Scuola Superiore
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# Corporate Responses to Climate Change: from a Mitigation to an Adaptation Perspective


Thesis presented by
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*"As we sit here in these negotiations, even as we vacillate and procrastinate here, the death toll is rising. There is massive and widespread devastation. Hundreds of thousands of people have been rendered without homes. And the ordeal is far from over, as typhoon Bopha has regained some strength as it approaches another populated area in the western part of the Philippines.*

*Madam chair, we have never had a typhoon like Bopha, which has wreaked havoc in a part of the country that has never seen a storm like this in half a century. And heartbreaking tragedies like this are not unique to the Philippines, because the whole world, especially developing countries struggling to address poverty and achieve social and human development, confront these same realities.*

*Madam chair, I speak on behalf of 100 million Filipinos, a quarter of a million of whom are seeking out a living working here in Qatar [as migrant labourers]. And I am making an urgent appeal, not as a negotiator, not as a leader of my delegation, but as a Filipino …"*

*I appeal to the whole world, I appeal to leaders from all over the world, to open our eyes to the stark reality that we face. I appeal to ministers. The outcome of our work is not about what our political masters want. It is about what is demanded of us by 7 billion people.*

*I appeal to all, please, no more delays, no more excuses. Please, let Doha be remembered as the place where we found the political will to turn things around. Please, let 2012 be remembered as the year the world found the courage to find the will to take responsibility for the future we want. I ask of all of us here, if not us, then who? If not now, then when? If not here, then where?"*[1]

Naderev Saño,
the lead negotiator of the Philippines delegation at United Nation's COP18, Doha, December 6, 2012.

[1] *The Guardian's* transcription

# Contents

# Acknowledgements

The value of this thesis relies not only in the possible contribution to academic research and to society but also in the contribution to my personal life. That is why these acknowledgements go in both directions.

Before starting this academic pathway, I felt worried and unsatisfied. I was dealing with the desire to give a contribution to the society with my work activities while going along with my ethics and beliefs. A key element of those beliefs has always been preserving the environment, and therefore saving the planet. Indeed, contributing to create a socially and environmentally sustainable society is a great ambition! Then, a couple of friends suggested the idea of starting a Ph.D. in environmental management. After three years as a Ph.D. student I believe that pursuing an academic career is one of the best ways for me to contribute at creating a socially and environmentally sustainable society. I want to thank Andrea Favilli and Luisa Gagliardi for their precious suggestion, without which I would not have started the academic pathway.

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# 1. Introduction

In 1988 the general interest in environmental issues and the need to investigate the relationship between human activities and climate change prompted the UNEP, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to create the IPCC, the Intergovernmental Panel on Climate Change. This is an international body composed of scientists who could provide the world with a clear scientific view on the current state of knowledge on climate change and the potential environmental and socio-economic impacts.

The first IPCC Assessment Report of 1990 unveiled the importance of climate change as a topic that was deserving of a political platform among countries to tackle its consequences. Therefore during the Rio Earth Summit in 1992 many countries joined an international treaty, the United Nations Framework Convention on Climate Change (UNFCCC), to cooperatively reduce global warming and to cope with the consequences of climate change. However, binding greenhouse gas (GHG) emissions reduction targets were only set in 1997 with the signing of the Kyoto Protocol. In fact, while the Convention encouraged industrialized countries to stabilize GHG emissions, the Protocol commits them to do so. The Kyoto Protocol sets binding targets for 37 industrialized countries and the European community for reducing GHG emissions. These amount to an average of five per cent against 1990 levels over the five-year period 2008-2012. This international agreement recognizes the principle of "common but differentiated responsibilities" according to which developed countries are considered to be principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, and hence the Protocol places a heavier burden on developed nations. The Protocol entered into force on 16 February 2005. At the end of 2012 the Kyoto Protocol's first commitment period and the international debate focused on the need for a new binding agreement. In December 2012 at its 18th session of the Conference of the Parties to the UNFCCC and the 8th session of the Conference of the Parties serving as the meeting of the Parties to

the Kyoto Protocol adopted an amendment to the Kyoto Protocol, in Doha, Qatar. The Doha Amendment establishes that the second commitment period will run from 2013 to 2020. The text includes a list of targets submitted by countries that have already expressed their willingness to participate in a second round. These countries are responsible of around 15% of global emissions. Among them are the European Union, Norway, Switzerland and , along with Australia that recently announced its availability to participate. On the contrary, Japan, Canada, Russia and New Zeeland, who were part of the first Kyoto period, clearly reaffirmed they would not be joining the second commitment period. In addition, China, India and Brazil did not take any binding targets. Therefore, this new agreement seems insufficient to keep an increasing global temperature below 2 degrees Celsius, as was agreed in 2010.

