 | 1,261 | 0,787 | 1,270 |

**Table 58: Carbon Reduction Regression statistics for banking sector (2012-2013)**

| | ROA | | | ROE | | | TOBIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | MODEL C1 | | | MODEL C2 | | | MODEL C3 | | |
| | | Tolerance | VIF | | Tolerance | VIF | | Tolerance | VIF |
| CARB_RED | 0,183* | 0,935 | 1,070 | -0,050 | 0,935 | 1,070 | 0,255** | 0,935 | 1,070 |
| SIZE | -0,296*** | 0,873 | 1,145 | 0,091 | 0,873 | 1,145 | -0,096 | 0,873 | 1,145 |
| LEV | -0,216** | 0,934 | 1,071 | -0,120 | 0,934 | 1,071 | -0,384*** | 0,934 | 1,071 |
| CAP_INT | 0,334*** | 0,790 | 1,265 | 0,610*** | 0,790 | 1,265 | 0,106 | 0,790 | 1,265 |
| R Square | 0,412 | | | 0,381 | | | 0,366 | | |
| F | 13,310*** | | | 11,682*** | | | 10,035*** | | |
| Durbin -Watson | 2,108 | | | 2,017 | | | 2,179 | | |

*p<0.10 **p<0.05 ***p<0.01

Regarding the explanatory power of our models, in models S1 – S4, where ROA is the dependent variable, the $R^2$ has a value ranging between 0,434 and 0,477 for a confidence level of 99% ($p < 0.01$). The explanatory power of our models is relatively high to similar studies. Specifically, Lannelonge *et al*. (2015), Gallego-Alvarez (2012), and Busch and Hoffman (2011), who also use ROA as a dependent variable, obtain values between 0.16 and 0,43 for the $R^2$. Regarding, models S9 to S12, where Tobin's q is examined as a dependent variable, we obtain $R^2$ values between 0,312 and 0,454, which are in accordance to the values of similar studies. More specifically, Wang et al. (2014) and Nakao *et al*. (2007) obtain $R^2$ values of 0,411 and 0,411 respectively, while Nishitani and Kokubu (2012) obtain $R^2$ values around 0,100.

The results obtained from the estimation of our proposed models using the ordinary least squares methodology are presented in Table 52, Table 54, Table 56 and Table 58 The models estimated determine the relationship between financial performance, climate change strategy, climate change risk management, carbon accounting and GHG reduction of business activities. A positive and significant relationship is found between carbon reduction and ROA for a significance level of 90% while a positive and significant relationship is also detected between carbon reduction and Tobin's q for a significance level of 95%. On the other hand, a negative but no significant relationship is detected between carbon reduction and ROE. This allows as to partly accept hypotheses $H_4$ . Moreover, a positive and significant relationship is detected between all climate change strategy indexes and the financial performance indexes. Regarding ROA, all climate change indexes contribute equally to enhanced financial performance, while regarding ROE, carbon reduction technology strategies and carbon compensation strategies have a more significant effect in financial performance than organizational management strategies. Finally, regarding carbon reduction technology strategies their effect is stronger to financial performance when examined in terms of Tobin's q. Based on the above, we accept hypotheses $H_{1a}$ , $H_{1b}$ and $H_{1c}$.

Regarding the relationship between climate change risk management and financial performance, all indexes are found to be positively and significantly related to the indexes measuring financial performance. Regulation and physical risk management have the strongest influence on ROA, while reputational risk management has the strongest influence on Tobin's q. These results allow us to accept all hypotheses $H_{2a}$ and $H_{2b}$ and $H_{2c}$. Finally, regarding the carbon accounting indexes, the core business carbon accounting and reporting index is positively and significantly related to ROA and Tobin's q, while it is positively but no significantly related to ROE. This allows us to partly accept hypothesis $H_{3a}$. The index measuring advance carbon accounting practices is positively and significantly related only to ROA, while it is positively and no significantly related to Tobin's q and negatively but no significantly related to ROE. This causes us to also partly accept hypothesis $H_{3b}$.

*5.3.2.2.2 Results and Analysis for the years 2014-2015*

*5.3.2.2.2.1 Descriptive Statistics and Bivariate Results*

Table 59 presents the descriptive statistics of the depended and independent variables. The minimum, maximum, mean and standard deviation values are reported. As we can see, the companies issue an average of 67,65 out of the 100 regarding the level of organizational management corporate commitment and 15,30 regarding carbon reduction technology management. Moreover, a very high mean average value is observed for core business carbon accounting and reporting (82,80). Additionally, a high variation is depicted for carbon compensation management strategies, reputational risk management, physical risk management and advance carbon accounting practices.

**Table 59: Descriptive Statistics for the banking sector (2014-2015)**

| N=84 | Median | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|
| ROA | 0,00 | 0,00 | -0,01 | 0,02 |
| ROE | 0,05 | 0,02 | 0,02 | 0,11 |
| TOBIN | 1,00 | 0,04 | 0,85 | 1,10 |
| ORG_MGM | 67,65 | 13,65 | 24,10 | 92,00 |
| TECH_MGM | 15,30 | 6,35 | 0,00 | 41,21 |
| COMP_MGM | 25,80 | 23,45 | 0,00 | 63,70 |
| REG_RISK | 33,80 | 13,63 | 0,00 | 62,60 |
| REP_RISK | 42,15 | 21,85 | 0,00 | 86,80 |
| PHYS_RISK | 46,90 | 23,54 | 0,00 | 100,00 |
| ACC_REP | 82,80 | 12,19 | 52,00 | 100,00 |
| ADV_ACC | 34,60 | 18,71 | 0,00 | 100,00 |
| CARB_RED | 0,07 | 0,10 | -0,19 | 0,30 |
| SIZE | 13,61 | 0,69 | 12,51 | 14,80 |
| LEV | 0,20 | 0,10 | 0,05 | 0,56 |
| CAP_INT | 0,04 | 0,01 | 0,01 | 0,07 |

The Pearson's correlation matrix for the regression variable is presented in Table 61 It is worth mentioning no significant correlations between carbon compensation strategies and the financial performance indexes are detected. On the other hand, organizational management strategies are highly correlated to all the financial performance indexes while carbon Reduction Technology Strategies are highly correlated to ROA and Tobin's q. Regarding the risk management indexes, regulation management is strongly correlated to ROA and ROE while reputation risk management is strongly correlated to ROE and Tobin's q. Physical risk management is highly correlated with all financial performance indexes. Finally, both carbon accounting measures are highly correlated to both ROA, ROE and Tobin's q.