Despite the fact that the international political debate is stalling on finding an effective and widespread agreement to reduce the greenhouse gas emissions causing climate change, the scientific discourse is advancing, in particular on the physical impacts of climate change. In fact, in March 2012 the IPCC published a special report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX) which focused on the relationship between climate change and extreme weather and climate events and aimed to investigate their impact and inform about the general strategies to manage the related risks. The report, which argues about the evidence in favour of the increasing frequency and severity of extreme weather and climate events, suggests that their physical hazards may have substantial negative effects when they occur in areas characterized by large populations and economic activities, in particular when these local human and economic resources have a propensity to suffer adverse effects in terms of predisposition, susceptibilities, fragilities, weaknesses, deficiencies, or lack of capacities (vulnerability) (Cadorna, et al., 2012). Climate change has to be considered a *'complex problem, which, although environmental in nature, has consequences for all spheres of existence on our planet. It either impacts on- or is impacted by- global issues, including poverty, economic development, population growth,*

*sustainable development and resource management. It is not surprising, then, that solutions come from all disciplines and fields of research and development'* (UNFCCC).[2] From a scientific point of view, once the role of human activities on climate change has been recognized (Solomon et al., 2007), research in the field needs to be oriented towards the analysis of alternative ways to mitigate the negative externalities coming from these activities, i.e. reducing greenhouse gas (GHG) emissions that impact on the rate and magnitude of change, and researching possible ways to adapt to its impacts on social and business activities. These two kinds of responses to climate change in terms of mitigation and adaptation actions can be complementary. However, the capacity to mitigate and adapt is dependent on socio-economic and environmental circumstances and on the availability of information and technologies (Wilbanks et al., 2007). Hence, climate change represents a major environmental policy challenge, both in the present and in the future (Levy, 1997), but it is also considered a business concern for many reasons. On the one hand, companies are directly (e.g. those producing fossil fuel and electricity) and indirectly (e.g. those consuming fossil fuels and electricity) responsible for GHGs emissions, and in certain cases to a greater extent than countries (Patenaude, 2011). This further implies that they can play a huge role in mitigation. For example, the mining group Rio Tinto rivals the emissions of New Zealand, but instead the GHG emissions of ExxonMobil are higher than those of Belgium (Patenaude, 2010). On the other hand, companies are affected by the impacts of climate change in terms of ecological changes, e.g. weather and climate events (Linnenluecke and Griffiths, 2010; Linnenluecke et al., 2012; Winn et al. 2011). The extent of these impacts is supposed to be even greater than those of globalization and information technology and it may potentially trigger a business revolution (Porter and Reinhardt, 2007). In fact, the direct and indirect impacts of climate change on business can be related to carbon policies at both international and national levels, to market changes or to climate-induced physical changes affecting the environment where

[2]UNFCCC http://unfccc.int/essential_background/items/6031.php accessed by Federica Gasbarro on 07/08/2012.

firms operate. In particular, the latter can pose major challenges to business companies, leading to a reconsideration of the relationship between organizations and their ecological environment, which until now was supposed to be stable (Winn et al. 2011). In fact, up to now this relationship has been considered through the perspective of how the firm's activities impact upon the climate (inside-out), yet now this also needs to be considered in terms of how the changing climate may affect the business environment in which a firm operates (outside-in) (Porter and Reinhardt, 2007; Weinhofer and Busch, 2012). Even organizational survival could be questioned in some cases (Linnenluecke, et al., 2012).

As a consequence, researchers studied corporate climate-related strategy in terms of the responses to carbon policy (e.g. Levy and Kolk, 2002; Levy and Egan, 2003; Kolk and Pinkse, 2007; Pinkse, 2007; Engau and Hoffmann, 2009, 2011a, 2011b), to market changes (e.g. Kolk and Pinkse, 2004, 2008; Hoffman, 2005; Lash and Wellington, 2007), and finally to climate-induced physical changes (e.g. Berkhout, et al., 2006; Linnenluecke, et al. 2011). The former two research lines are related to mitigation, while the latter is related to adaptation response, according to the evolution of business concern over time. In fact, when climate change first emerged as an international policy concern, energy intensive industries, in particular the oil and automotive industries were opposed to any international effort to regulate GHGs (Pulver, 2007). For example, oil companies set up a lobbying group in 1989 called the Global Climate Coalition (GCC), to fight against mandatory climate policy at US and international levels. Through the GCC they questioned the scientific basis of the problem and raised concerns about the economic costs of binding emission reduction targets (van den Hove et al., 2002). This position found in Exxon its main supporter. At the same time, other industries, such those investing in gas and renewables and banks and insurance companies, supported climate policy initiatives. However, after British Petroleum's CEO, John Browne, announced to the world in a public speech that BP accepted the occurrence of climate change, and its intention to reduce its contributions to the process in 1997 (Lowe and Harris, 1998), Shell and a few other oil companies also

broke ranks and supported international actions on tackling climate change (Pulver, 2007). Hence, companies' focus has moved from lobbying against mandatory emission reduction targets to climate change impacts on the market. In fact, once they have recognized the occurrence of climate change, firms can reduce their emissions through product and process improvements and also benefit from some business opportunities related to these improvements or to emissions trading. However, the focus on carbon policies is still considered to be important in setting the rules for carbon emissions and consequently for the impact on technological innovation, e.g. giving the time of implementation of the emissions reduction measures, deciding the industries to be involved, and so on. For example, the European Union defined an Emissions Trading Scheme (EU ETS), which is considered to be a flexible policy instrument compared to the traditional command and control environmental regulation to cut GHG emissions in order to achieve Kyoto's reduction targets. The ETS is a market-based policy instrument based on the cap-and-trade system which offers, in theory, the opportunity to meet environmental targets in the most cost-effective way. In other words, setting a cap on the permitted amount of emissions, corresponding to allocated allowances, and introducing a market for allowances grant companies with the flexibility to define their strategy (Rogge et al., 2011). In this way the price for allowances sets monetary incentives to adopt new solutions for energy-and carbon-efficient improvements, but it is practically influenced by the ETS design, e.g. rules of allowance allocations, cap definition and the use of credits from other Kyoto Mechanisms (Schleich et al. 2009).

Furthermore, in recent years businesses have also focused on adaptation responses to climate-induced physical changes that can have physical and financial impacts on organizations. These ecological changes differ from other kinds of environmental changes due to their greater scope and scale both in spatial and temporal terms, through their impacts and systemic origin, non linearity and related unpredictability, which implies difficulty in controllability and manageability, and finally by their irreversible and destructive characteristics (Winn et al. 2011). Based on the peculiarity of the

characteristics of the weather and climate events, some research studies argue about the need to incorporate the theory of organizational adaptation and the physical effects of climate-related physical changes through a resilience framework (Linnenluecke and Griffiths, 2010), and to incorporate anticipatory adaptation and organizational resilience capacities in strategic decision making (Linnenluecke et al., 2012).

Therefore, as suggested by Okereke et al. (2012), corporate responses to climate change could be considered along two main dimensions: 1) whether firms address actions arising from the causes or the consequences of climate change (mitigation vs. adaptation), and 2) the system that corporate activities are intended to influence (biophysical vs. socio-economic). Considering the increased frequency and intensity of weather and climate events in present and future years, the development of European and international policy on carbon emissions reduction, e.g. the European climate and energy package 20-20-20, and on climate adaptation, the growing attention of shareholders towards multinationals' carbon disclosure and the market changes, corporate responses to all these challenges are expected to gain strategic importance at corporate level.

This dissertation aims to examine how firms respond to climate change with three specific focuses: firstly the progress of corporate strategies from a mitigation to an adaptation perspective, secondly the identification of adaptation behaviour and finally the impact of EU ETS on organizations' management and environmental planning. To this end, the dissertation will answer the following questions:

- What is the state-of-the-art literature on corporate responses to climate change and what contributions have been made to the development of a theoretical reference frame on business and climate change?
- How do companies perceive and interpret their exposure and vulnerability to weather and climate events in terms of business impacts and financial implications and how has this subsequently been translated into adaptation and resilience strategies?

- How has EU ETS management been implemented in companies adopting an EMS? Who are the persons in charge of ETS-related activities within companies that have EMSs? Is the EU ETS able to influence corporate organizations and to trigger investment planning to a greater extent than the pre-existing EMS program and how?

These questions have been addressed in the corresponding studies collected in this dissertation. The papers are trying to investigate the issues related to the main topic of corporate responses to climate change. However each paper focuses on one main aspect of business responses following the development of business and scholar attention, as previously mentioned.

The first study comes from the need to understand the state-of-the-art literature about how companies respond to challenges related to climate change. In fact, after the signing of the Kyoto Protocol in 1997 academic interest in business climate-related issues increased, and a specific line of research arose in both management and business journals and in other disciplines such as natural environment and business, economics, and natural sciences journals. Previous research showed that scholars were not very engaged in the field of the business and management challenges that global warming is bringing (Goodall, 2008; Patenaude, 2011). These studies have documented the coverage of climate change management of business organizations in academic literature. Goodall (2008) limited the analysis to the distribution of publications in academic journals, in particular in leading journals. This analysis showed that the top 30 management journals from 1970 to 2006 only published 9 articles on climate change, none of which appear in top journals such as the *Academy of Management Journal* and the *Academy of Management Review*. Patenaude (2011) focused on the differences in the coverage in academic journals and press media, and found an overall increase in the proportional coverage in all databases and some tipping points. However, these two research studies did not analyze the content of these publications, the main research topics, such as the main objects of investigation e.g. the firm and industry, and the main research areas

and gaps. On the contrary, my study enabled me to group existing research studies on the basis of the aim of the corporate response to climate change (mitigation vs. adaptation) and on the basis of the problem context, representing a reference point for the development of further research.