*5.3.2.2.2.2 Regression Analysis*

In order to estimate the regression model, several statistical assumptions of the regression analysis were used. Regarding normality, we applied the Kolmogorov–Smirnov test which showed us that the variables generally follow a normal distribution (Table 60). However, for some of the variables that do not show normal distribution, according to Gallego-Alvarez (2012) and Lumley *et al*. (2002), the absence of a normal distribution does not reduce the validity of the model. Regarding autocorrelation, we conducted the Durbin-Watson's test. Our models exhibit values around 2 (Table 62, Table 64, Table 66 and Table 68 ), which reflects the absence of autocorrelation in the residuals. Finally, the values obtained for tolerances are between 0,650 and 0,967, and values obtained for VIFs are between 1,036 and 1,175, indicating the absence of multicollinearity (Table 63, Table 65, Table 67, Table 68)

## Table 60: Kolmogorov-Smirnov Test for the banking sector (2014-2015)

| | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|
| ROA | ,665 | ,769 |
| ROE | 1,191 | ,117 |
| TOBIN | 1,137 | ,151 |
| ORG_MGM | 1,882 | ,002 |
| TECH_MGM | 4,048 | 0,000 |
| COMP_MGM | 2,712 | ,000 |
| REG_RISK | 1,648 | ,009 |
| REP_RISK | 1,226 | ,099 |
| PHYS_RISK | 1,315 | ,063 |
| ACC_REP | 2,381 | ,000 |
| ADV_ACC | 3,956 | 0,000 |
| CARB_RED | ,931 | ,351 |
| SIZE | 1,016 | ,253 |
| LEV | 1,028 | ,241 |
| CAP_INT | ,718 | ,682 |

a. Test distribution is Normal.

b. Calculated from data.

**Table 61: Correlations for the banking sector for the years 2014-2015**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ROA | 1 | | | | | | | | | | | | | | |
| 2 | ROE | ,591** | 1 | | | | | | | | | | | | | |
| 3 | TOBIN | ,609** | ,498** | 1 | | | | | | | | | | | | |
| 4 | ORG_MGM | ,448** | ,513** | ,522** | 1 | | | | | | | | | | | |
| 5 | TECH_MGM | ,348** | ,225* | ,363** | ,286** | 1 | | | | | | | | | | |
| 6 | COMP_MGM | 0,139 | 0,095 | 0,071 | -0,017 | 0,1 | 1 | | | | | | | | | |
| 7 | REG_RISK | ,391** | ,445** | ,264* | ,414** | 0,158 | ,260* | 1 | | | | | | | | |
| 8 | REP_RISK | ,380** | ,491** | ,504** | ,595** | 0,197 | -0,098 | ,260* | 1 | | | | | | | |
| 9 | PHYS_RISK | ,499** | ,611** | ,499** | ,536** | ,340** | 0,016 | ,404** | ,450** | 1 | | | | | | |
| 10 | ACC_REP | ,614** | ,440** | ,522** | ,518** | ,282** | 0,195 | ,381** | ,294** | ,469** | 1 | | | | | |
| 11 | ADV_ACC | ,568** | ,354** | ,426** | ,335** | ,257* | 0,144 | ,287** | 0,205 | ,385** | ,431** | 1 | | | | |
| 12 | CARB_RED | ,404** | ,269* | ,462** | 0,144 | 0,199 | 0,111 | 0,095 | ,270* | ,339** | ,225* | 0,123 | 1 | | | |
| 13 | SIZE | -,363** | -0,009 | -,281** | -0,114 | -0,106 | 0,093 | 0,147 | -,237* | -0,007 | -0,208 | -0,2 | -0,201 | 1 | | |
| 14 | LEV | -0,168 | -0,196 | -,243* | -0,054 | 0,074 | 0,039 | -0,135 | -0,109 | -0,06 | -0,168 | -0,198 | 0,047 | -0,175 | 1 | |
| 15 | CAP_INT | ,368** | ,483** | ,283** | ,235* | -0,031 | 0,092 | 0,205 | 0,129 | ,349** | ,252* | 0,195 | ,268* | -0,152 | 0,02 | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**Table 62: Strategy Regression statistics for the banking sector (2014-2015)**

| | Model S1 | Model S2 | Model S3 | Model S4 | Model S5 | Model S6 | Model S7 | Model S8 | Model S9 | Model S10 | Model S11 | Model S12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| ORG_MGM | 0,343*** | | | 0,270*** | 0,417*** | | | 0,369*** | 0,443*** | | | 0,369*** |
| TECH_MGM | | 0,343*** | | 0,249*** | | 0,263*** | | 0,159* | | 0,423*** | | 0,351*** |
| COMP_MGM | | | 0,156 | 0,134 | | | 0,078 | 0,043 | | | 0,089 | 0,071 |
| SIZE | -0,348*** | -0,354*** | -0,377*** | -0,369*** | 0,039 | 0,031 | 0,024 | 0,036 | -0,285*** | -0,296*** | -0,303*** | -0,291*** |
| LEV | -0,200** | -0,237** | -0,230** | -0,197** | -0,150* | -0,202** | -0,198** | -0,151* | -0,24*** | -0,299*** | -0,297*** | -0,237*** |
| CAP_INT | 0,243*** | 0,307*** | 0,308*** | 0,227** | 0,369*** | 0,472*** | 0,489*** | 0,363*** | 0,102 | 0,245** | 0,240** | 0,112 |
| R Square | 0,396 | 0,402 | 0,310 | 0,477 | 0,440 | 0,345 | 0,283 | 0,463 | 0,409 | 0,358 | 0,233 | 0,475 |
| F | 12,953*** | 13,288*** | 8,866*** | 11,713*** | 15,505*** | 10,398*** | 7,790*** | 11,062*** | 13,039*** | 10,998*** | 6,002*** | 11,640*** |
| Durbin - Watson | 1,897 | 1,968 | 1,965 | 1,884 | 2,177 | 2,248 | 2,170 | 2,125 | 1,810 | 2,163 | 2,066 | 1,850 |

*p<0.10  **p<0.05 ***p<0.01

**Table 63: Strategy Multicollinearity Diagnostics the banking sector (2014-2015)**

| | MODEL S1 | | MODEL S2 | | MODEL S3 | | MODEL S4 | | MODEL S5 | | MODEL S6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | ,880 | 1,136 | | | | | ,851 | 1,175 | ,880 | 1,136 | | |
| TECH_MGM | | | ,964 | 1,038 | | | ,927 | 1,079 | | | ,964 | 1,038 |
| COMP_MGM | | | | | ,992 | 1,008 | ,979 | 1,022 | | | | |
| SIZE | ,947 | 1,056 | ,947 | 1,056 | ,942 | 1,062 | ,941 | 1,063 | ,947 | 1,056 | ,947 | 1,056 |
| LEV | ,952 | 1,051 | ,969 | 1,032 | ,969 | 1,032 | ,950 | 1,053 | ,952 | 1,051 | ,969 | 1,032 |
| CAP_INT | ,877 | 1,140 | ,944 | 1,060 | ,975 | 1,025 | ,864 | 1,158 | ,877 | 1,140 | ,944 | 1,060 |
| | MODEL S7 | | MODEL S8 | | MODEL S9 | | MODEL S10 | | MODEL S11 | | MODEL S12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ORG_MGM | | | ,851 | 1,175 | ,880 | 1,136 | | | | | ,851 | 1,175 |
| TECH_MGM | | | ,927 | 1,079 | | | ,964 | 1,038 | | | ,927 | 1,079 |
| COMP_MGM | ,992 | 1,008 | ,979 | 1,022 | | | | | ,992 | 1,008 | ,979 | 1,022 |
| SIZE | ,942 | 1,062 | ,941 | 1,063 | ,947 | 1,056 | ,947 | 1,056 | ,942 | 1,062 | ,941 | 1,063 |
| LEV | ,969 | 1,032 | ,950 | 1,053 | ,952 | 1,051 | ,969 | 1,032 | ,969 | 1,032 | ,950 | 1,053 |
| CAP_INT | ,975 | 1,025 | ,864 | 1,158 | ,877 | 1,140 | ,944 | 1,060 | ,975 | 1,025 | ,864 | 1,158 |