From this literature review arose how earlier literature was focused on mitigation, while it is only in recent years that scholars have also started to be engaged in understanding adaptation responses. Corporate adaptation and resilience strategies for climate-induced physical changes are less well understood, in part because firms have not (yet) addressed adaptation to the same extent as policymakers and scientists have done (Linnenluecke and Griffiths 2010; Sussman and Freed 2008). More recently the emergence of a new stream of literature contributes to the understanding of corporate adaptation and resilience strategies through conceptual frameworks based in organization theory (Linnenluecke and Griffiths 2010; Linnenluecke et al. 2012; Winn et al. 2011) and empirical work using case studies and surveys within specific industries (Beermann 2011; Busch 2011; Galbreath 2011; Haigh and Griffiths 2012; Hertin et al. 2003; Hoffmann et al. 2009; Linnenluecke et al. 2011; Scott and McBoyle 2007; Weinhofer and Busch 2012). These research studies have unearthed factors that influence the adaptation and resilience strategies firms deploy, e.g. awareness of climate-related physical threats, degree of uncertainty, and risk management capabilities. In the second paper, I build on these emerging research studies by examining how the way firms make sense of climate stimuli informs their strategies to adapt and become more resilient to climate-induced physical change. It has been argued that adaptation is an organizational change process in response to direct and indirect climate stimuli (Berkhout et al. 2006; Winn et al. 2011). What remained ambiguous, however, was what firms perceive as relevant climate stimuli that they might act upon. It can be said that this is the outcome of a sensemaking process where firms first interpret how climate change will (or has come to) affect their organizations before they take action (Linnenluecke et al. 2012). Due to the discontinuous nature and futurity of climate change impacts (Winn et al. 2011; Yusoff and Gabrys 2011), the outcome of

this sensemaking process is likely to vary considerably across firms. Therefore, I expect that firms' sensemaking of climate change will explain much of the variation in the adaptation and resilience activities of firms. To empirically explore the influence of corporate sensemaking of climate stimuli on adaptation and resilience strategies, I focus on the global oil and gas industry. This industry is particularly sensitive to physical changes due to its reliance on natural resources such as water supply; the fact that operations are located in geographic areas exposed to extremes; a high dependence on large-scale infrastructures; and its long-lived and relatively immobile capital assets. Using data from the 2010 Carbon Disclosure Project survey, I analyse how oil and gas firms perceive and interpret their exposure and vulnerability to weather and climate events in terms of business impacts and financial implications and how this has subsequently been translated into adaptation and resilience strategies.

Besides, the third paper address corporate response to regulatory policies related to climate change, in particular to the EU ETS. In fact, up to now, knowledge of the mutual influences of strategic planning, ETS management and EMSs is still incomplete, and their implications are not fully understood. My study tries to identify whether the involvement of a firm in the ETS with the adoption of an EMS favours the generation of corporate strategic synergies in terms of organizational management and environmental planning. In fact, it is still unclear whether ETS-related activities are allocated to existent departments and functions; for example, to those involved in EMSs, or companies setting up new ones. To this end, we provide an analysis of how ETS management has been implemented in companies adopting an EMS. In detail, the analysis focuses on the identification of the persons in charge of ETS-related activities within companies with EMSs. Another objective of the research is to understand whether the ETS is able to influence a corporate organization and to trigger investment planning to a greater extent than a pre-existing EMS program. I addressed these questions by carrying out multiple case studies of the Italian pulp and paper industry. This industry has been very receptive to environmental voluntary regulations and features

organizations with installations that represent the most important European emitters in terms of emission size.

Since these three papers have been written for publication separately, each one is divided into the typical elements of a scientific study: an introduction, a literature review, the methodology, the findings, and finally the discussions and the conclusions. The next three chapters correspond to each of the papers. The final chapter draws conclusions and presents a research agenda.

- **Research on Organizations and Climate Change: a literature review**
- **Managing physical impacts of climate change: How awareness and vulnerability induce adaptation**
- **The mutual influence of Environmental Management Systems and the EU ETS: findings for the Italian pulp and paper industry**

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# 2. Research on Organizations and Climate Change: A Literature Review

## 2.1. Abstract

In recent years, climate change has caught the attention not only of scientists but also of public debate, legislation and business. In this paper a review of literature has been carried out with the aim of identifying if and what the contributions have been to the development of a theoretical reference frame on business and climate change. A sufficient body of available academic peer-reviewed articles enabled me to propose a first classification of research topics and areas, which are useful to identify gaps, issues and opportunities for further studies and research.

## 2.2. Introduction

From a scientific point of view, once the role of human activities on climate change has been recognized (Solomon et al., 2007), research in the field needs to be oriented towards the analysis of alternative ways to mitigate the negative externalities coming from these activities, i.e. reducing greenhouse gas (GHG) emissions that impact on the rate and magnitude of change, and researching possible ways to adapt to its impacts on social and business activities. These two kinds of responses to climate change in terms of mitigation and adaptation actions can be complementary. However, the capacity to mitigate and adapt is dependent on socio-economic and environmental circumstances and on the availability of information and technologies (Wilbanks et al., 2007). Hence, climate change represents a major environmental policy challenge, both in the present and in the future (Levy, 1997), but it is also considered a business concern for many reasons. On the one hand, companies are directly (e.g. those producing fossil fuel and electricity) and indirectly (e.g. those consuming fossil fuels and electricity) responsible for GHGs emissions, and in certain cases to a greater extent than countries (Patenaude, 2011). This further implies that they can play a huge role in mitigation. For example, the

mining group Rio Tinto rivals the emissions of New Zealand, but instead the GHG emissions of ExxonMobil are higher than those of Belgium (Patenaude, 2010). On the other hand, companies are affected by the impacts of climate change in terms of ecological changes, e.g. weather and climate events (Linnenluecke and Griffiths, 2010; Linnenluecke et al., 2012; Winn et al. 2011). The extent of these impacts is supposed to be even greater than those of globalization and information technology and it may potentially trigger a business revolution (Porter and Reinhardt, 2007). In fact, the direct and indirect impacts of climate change on business can be related to carbon policies at both international and national levels, to market changes or to climate-induced physical changes affecting the environment where firms operate. In particular, the latter can pose major challenges to business companies, leading to a reconsideration of the relationship between organizations and their ecological environment, which until now was supposed to be stable (Winn et al. 2011). However, if well managed, the challenge of climate change could represent an opportunity for companies, for example for those that want to develop new market products or that achieve GHGs emissions reduction and profit from allowances sale on emerging emission trading systems (Kolk and Pinkse, 2004). Corporate responses to climate change can differ across industries and countries and can depend on multiple internal and external factors. Corporate responses to climate change can have market or non-market drivers. Generally, the main steps implemented by business companies to deal with the climate-related challenges are the assessment of corporate vulnerability and opportunities, the definition of the emission profile and the carbon emission management, the development of climate-related strategies and the disclosure of corporate climate-related information.

In this article I propose a review of the academic literature on how companies respond to the challenges related to climate change. After the signing of the Kyoto Protocol in 1997, academic interest in climate-related issues increased, and a specific line of research arose in management and business journals. Indeed, the implications of global warming in business policies, operations, market and financial aspects have caught the attention of organizations and thus of

researchers. Nevertheless, previous research showed that scholars in the field of business and management have not been very engaged with the challenges that global warming is bringing (Goodall, 2008; Patenaude, 2011). Until now, only a couple of studies have documented the coverage of climate change management of business organizations in academic literature. The first one limited the analysis to the distribution of publications in academic journals, in particular in leading journals (Goodall, 2008). This analysis showed that the top 30 management journals from 1970 to 2006 only published 9 articles on climate change, and none of them appear in top journals such as the *Academy of Management Journal* and the *Academy of Management Review*. While the second study focused on the difference in the coverage of academic journals and press media (Patenaude, 2011), it found an overall increase in proportional coverage in all databases and some tipping points. Instead, in this study I identified not only the coverage of the topic in academic journals mainly in the field of business and management, but also analyzed the content of these publications, identifying the main research topics, such as the main objects of investigation e.g. the firm and industry, and the main research areas. This kind of analysis enabled me to group existing research on the basis of the aim of the corporate responses to climate change (mitigation vs. adaptation) and on the basis of the problem context. Five main areas of research in business climate-related issues emerged: a) risks and opportunities; b) carbon accounting; c) business responses to climate change with the aim of emission reduction; d) carbon disclosure; and finally e) corporate adaptation. Furthermore, I labeled scholars' contributions according to the tone of the article: Descriptive, Investigative or Normative. This kind of labeling tends to confirm and extend preview studies on business and the natural environment (Etzion, 2007). The literature frame presented here could provide scholars and schools of management with a reference point to study in depth the theoretical contributions of the responses of business organizations to the challenges of climate change and to develop further research.

In the next sections, after providing details of the method used to obtain the coverage of Corporate Responses to Climate Change

(CRtoCC) in academic journals and to perform my content analysis, I show the results of this study. Then, in the following part, I provide a literature classification representing a reference framework on CRtoCC. At the end of the paper, I draw some conclusions identifying the limits of the available research and potential issues and opportunities for further studies.