**Table 64: Risk Management Regression statistics for the banking sector (2014-2015)**

| | Model R1 | Model R2 | Model R3 | Model R4 | Model R5 | Model R6 | Model R7 | Model R8 | Model R9 | Model R10 | Model R11 | Model R12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ROA | | | | ROE | | | | TOBIN | | | |
| REG_RISK | 0,379*** | | | 0,266*** | 0,342*** | | | 0,171** | 0,237** | | | 0,065 |
| REP_RISK | | 0,251** | | 0,038 | | 0,427*** | | 0,252*** | | 0,408*** | | 0,259*** |
| PHYS_RISK | | | 0,463*** | 0,339*** | | | 0,489*** | 0,314*** | | | 0,452*** | 0,312*** |
| SIZE | -0,417*** | -0,310*** | -0,371*** | -0,417*** | -0,025 | 0,134 | 0,012 | 0,052 | -0,334*** | -0,196** | -0,312*** | -0,255*** |
| LEV | -0,194** | -0,208** | -0,210** | -0,189** | -0,162* | -0,135 | -0,170** | -0,123 | -0,272*** | -0,237** | -0,271*** | -0,233*** |
| CAP_INT | 0,231** | 0,301*** | 0,167* | 0,138 | 0,412*** | 0,451*** | 0,317*** | 0,316*** | 0,189* | 0,205** | 0,083 | 0,093 |
| R Square | 0,417 | 0,317 | 0,444 | 0,501 | 0,384 | 0,444 | 0,486 | 0,417 | 0,277 | 0,377 | 0,403 | 0,460 |
| F | 14,146*** | 9,184*** | 15,797*** | 12,860*** | 12,310*** | 15,774*** | 18,663*** | 14,146*** | 7,560*** | 11,969*** | 13,355*** | 10,914*** |
| Durbin - Watson | 2,099 | 1,905 | 2,071 | 2,143 | 2,182 | 2,198 | 2,316 | 2,099 | 2,080 | 1,912 | 2,157 | 2,020 |

*p<0.10 **p<0.05 ***p<0.01

**Table 65: Risk Management Multicollinearity Diagnostics banking sector(2014-2015)**

| | MODEL R1 | | MODEL R2 | | MODEL R3 | | MODEL R4 | | MODEL R5 | | MODEL R6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | ,914 | 1,095 | | | | | ,789 | 1,268 | ,914 | 1,095 | | |
| REP_RISK | | | ,915 | 1,093 | | | ,735 | 1,361 | | | ,915 | 1,093 |
| PHYS_RISK | | | | | ,872 | 1,146 | ,650 | 1,538 | | | | |
| SIZE | ,922 | 1,084 | ,893 | 1,120 | ,946 | 1,057 | ,842 | 1,188 | ,922 | 1,084 | ,893 | 1,120 |
| LEV | ,957 | 1,045 | ,946 | 1,057 | ,966 | 1,036 | ,940 | 1,064 | ,957 | 1,045 | ,946 | 1,057 |
| CAP_INT | ,924 | 1,083 | ,967 | 1,034 | ,855 | 1,169 | ,841 | 1,189 | ,924 | 1,083 | ,967 | 1,034 |
| | MODEL R7 | | MODEL R8 | | MODEL R9 | | MODEL R10 | | MODEL R11 | | MODEL R12 | |
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| REG_RISK | | | ,789 | 1,268 | ,914 | 1,095 | | | | | ,789 | 1,268 |
| REP_RISK | | | ,735 | 1,361 | | | ,915 | 1,093 | | | ,735 | 1,361 |
| PHYS_RISK | ,872 | 1,146 | ,650 | 1,538 | | | | | ,872 | 1,146 | ,650 | 1,538 |
| SIZE | ,946 | 1,057 | ,842 | 1,188 | ,922 | 1,084 | ,893 | 1,120 | ,946 | 1,057 | ,842 | 1,188 |
| LEV | ,966 | 1,036 | ,940 | 1,064 | ,957 | 1,045 | ,946 | 1,057 | ,966 | 1,036 | ,940 | 1,064 |
| CAP_INT | ,855 | 1,169 | ,841 | 1,189 | ,924 | 1,083 | ,967 | 1,034 | ,855 | 1,169 | ,841 | 1,189 |

**Table 66: Carbon Accounting Regression statistics for the banking sector (2014-2015)**

| | Model A1 | Model A2 | Model A3 | Model A4 | Model A5 | Model A6 | Model A7 | Model A8 | Model A9 |
|---|---|---|---|---|---|---|---|---|---|
| | | ROA | | | ROE | | | TOBIN | |
| ACC_REP | 0,486*** | | 0,376*** | 0,333*** | | 0,278*** | 0,403*** | | 0,340*** |
| ADV_ACC | | 0,442*** | 0,312*** | | 0,255** | 0,158 | | 0,296*** | 0,178* |
| SIZE | -0,253*** | -0,259*** | -0,208*** | 0,100 | 0,085 | 0,123 | -0,211** | -0,232** | -0,186* |
| LEV | -0,134 | -0,130 | -0,082 | -0,130 | -0,139 | -0,104 | -0,214** | -0,228** | -0,185* |
| CAP_INT | 0,210** | 0,245*** | 0,182** | 0,417*** | 0,449*** | 0,403*** | 0,154 | 0,194** | 0,138 |
| R Square | 0,490 | 0,458 | 0,565 | 0,373 | 0,334 | 0,393 | 0,366 | 0,302 | 0,390 |
| F | 18,989*** | 16,689*** | 20,286*** | 11,761*** | 9,9069*** | 10,087*** | 11,383*** | 8,557*** | 9,980*** |
| Durbin -Watson | 1,765 | 2,222 | 1,935 | 2,157 | 2,214 | 2,136 | 1,729 | 2,182 | 1,798 |