## 2.3. Methods

In order to identify major works on corporate climate change research, and thereafter analyzing and classifying them into narrower research areas, I carried out a literature review. I firstly defined the unit of analysis, choosing to limit the study to academic peer-reviewed articles. I only made one exception for a research study carried out by an academic researcher (Hoffman, 2006) on behalf of the Pew Center on Global Climate Change and presented with a peer-reviewed article on the *Harvard Business Review* (Fryer, 2007). I also delimited the problem context to studies focused directly or indirectly on business perceptions, reactions and interactions with climate change challenges. I firstly collected articles that had mentions of *'corporate responses', 'carbon management', 'business strategies'* AND *'global warming', 'climate change', 'Green House Gases'* and similar keywords using two main library databases: *ISI Web of knowledge*, similar to the two previous research studies on CRtoCC academic journals coverage, and *ELSEVIER Science Direct*. Through this method, I identified nearly 60 articles, and in contrast to previous works, I went back to other papers by cross-referencing. This allowed me to find another 73 articles that focused on CRtoCC, for a total of 133 papers published until mid 2012. After reading and analyzing these articles I selected 114 final papers that were pertinent with the aim of this literature review and excluded highly technical works on topics such as carbon footprint or technological responses, which focused on a specific regulation system such as the European Emissions Trading Scheme (EU ETS), and a couple of other articles that focused on the broad topic of sustainability or international organizations' responses to climate change.

After the paper selection I carried out content analysis with the aim of identifying the main research areas and topics. I pointed out the kind of firms (including firm size and home country, where specified) and industries investigated, or even cited. Furthermore, in the first step, I labeled the research tone of articles as descriptive (D), and prescriptive (P), as suggested by Etzion (2007), but diversified the former into two narrower categories: descriptive (D) and investigative (I). By Prescriptive tone I mean that the author shows a clear goal to yield insights that can allow firms to perform better than their competitors over time or to cope with climate change. The diversification into a descriptive and investigative tone comes from the need to diversify the research tone aimed at describing new facts, events and actions, which can be particularly numerous and sometimes disruptive in relation to climate change, in the case of the former, and aimed at also identifying mechanisms and causal links, in the case of the latter. The list of the 113 references analyzed is given at the end of the paper.

## 2.4. Academic coverage and content analysis results

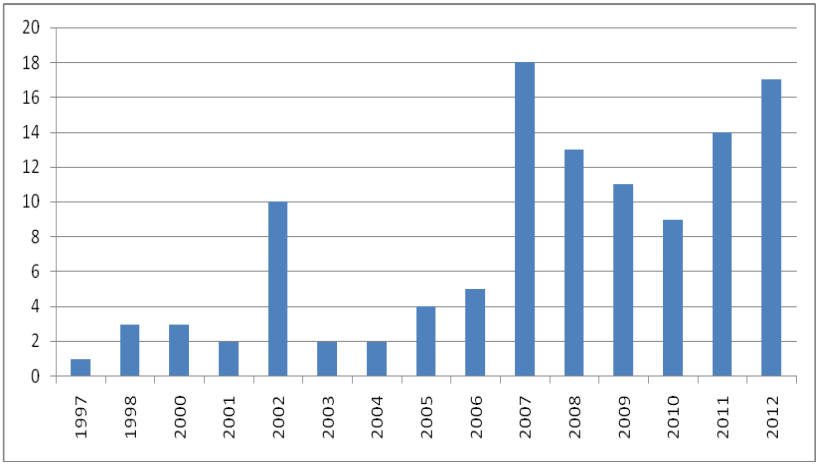
This section is subdivided into the key conceptual elements introduced earlier: academic coverage of the topic, particular elements of the articles such as the investigation object and regional boundaries of the study, the companies and industries investigated, methodologies and sources of data, and finally the research tone.

### *2.4.1. Academic coverage of CRCC*

My analysis suggests that in the last few years an increasing number of articles on CRtoCC have been published in academic journals. Figure 1 shows that from 1997 to 2006 only a few articles were published, with a tipping point in 2002, due to one special issue of *Greener Management International* that focused on the topic. However, since 2007 scholars' attention seems to have reverted. In fact, in 2007 I found 18 peer-reviewed papers and on average a growing number of articles in the following years than there had been in the previous years. We could attribute this increased attention of scholars to some particular events that happened between 2005 and

2007 that contribute to disseminating knowledge and increasing public awareness (Patenaude, 2011), for example, the coming into force of the Kyoto Protocol in February 2005; the warning of global warming with the involvement of Al Gore through the documentary and the book "An Inconvenient Truth" in 2006 (Al Gore, 2006), followed by the awarding of the Nobel Prize in 2007 together with the Intergovernmental Panel on Climate Change (IPCC), which published its IV Assessment Report (IPCC, 2007); and finally the publication of the Stern Review on the Economics of Climate Change (Stern, 2006). As was to be expected, since 2007 the average number of academic publications has increased per year, as some journals put together a special issue on CRtoCC, such as the *Harvard Business Review* and the *European Management Journal* in 2007 and *Business & Society* in 2012. However, considering the novelty of the topic and the implications for business, we could say that the literature on CRtoCC is still limited in quantitative terms.