*p<0.10  **p<0.05 ***p<0.01

## Table 67: Carbon Accounting Multicollinearity Diagnostics banking sector(2014-2015)

| | MODEL A1 | | MODEL A2 | | MODEL A3 | | MODEL A4 | | MODEL A5 | | MODEL A6 | | MODEL A7 | | MODEL A8 | | MODEL A9 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF | Tolerance | VIF |
| ACC_REP | ,864 | 1,157 | | | ,759 | 1,318 | ,864 | 1,157 | | | ,759 | 1,318 | ,864 | 1,157 | | | ,759 | 1,318 |
| ADV_ACC | | | ,877 | 1,140 | ,770 | 1,298 | | | ,877 | 1,140 | ,770 | 1,298 | | | ,877 | 1,140 | ,770 | 1,298 |
| SIZE | ,903 | 1,107 | ,902 | 1,109 | ,883 | 1,133 | ,903 | 1,107 | ,902 | 1,109 | ,883 | 1,133 | ,903 | 1,107 | ,902 | 1,109 | ,883 | 1,133 |
| LEV | ,924 | 1,082 | ,912 | 1,097 | ,895 | 1,118 | ,924 | 1,082 | ,912 | 1,097 | ,895 | 1,118 | ,924 | 1,082 | ,912 | 1,097 | ,895 | 1,118 |
| CAP_INT | ,924 | 1,082 | ,947 | 1,056 | ,916 | 1,092 | ,924 | 1,082 | ,947 | 1,056 | ,916 | 1,092 | ,924 | 1,082 | ,947 | 1,056 | ,916 | 1,092 |

## Table 68: Carbon Reduction Regression statistics for the banking sector (2014-2015)

| | ROA | | | ROE | | | TOBIN | | |
|---|---|---|---|---|---|---|---|---|---|
| | MODEL C1 | | | MODEL C2 | | | MODEL C3 | | |
| | | Tolerance | VIF | | Tolerance | VIF | | Tolerance | VIF |
| CARB_RED | 0,286*** | 0,902 | 1,109 | 0,169* | 0,902 | 1,109 | 0,389*** | 0,902 | 1,109 |
| SIZE | -0,309*** | 0,922 | 1,084 | 0,057 | 0,922 | 1,084 | -0,233** | 0,922 | 1,084 |
| LEV | -0,240** | 0,969 | 1,032 | -0,202** | 0,969 | 1,032 | -0,304*** | 0,969 | 1,032 |
| CAP_INT | 0,249** | 0,918 | 1,089 | 0,450*** | 0,918 | 1,089 | 0,149 | 0,918 | 1,089 |
| R Square | 0,360 | | | 0,303 | | | 0,362 | | |
| F | 11,120*** | | | 9,575*** | | | 11,203*** | | |
| Durbin -Watson | 1,985 | | | 2,176 | | | 2,085 | | |

*p<0.10 **p<0.05 ***p<0.01

Regarding the explanatory power of our models, in models S1 – S4, R1 – R4 and A1 – A3, where ROA is the dependent variable, the $R^2$ has a value ranging between 0,310 and 0,565 for a confidence level of 99% ($p < 0.01$). The explanatory power of our models is relatively high to similar studies. Specifically, Lannelonge *et al*. (2015), Gallego-Alvarez (2012), and Busch and Hoffman (2011), who also use ROA as a dependent variable, obtain values between 0.160 and 0,430 for the $R^2$. Regarding, models Tobin's q is examined as a dependent variable, we obtain $R^2$ values between 0,233 and 0,475, which are in accordance to the values of similar studies. More specifically, Wang et al. (2014) and Nakao *et al*. (2007) obtain $R^2$ values of 0,411 and 0,411 respectively, while Nishitani and Kokubu (2012) obtain $R^2$ values around 0,100.

The results obtained from the estimation of our proposed models using the ordinary least squares methodology are presented in Table 62, Table 64, Table 66 and Table 68. A positive and significant relationship is detected among carbon reduction and all financial performance indexes, with Tobin's q having the strongest relation to carbon reduction (0,389). Positive significant relationship between ROE and carbon reduction is detected for a confidence level of 90%. This allows as to accept hypotheses $H_4$. Moreover, a positive and significant relationship is detected between all organizational management, carbon reduction technologies and all financial performance indexes. Contrary to the period 2012-2013, a positive but no significant relationship is detected between carbon compensation strategies and financial performance.

Regarding carbon reduction technologies, the strongest relationship is observed for Tobin's q. Based on the above results, we accept hypotheses $H_{1a}$ , $H_{1b}$ and reject hypothesis $H_{1c}$ . Regarding the relationship between climate change risk management and financial performance, all indexes are found to be positively and significantly related to the indexes measuring financial performance. Regulation and physical risk management have the strongest influence on ROA, while reputational and physical risk management have the strongest influence on ROE and Tobin's q. These results allow us to accept all hypotheses $H_{2a}$ and $H_{2b}$ and $H_{2c}$. Finally, regarding the carbon accounting indexes, they are all positively and significantly related to all financial performance indexes. However the strongest relationship is found for ROA. Regarding ROE and Tobin's q, core business carbon accounting and reporting has a stronger influence than advance carbon accounting practices. Based on the above, we accept both hypotheses $H_{3a}$ and $H_{3b}$.

## 5.4 Discussion of Results

### 5.4.1 Discussion of Results on the Oil and Gas Sector

Regarding corporate commitment in climate change strategy, we can see that the index corresponding to organizational management is positively and significantly associated to financial performance both regarding ROA, ROE and Tobin's Q. Furthermore, we can observe that this association is stronger for the Tobin's Q measure of financial performance, which means that a high level of corporate commitment regarding climate change management does not only enhance performance in terms of economic efficiency (which the accounting measures ROA and ROE express) but also enhances the market performance of a company. What is also very interesting is the fact that among the three climate change strategy indexes, the strongest relationship is detected between the carbon reduction technology index and Tobin's Q both for the time periods 2012-2013 and 2014-2015. Additionally, the relationship between carbon technology reduction strategies and financial performance weakens between the two time periods, in terms of ROA and ROE while it remains the same regarding Tobin's q. This result can be interpreted if we take into account the fact that investing in new carbon technology does not always compensate for the additional costs made for developing new technologies in strictly accounting terms. However, the fact that corporate commitment in developing carbon reduction technologies has a strong effect on market performance means that the market generally places high value in innovative firms which can compensate for the increased costs of developing new technologies.

Finally, it is noticeable, that carbon compensation strategies, which include participation in emission trading schemes and buying and selling carbon offsets, are not significantly related to financial performance of companies for the period 2012-2013 while they become significantly associated to financial performance in the period 2014-2015. This can be explained by the fact that in 2012 the second phase of the EU ETS ended. As we have discussed above, during phases 1 and 2 a large number of carbon emission allowances were initially granted to companies participating in the EU ETS for free. However, from 2013 and afterwards, the number of initial free allocation allowance decreased, which added an additional cost to carbon intensive firms. Furthermore, the costs of no compliance to the emissions allowed for each company increased while the amount of emissions allowed for each company has been steadily decreasing from year to year. As a result, companies have begun to place greater attention to carbon trading schemes and emission allowances which explains the difference between the significance levels regarding the relationship between financial performance and corporate commitment in implementing carbon compensation strategies.