**Figure 1. No. of peer-reviewed articles on CRtoCC per year**




By analysing the journals involved in the publications on CRtoCC we can see, as shown in Table 1, that a journal with a major number of publications is *Business Strategy and the Environment* with 11 publications on CRtoCC (Galbreath, 2010; Jeswani et al., 2008; Pinkse, 2007; Weinhofer and Hoffmann, 2010; Haigh and Griffiths,

2009; Martin and Rice, 2010; Pinkse and Kolk, 2010; Sprengel and Busch, 2011; Linnenluecke et al., 2012; Winn et al., 2011; Weinhofer and Busch, 2012), followed by the *Harvard Business Review* with 10 articles (Fryer, 2007; Hoffman, 2007; Hoffman, 2004; Lash and Wellington, 2007; Levy et al. 2007; Packard and Reinhardt, 2000; Porter and Reinhardt, 2007; Rau et al., 2010), *Business & Society* with 8 papers (Clark and Crawford, 2012; Haigh, and Griffiths, 2012; Linnenluecke and Griffiths, 2010; Okereke et al., 2012; Pinkse and Kolk, 2012a; Rothenberg and Levy, 2012; Thistlethwaite, 2012; Furrer, et al, 2012), and the *European Management Journal* with 7 papers (Jones and Levy, 2007; Kolk and Hoffmann, 2007; Kolk and Levy, 2001; Kolk and Pinkse, 2004; Okereke, 2007; Pinkse and Kolk, 2007; Schultz and Williamson, 2005), *Greener Management International* with 5 articles (Dlugolecki and Keykhah, 2002; Dunn, 2002; Hofman, 2002; Nordqvist et al., 2002; van der Woerd et al. 2002) together with the *Journal of Cleaner Production* (Beermann, 2011; Dragomir, 2012; Gallego-Álvarez et al., 2011; Pellegrino and Lodhia, 2012; Schaltegger and Csutora, 2012). Besides, *Climate Policy*, *Climatic Change*, *Corporate Environmental Strategy*, *Global Environmental Change*, *Journal of Business Ethics* and *Journal of International Business Studies* published three papers about CRtoCC. It is also worth mentioning that three leading journals included in the list of the top 30 business and management journals (Goodall, 2008) published studies on CRtoCC: *California Management Review*, with four articles (Hoffman, 2005; Kolk and Pinkse, 2005; Levy, 1997; Okereke and Russel, 2010), together with the *Harvard Business Review* and the *Journal of International Business Studies* (Pinkse and Kolk, 2012b; Kolk and Pinkse, 2008; Romilly, 2007). Moreover, other journals not listed in Table 1, but included in my review, published one or two articles on CRtoCC.

**Table 1. Number of peer-reviewed articles on CRtoCC per journal with at least 3 publications**

| Journal | No. of peer-reviewed articles on CRtoCC |
|---|---|
| *Business Strategy and the Environment* | 11 |
| *Harvard Business Review* | 10 |
| *Business & Society* | 8 |
| *European Management Journal* | 7 |
| *Greener Management International* | 5 |
| *Journal of Cleaner Production* | 5 |
| *California Management Review* | 4 |
| *Climate Policy* | 3 |
| *Climatic Change* | 3 |
| *Corporate Environmental Strategy* | 3 |
| *Global Environmental Change* | 3 |
| *Journal of Business Ethics* | 3 |
| *Journal of International Business Studies* | 3 |

### *2.4.2. Content Analysis*

The analysis of articles' characteristics pointed out some interesting results. As in an emerging research area, there are poor sources of data, and scholar studies are affected by this limitation. In fact, in CRtoCC studies, the first source of data seems to be directly interviewing the companies investigated, the data source employed in 26 articles. The second source of data is the annual reports and Corporate Social Responsibility Reports, used in 20 analyses. The third source of data is the Carbon Disclosure Project (CDP), which was launched in 2000 and has gained information on the corporate climate profile of the *Financial Times* 500 firms, though it now surveys a much larger and more international group of firms. To date, CDP represents the most important database about business climate-related responses in terms of perceived risk and opportunities, climate-related strategies and carbon accounting. That is why this database provided data for 18 peer-reviewed articles on CRtoCC. Other sources of data are quite widespread: websites, documentary analysis, direct surveys or surveys conducted by a third party e.g., the Pew Center on

Global Climate Change, the CERES and so on, and CEO and CFO public declarations. However nearly one half of the articles do not mention any source of data. Concerning the methods employed in CRtoCC studies, 36 articles do not contain mention of methods for the analysis, while many articles try to approach the new topic with case studies, qualitative analysis, content analysis, simulation models and so on, whereas, only 12 studies are based on quantitative analysis. The limited use of quantitative analysis could be explained both by the lack of data sources and by the necessity of highlighting the importance of the new problem, defining the meaning of various terms and the context, delimiting research boundaries, and suggesting further research areas, as in any emerging research area (Srivastava, 2007).