Regarding corporate commitment in climate change risk management, we can observe an increase in the significance level between regulation-induced risk management and financial performance from the period 2012-2013 to the period 2014-2015 which can be attributed to the fact that climate change regulation has increased during the last years, with the introduction of carbon taxes and the establishment of carbon trading schemes, whose rules, are becoming more strict from year to year. Reputation remains a highly significant risk related to corporate performance in both time periods. However, as we can observe in Models R4, R8 and R12 its significance in relation to the other types of risk management has decreased from the period 2012-2013 to the period 2014-2015. On the other hand, the significance of physical risk management has also increased from the first to the second period. This means that companies in the oil and gas sector have begun to treat climate change implications at a more substantial level and not purely as a CSR issue. That is not to claim that reputation risk management does not contribute to increased financial performance, but rather that attention has been shifted towards more direct risk management issues, such as adhering to climate change regulation and managing physical implications of climate change.

Finally, regarding corporate commitment on carbon accounting, a positive and significant relationship between Core Business Carbon Accounting and Reporting, Advanced Carbon Accounting Practices and financial performance is detected at both time periods. Nevertheless, there is a tendency for this relationship to become more significant in the period 2014-2015 in terms of ROA. On the other hand, relationship between the carbon accounting indexes and Tobin's q is found to be highly significant in both time periods. This is closely linked to the increased demand for disclosure regarding carbon emissions of companies or carbon intensity of business activities. The fact that the relationship between carbon accounting and market performance was of higher significance than this between accounting performance and carbon accounting in the first time period, means that it was the market's demand (or the stakeholders' demand), who began to value the importance of corporate commitment of carbon accounting earlier than the firms themselves, and who eventually demanded for more information regarding corporate carbon accounting practices.

### 5.4.2 Discussion of Results in the Banking Sector

Climate change strategy corporate commitment, organizational management strategies and carbon reduction strategies are found to be positively and significantly correlated to financial performance in both time periods. Furthermore, we can observe that the significance level increased from the first to the second time period. This is in accordance with the general trend to invest both in carbon friendly technologies, to include sustainability criteria in the financing of projects and to develop business processes that reduce energy consumption, such as promoting e-banking services. Moreover, in the transition from the first to the second time period we observe an increase in the significance level of organizational management strategies related to both ROA and Tobin's q. As these two particular financial indexes reflect stakeholder attitudes towards corporate performance (with ROA taking expressing shareholders' interests and Tobin's q reflecting market expectations on corporate performance), we can claim that there is an increasing demand from stakeholders to demand higher corporate commitment regarding climate change strategies. Furthermore, the fact that the carbon reduction technology index has the strongest connection to Tobin's q at both time periods, means that the market generally rewards companies who invest in innovation technologies or finance technological innovation projects.

Regarding carbon compensation strategies, their relationship to corporate performance is found to be positive and significant in the period 2012-2013 but insignificant in the period 2014-2015. Carbon compensation strategies include participation in emissions trading schemes, creating project-based carbon credits and purchasing carbon credits. These practices are of course not directly related to the operational activities of banks, since banks are not considered to be a carbon intensive sector. Therefore, the assessment of this index refers to the services provided by banks to other companies related to the specific climate change strategies. If we examine this index form this point of view, we can interpret the high significance level between financial performance and carbon compensation strategies during the first time period as well as the lack of significance during the second time period. During the first time period, the provision of services regarding emissions trading or buying and selling emission allowances could have possibly been considered as a competitive advantage for banks who decided to provide these types of services, therefore enhancing their financial performance. However, as years passed from the introduction of emissions trading schemes, the provision of related services gradually seized to be a competitive advantage since it became a mainstream service provided by the majority of financial institutions. As a result, the relationship between carbon compensation strategies and financial performance in the second time period seized to be significant.

In examining the trends between corporate commitment in climate change risk management and financial performance, we observe that the effect of regulation risk management on financial performance slightly decreases, while on the other hand the effect of physical risk management on financial performance increases. The decrease in the significant level of regulation risk management can be explained by taking into account the fact that, as years pass, climate change regulation becomes more clear and substantial, making it easier for financial institutions to incorporate climate change performance criteria into their investment decisions. Therefore, as we have discussed above about the relationship between carbon compensation strategies and financial performance, in the same line of thought, the effect of corporate commitment in regulation risk management also decreases. On the other hand, the fact that the relationship between physical risk management and financial performance becomes stronger can be explained by the fact that as years pass, the incurrence of extreme weather events and changes in precipitation patterns becomes more evident, thereby affecting the business activities and profitability of the majority of firms. For that reason, devoting management effort in assessing the exposure of their clients to the physical risks of climate change will probably have a strong effect on the financial performance of banks. As far as reputational risk management is concerned, we can observe that its significance increases from the 2012-2013 period to the 2014-2015 period, in relation to ROE and Tobin's q which also enhances our claim that corporate stakeholders have begun to pay more attentions to the corporate practices of financial institutions regarding climate change management.

Finally, regarding the relationship between carbon accounting and financial performance, this becomes significantly stronger from the first to the second time period for all financial performance indicators. As discussed above, this confirms the increased demand form stakeholders for more information regarding the corporate climate change practices of firms, which explains the strong relationship between core business carbon accounting and reporting and both ROA, ROE and Tobin's q. Furthermore, it highlights the need for incorporating advance carbon accounting practices, including the development of internal price of carbon schemes in order for financial institutions to accurately measure the carbon profile of a potential client and to assess its exposure to the adverse effects of climate change.

# 6 CONCLUSION

Climate change has been globally acknowledged as a major source of physical, economic and social risk. The mandatory GHGs – reduction targets that have been set for the industrialized countries under the auspices of the Kyoto Protocol have given rise to the adoption of climate change mitigation policies at national and international level. These include putting a price on carbon emissions through setting process and product standards for industry, carbon taxes and the establishment of carbon trading programs such as the EU ETS. As a result companies are expected to face increased costs in their production processes both directly for the GHG-intensive sectors and indirectly by passing carbon – related cost through the supply chain, thereby affecting the profitability of the majority of firms.

These increased risks that companies face 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 on companies' part, regarding their corporate climate change practices. The aim of this study was to examine the various climate change management practices adopted by firms and how these practices affect their financial performance. In order to do so, we examined three dimensions of climate change management: Strategy, Risk Management and Carbon Accounting and Reporting. Our claim was that devoting corporate resources in the implementation of climate change strategies, in the identification, assessment and management of climate change risks and in the accurate and precise accounting and reporting of carbon emissions enhances the financial performance of firms. Furthermore, we proposed that reducing $CO_2$ emissions also enhances corporate financial performance.

In order to prove the validity of our claims we developed eight corporate indexes for measuring the level of commitment (i.e. management effort) a firm shows regarding the implementation of climate change strategies, in the identification and assessment of climate change risks and the adoption of carbon accounting practices: *Climate Change Organizational Management Strategies, Carbon Reduction Technology Strategies, Carbon Compensation Strategies, Regulation-induced Risk Management, Reputation - induced Risk Management, Physical Risk Management, Core Business Carbon Accounting and Reporting* and *Advanced Carbon Accounting Practices*. For the carbon reduction index, we used emissions data provided by the CDP.

In order the measure the level of corporate commitment regarding its climate change practices we decided to weight the corporate indexes according to the level of difficulty in implementing the climate change practice included in each respective index. In order to assign proper weighs to our indexes we developed and validated critical factors of climate change strategy, climate change risk management and carbon accounting by conducting separate surveys for climate change strategy, risk management and carbon accounting and reporting. After collecting our data, we conducted validity assessment, by using exploratory factor analysis, and reliability assessment, by using the internal consistency method, of our survey instruments. According to the results of this process, we will developed the respective climate change indexes described above and assigned relevant weights according to the mean average values of the variables included in each index.

After this procedure we tested the indexes in two different business sectors: the Oil and Gas sector and the Banking sector for the years 2012-2015. The assessment of the selected companies was conducted through a predefined scoring methodology that was based on weighted content analysis. After the extracting the relevant scores for its company, we separated our initial sample into two sub-sample, one for the years 2012-2013 and one for the years 2014-2015. We then examined the relationship between the respective indexes and corporate financial performance of our sample firms for the two different time periods, by using linear regression analysis. The financial performance indicators used in this research were ROA, ROE and Tobin's q.

Regarding the oil and gas companies, for the first times period, a positive but no significant relationship was found between carbon reductions and ROA while a positive and significant relationship was found between ROE and Tobin's Q. Moreover, a positive and significant relationship was detected between organizational management strategies, carbon reduction technology strategies and financial performance measured by both ROA, ROE and Tobin's q while a positive but no significant relationship was observed between carbon compensation strategies and the financial performance measures. Regarding the relationship between corporate commitment in climate change risk management, a positive and significant relationship was detected between all the risk management indexes and the financial performance measures, with the exception of physical risk management and ROE, where no significant relationship was detected. Furthermore, the strongest relationship was detected between reputation risk management and financial performance. Additionally, all risk management indexes had the strongest connection to the Tobin's q index. Finally, regarding the carbon accounting indexes, they were positively and significantly related to the financial performance indexes, with the strongest relationship detected between the Tobin's q index.

Contrary to the results in the time period 2012-2013, in the second time period a positive and significant relationship was found between carbon reductions and ROA while a positive and significant relationship was also detected between carbon reductions, ROE and Tobin's Q. Moreover, a positive and significant relationship was detected between organizational management strategies, carbon reduction technology strategies and financial performance measured by both ROA, ROE and Tobin’s q . In contrast to the previous time period a positive but significant relationship was observed between carbon compensation strategies and the financial performance measures. Regarding the relationship between corporate commitment in climate change risk management, a positive and significant relationship was detected between all the risk management indexes and the financial performance measures. Physical risk management has the strongest influence related to the other risk management indexes in terms of ROA, while regulation and reputational risk management influence financial performance to a higher degree than physical risk management. Moreover, regarding Tobin’s q all types of risk management contribute equally to enhanced financial performance. Finally, regarding the carbon accounting indexes, they were all found to be positively and significantly related to the financial performance indexes, with the strongest relationship detected for the Tobin’s q index.

Regarding the banking sector, for the period 2012-2013, a positive and significant relationship was found between carbon reduction, ROA and Tobin’s q while a negative but no significant relationship was detected between carbon reduction and ROE. Moreover, a positive and significant relationship was detected between all climate change strategy indexes and the financial performance indexes. Regarding carbon reduction technology strategies, their effect is stronger to financial performance when examined in terms of Tobin’s q. All risk management indexes were found to be positively and significantly related to the indexes measuring financial performance. Regulation and physical risk management have the strongest influence on ROA, while reputational risk management has the strongest influence on Tobin’s q. Finally, regarding the carbon accounting indexes, the core business carbon accounting and reporting index was positively and significantly related to ROA and

Tobin's q, while it was positively but no significantly related to ROE, while the index measuring advance carbon accounting practices was positively and significantly related only to ROA, while it was positively but no significantly related to Tobin's q and negatively but no significantly related to ROE.

Regarding the period 2014-2015, a positive and significant relationship was detected among carbon reduction and all financial performance indexes. Moreover, a positive and significant relationship was detected between organizational management, carbon reduction technologies and all financial performance indexes. Contrary to the period 2012-2013, a positive but no significant relationship was detected between carbon compensation strategies and financial performance. Regarding carbon reduction technologies, the strongest relationship is observed for Tobin's q. All risk management indexes are found to be positively and significantly related to the indexes measuring financial performance, with regulation and physical risk management having the strongest influence on ROA, while reputational risk management having the strongest influence on ROE and Tobin's q. Finally, regarding the carbon accounting indexes, they are all positively and significantly related to all financial performance indexes.

Summarizing, our results show that devoting resources in the implementation of climate change corporate practices enhances corporate performance of firms, and this relationship tends to be even stronger as years pass. Furthermore, we detect a strong steady relationship between carbon reduction technologies and Tobin's q, which reinforces Porter's win-win hypothesis that innovation enhances corporate performance. Our research has a number of limitations. First, in order to weight 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, which were also the target population of our oil and gas companies and our banks, 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 on the oil and gas or the banking sector, due to the fact that our target population was very limited. If we were to conduct our survey only on experts in the specific two sectors, we would have been unable to gather enough data to be able to perform validity and reliability analysis of our questionnaire. We believe that in the future we will be able to locate more experts of each respective sector in order to have more precise responses regarding the difficulty level of implementing climate change practices. Furthermore, future research could also examine other economic sectors, and do comparative research between carbon – intensive and non-carbon intensive sectors, as we also did in this study.

Additionally, in the factor analysis regarding climate change risk management, an additional factor, namely legal risk management was extracted. However, in the analysis of the climate change practices of our sample firms, we did not examine corporate commitment regarding legal risk management. The reason we decided not to examine legal risks is because we couldn't find reliable data regarding corporate practices in this particular field. Future research could examine the relationship between climate change legal risks related and financial performance, especially as climate change regulation evolves and becomes more precise and strict. Finally, our research was focused on large multinational companies and on their corporate climate change practices. Future research should also focus on examining the climate change practices of smaller firms and the capabilities they have in implementing climate change strategies, identifying risks and tracking down their carbon emissions.

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# 8 APPENDICES

## APPENDIX A: CLIMATE CHANGE SURVEY QUESTIONAIRE

### Climate Change Strategy

#### Introduction

Dear Participant,

Based on your personal experience, we would like you to assess the difficulty level of implementing corporate climate change practices regarding stakeholder engagement and carbon reduction strategies.

Our aim is to develop a weighted climate change corporate performance index based on the perceptions and experience of climate change experts.

Your participation in this survey is voluntary and you have the right to withdraw from participation at any time without obligation. We do not collect identifying information of any respondent and your responses will be kept completely confidential.

The survey is user-friendly and you should be able to complete it within 5-10 minutes or less.

If you have any questions about the project, you can contact:

Evgenia Anagnostopoulou (Researcher) +30 6932 444429, eanagno@uom.edu.gr
Iordanis Eleftheriadis (Supervisor) +30 2310 891591, jordan@uom.edu.gr

Thank you for participating in our survey. Your feedback is important.

Sincerely,

Iordanis, M. Eleftheriadis,
Associate Proffessor
Department of Business Administration
University of Macedonia

Evgenia, G.Anagnostopoulou,
Ph.D Candidate
Department of Business Administration
University of Macedonia

## Climate Change Strategy

### Climate Change Governance

1. How easy or difficult do you think it is for...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| The Board of Directors (or a committee of the Board) to provide oversight and accountability for corporate climate change strategy and performance. | | | | | | | | |
| Company management (from CEO to business unit managers) to have clear responsibilities for achieving climate change goals. | | | | | | | | |
| Executive compensation to be linked to climate change performance, including attainment of targets such as greenhouse gas (GHG) reduction. | | | | | | | | |

## Climate Change Strategy

### Climate Change Risk Management

2. Climate Change Risk Management.
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Integrate climate change risk management processes into core business risk management processes. | | | | | | | | |
| Identify risks and opportunities at asset level. | | | | | | | | |
| Identify risks and opportunities at company level. | | | | | | | | |
| Prioritize risks and opportunities related to climate change. | | | | | | | | |

## Climate Change Strategy

### Carbon Reduction Targets

3. Carbon Reduction Targets
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Develop short-term *absolute* CO2 emission reduction targets. | | | | | | | | |
| Develop short-term *intensity* CO2 emission reduction targets (Intensity ratios express CO2 emissions per unit of physical activity or unit of economic output). | | | | | | | | |
| Develop long-term *absolute* CO2 emission reduction targets. | | | | | | | | |
| Develop long-term *intensity* CO2 emission reduction targets (Intensity ratios express CO2 emissions per unit of physical activity or unit of economic output). | | | | | | | | |

## Climate Change Strategy

### Carbon Reduction Strategies

4. Energy efficiency and Carbon reduction.
How easy or difficult do you think it is to implement the carbon reduction strategies described below.

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Fossil fuel switching, from coal to natural gas. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Increased boiler efficiency, by implementing the best available technology. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Usage of Combined Heat and Power Technology (cogeneration). | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Energy source switching, from fossil fuels to renewable energy sources. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Capture and Storage of CO2. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

5. Business processes emissions reduction.
How easy or difficult do you think it is to implement the carbon reduction strategies described below.

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Replacement of carbon-based products by non-carbon based products. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Implementation of end-use energy efficiency processes (e.g. turning down heating and cooling during non-working hours, reduce non-necessary travel). | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Optimization of current business processes in order to reduce CO2 emissions. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Control of non-CO2 gas emissions (e.g. CH4, H2O). | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## Climate Change Strategy

### Carbon Compensation Strategies

6. Emissions Trading Systems
How easy or difficult do you think it is to implement the carbon compensation strategies described below.

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Participating in emissions trading schemes | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Creating project - based carbon credits | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Purchasing carbon credits | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## Climate Change Strategy

### Tell us a little bit about yourself...

7. Are you male or female?

- ◯ Male
- ◯ Female

8. Age

- ◯ <18
- ◯ 18 - 29
- ◯ 30 - 44
- ◯ 45 - 59
- ◯ 60+

9. What is the highest level of school you have completed or the highest degree you have received?

- ◯ Less than high school degree
- ◯ High school degree or equivalent (e.g., GED)
- ◯ Some college but no degree
- ◯ Associate degree
- ◯ Bachelor degree
- ◯ Graduate degree

10. What industry does your company belong to?

11. Please indicate your main role in your company/organization.

- ○ Engineering
- ○ Finance/Accounting
- ○ Human Resources
- ○ Legal
- ○ Management
- ○ Manufacturing
- ○ Project Management
- ○ Research
- ○ Risk Management
- ○ Sales / Marketing
- ○ Strategy/Planning
- ○ Other (please specify)

12. Which of the following best describes your current job level?

- ○ Owner/Executive/C-Level
- ○ Senior Management
- ○ Middle Management
- ○ Intermediate
- ○ Entry Level
- ○ Other (please specify)

13. About how many years of experience do you have in climate change related issues?

- ○ Less than 1 year
- ○ At least 1 year but less than 3 years
- ○ At least 3 years but less than 5 years
- ○ At least 5 years but less than 10 years
- ○ 10 years or more

## APPENDIX B: RISK MANAGEMENT SURVEY QUESTIONAIRE

### Climate Change Risk Management

#### Introduction

Dear Participant,

Based on your personal experience, we would like you to assess the difficulty level of identifying and calculating the cost of different climate change risks.

Our aim is to develop a weighted climate change corporate performance index based on the perceptions and experience of climate change experts.

Your participation in this survey is voluntary and you have the right to withdraw from participation at any time without obligation. We do not collect identifying information of any respondent and your responses will be kept completely confidential.

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If you have any questions about the project, you can contact:

Evgenia Anagnostopoulou (Researcher) +30 6932 444429, eanagno@uom.edu.gr
Iordanis Eleftheriadis (Supervisor) +30 2310 891591, jordan@uom.edu.gr

Thank you for participating in our survey. Your feedback is important.

Sincerely,

Iordanis, M. Eleftheriadis,
Associate Proffessor
Department of Business Administration
University of Macedonia

Evgenia, G.Anagnostopoulou,
Ph.D Candidate
Department of Business Administration
University of Macedonia

## Climate Change Risk Management

### Regulation Risks

1. Regulation Risks - Command and Control Climate Change Regulation
(process and product standards, performance and technology standards)
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by changes in command and control climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications from changes in command and control climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address impacts from changes in command and control climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address impacts from changes in command and control climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

2. Regulation Risks - Market-based Regulation
(carbon taxes, emissions trading schemes, fuel tariffs etc.)
How easy or difficult do you think it is to ...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by changes in market-based climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications from changes in market-based climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address impacts from changes in market-based climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address impacts from changes in market-based climate change regulation. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Climate Change Risk Management

### Physical Risks

3. Physical Risks - Extreme Weather Events
(weather related events such as increased storms and floods, hurricanes, typhoons etc.)
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by climate change physical risks (extreme weather events) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications driven by climate change physical risks (extreme weather events) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address the climate change physical risks (extreme weather events) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address the climate change physical risks (extreme weather events) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

4. Physical Risks - Changes in Precipitation extremes and Droughts.
(impacts such as reduced water supplies,droughts etc.)
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by climate change physical risks (precipitation changes and droughts) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications driven by climate change physical risks (precipitation changes and droughts) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address the climate change physical risks (precipitation changes and droughts) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address the climate change physical risks (precipitation changes and droughts) on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Climate Change Risk Management

### Reputational Risks

5. Reputational Risks.
(any risk of negative publicity regarding business practices, due to heightened attention to climate change)
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by reputational risks, related to climate change, on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications driven by reputational risks, related to climate change, on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address reputational risks, related to climate change, on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address reputational risks, related to climate change, on business activities. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Climate Change Risk Management

### Legal Risks

8. Legal Risks.
(any risk of tort liability, civil liability, fines / penalties, or other litigation)
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by climate change legal risks. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate potential financial implications driven by climate change legal risks. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Identify management methods in order to address climate change legal risks. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the cost of management methods needed to address climate change legal risks. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Climate Change Risk Management

### Competitive Risks

6. Competitive Risks - Uncertainty in Market signals.
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by climate change competitive risks regarding uncertainty in market signals. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate potential financial implications driven by climate change competitive risks regarding uncertainty in market signals. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Identify management methods in order to address climate change competitive risks regarding uncertainty in market signals. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate the cost of management methods needed to address climate change competitive risks regarding uncertainty in market signals. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

7. Competitive Risks - Changing Consumer Behavior.
How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Identify potential impacts driven by climate change competitive risks in relation to changing consumer behavior. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate potential financial implications driven by climate change competitive risks in relation to changing consumer behavior. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Identify management methods in order to address climate change competitive risks in relation to changing consumer behavior. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate the cost of management methods needed to address climate change competitive risks in relation to changing consumer behavior. | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## Climate Change Risk Management

### Tell us a little bit about yourself...

9. Are you male or female?

- ◯ Male
- ◯ Female

10. Age

- ◯ <18
- ◯ 18 - 29
- ◯ 30 - 44
- ◯ 45 - 59
- ◯ 60+

11. What is the highest level of school you have completed or the highest degree you have received?

- ◯ Less than high school degree
- ◯ High school degree or equivalent (e.g., GED)
- ◯ Some college but no degree
- ◯ Associate degree
- ◯ Bachelor degree
- ◯ Graduate degree

12. What industry does your company belong to?

13. Please indicate your main role in your company/organization.

- ◯ Engineering
- ◯ Finance/Accounting
- ◯ Human Resources
- ◯ Legal
- ◯ Management
- ◯ Manufacturing
- ◯ Project Management
- ◯ Research
- ◯ Risk Management
- ◯ Sales / Marketing
- ◯ Strategy/Planning
- ◯ Other (please specify)

14. Which of the following best describes your current job level?

- ◯ Owner/Executive/C-Level
- ◯ Senior Management
- ◯ Middle Management
- ◯ Intermediate
- ◯ Entry Level
- ◯ Other (please specify)

15. About how many years of experience do you have in climate change related issues?

- ◯ Less than 1 year
- ◯ At least 1 year but less than 3 years
- ◯ At least 3 years but less than 5 years
- ◯ At least 5 years but less than 10 years
- ◯ 10 years or more

# APPENDIX C: CARBON ACCOUNTING SURVEY QUESTIONAIRE

## Carbon Accounting and Reporting

### Introduction

**Dear Participant,**

**Based on your personal experience, we would like you to assess the difficulty level of implementing corporate climate change practices regarding carbon pricing and trading, carbon accounting, carbon reporting and verification.**

**Our aim is to develop a weighted climate change corporate performance index based on the perceptions and experience of climate change experts.**

**Your participation in this survey is voluntary and you have the right to withdraw from participation at any time without obligation. We do not collect identifying information of any respondent and your responses will be kept completely confidential.**

**The survey is user-friendly and you should be able to complete it within 5 minutes or less.**

**If you have any questions about the project, you can contact:**

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**Evgenia, G.Anagnostopoulou,**
**Ph.D Candidate**
**Department of Business Administration**
**University of Macedonia**

## Carbon Accounting and Reporting

### Internal Price of Carbon

1. How easy or difficult do you think it is to implement the climate change strategies described below.

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Developing an internal price of carbon scheme. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate internal price of carbon | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Carbon Accounting and Reporting

### Identification and Calculation of Carbon Emissions

2. How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Set an emissions baseline year under which future emission trends are calculated. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate *scope 1* CO2 emissions (direct GHG emissions that occur from sources that are owned or controlled by the company, e.g. emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate *scope 2* CO2 emissions (indirect GHG emissions from purchased electricity consumed by the company). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate *scope 3* CO2 emissions (indirect GHG emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company, e.g. extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the amount of emissions that are avoided by the implementation of CO2 saving projects. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Use an established methodology to calculate CO2 emissions, e.g. GHG Protocol, USA EPA, Climate Registry, etc. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Carbon Accounting and Reporting

### Carbon Reporting and Verification

3. How easy or difficult do you think it is to...

| | Very Easy 1 | 2 | 3 | 4 | 5 | 6 | Very Difficult 7 | N/A |
|---|---|---|---|---|---|---|---|---|
| Have CO2 emissions verified through an internal auditing process | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Have CO2 emissions verified through an independent external auditing process (third-party verification). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Achieve Reasonable Assurance verification for CO2 emissions through an independent external auditing process (Assurance providers often offer two levels: 'reasonable assurance' (i.e. high but not absolute) or 'limited assurance' (i.e. moderate)). | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Report CO2 emissions to *voluntary* GHG reporting programs. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Report CO2 emissions to *mandatory* GHG reporting programs. | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## Carbon Accounting and Reporting

### Tell us a little bit about yourself...

4. Are you male or female?

- ◯ Male
- ◯ Female

5. Age

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- ◯ 18 - 29
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- ◯ 45 - 59
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6. What is the highest level of school you have completed or the highest degree you have received?

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8. Please indicate your main role in your company/organization.

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- ◯ Finance/Accounting
- ◯ Human Resources
- ◯ Legal
- ◯ Management
- ◯ Manufacturing
- ◯ Project Management
- ◯ Research
- ◯ Risk Management
- ◯ Sales / Marketing
- ◯ Strategy/Planning
- ◯ Other (please specify)

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- ◯ Senior Management
- ◯ Middle Management
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- ◯ Entry Level
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10. About how many years of experience do you have in climate change related issues?

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- ◯ At least 3 years but less than 5 years
- ◯ At least 5 years but less than 10 years
- ◯ 10 years or more