The analysis and the classification of the literature on CRtoCC according to the research tone provide some interesting insights. In fact, as shown in Table 2, I found that 33% of the literature considered has a descriptive tone, including articles that try to give an interpretation of corporate stance and actions in response to climate change with available theories (e.g. Levy, 1997; Newell and Paterson, 1998; Levy and Newell, 2000; Levy and Egan, 2003; Kolk and Pinkse, 2007); around 46% have an investigative tone, while 20% of the papers have a prescriptive tone. On the one hand, the analysis confirmed that this early literature on CRtoCC focuses on the necessity and the importance of climate change for business (Porter and Reinhardt, 2007), defines the context, delimits research boundaries and tries to foresee a perspective for companies dealing with the challenge of climate change. On the other hand, articles with a prescriptive tone are still fewer in number in quantitative terms than descriptive and investigative studies. One possible cause for this could be the novelty of the topic and the incertitude linked to possible ways for coping with climate change for the achievement of a competitive advantage or for dealing with its physical impacts.

**Table 2. Analysis of the literature according to the research tone**

| Research Tone | No. Papers | % of Papers |
|---|---|---|
| D | 38 | 33 |
| I | 53 | 46 |
| P | 23 | 20 |
| tot | 114 | 100 |

Considering the object of investigation, where mentioned or specified, I found that the main objects of investigation are multinational companies (MNCs) (investigated in 40 papers), while only a couple of studies have been carried out on small and medium enterprises (Beermann, 2011; Pelling et al., 2008). Furthermore, the regional boundaries of the research, where mentioned or specified, are mainly the USA (17 articles) and the EU (35 articles), both alone and together. Sometimes, the European Union is targeted by the analysis not as a whole, but with a focus on one specific country, such as the United Kingdom (10 articles) and Germany (3 articles). Instead, fewer research studies are based on other developed countries such as Canada (2 articles), Australia (10 articles) and Japan (3 articles), and even less on developing countries such as Turkey (Kaya, 2008), Pakistan (Jeswani et al., 2008) and South Africa (Reyers et al., 2011). Looking at the literature production on CRtoCC about the kind of industry investigated and companies mainly involved in the research or even cited, I found that academic studies have focused in particular on carbon intensive industries, such as oil and gas, energy (e.g. Linnenluecke et al., 2011; Busch, 2011; Haigh and Griffiths, 2012) and automotive (e.g. Rothenberg and Levy, 2012) industries. In particular there is a specific research line that focused on the oil and gas industry (Lowe and Harris, 1998; Rowlands, 2000; Skjærseth and Skodvin, 2001; Kolk and Levy, 2001; van den Hove et al., 2002; Le Menestrel et al., 2002; Levy and Kolk, 2002; Pulver, 2007). According to these results, the companies that have been investigated the most are British Petroleum (8 articles), Exxon-Mobil (7 articles) and Shell (6 articles). Even if we analyze the most cited companies and industries that scholars use to support their analyses in relation to CRtoCC, I found that BP is cited in at least 23 articles, Shell in at least

19 articles and Exxon-Mobil in at least 11 articles. Other companies frequently cited are Dupont (11 articles), Ford (10 articles) and Toyota (9 articles). The most cited industry is oil and gas, followed by the insurance industry, which is often cited to explain the physical impacts of climate change and climate-related risks, even if only a few articles investigate the CRtoCC of the insurance industry (Dlugolecki and Keykhah, 2002; Mills, 2009; Thistlethwaite, 2012). Presumably this attention comes from the different stance publicly announced by two of the major oil companies in the early stages of the issue. In fact, when climate change first emerged as an international policy concern, the oil companies, united, opposed to any international effort to regulate GHGs (Pulver, 2007). They set up a lobbying group in 1989 called the Global Climate Coalition (GCC), to fight against mandatory climate policy at US and international levels. Through the GCC they questioned the scientific basis of the problem and raised concerns about the economic costs of binding emission reduction targets (van den Hove et al., 2002). This position found in Exxon its main supporter. At the same time, other industries, such those investing in gas and renewables and banks and insurance companies, supported climate policy initiatives. However, after British Petroleum's CEO, John Browne, announced to the world in a public speech that BP accepted the occurrence of climate change, and its intention to reduce its contributions to the process in 1997 (Lowe and Harris, 1998), Shell and a few other oil companies also broke ranks and supported international actions on tackling climate change (Pulver, 2007). However other industries have not been neglected, such as winter tourism (Scott and McBoyle, 2007; Hoffmann et al., 2009); the public water supply (Arnell and Delaney, 2006; Wilby and Vaughan, 2011); the food industry (Beermann, 2011, Galbreath, 2011; Pelling et al., 2008); the building industry (e.g. Hertin, et al. 2003) and so on.

These results highlight some limits in the present literature such as the focus on MNCs and on USA and EU boundaries, and the focus on carbon intensive industries, in particular the oil industry, which presents many peculiarities. On the one hand, these limits could be due to the lack of data, considering that the main database on CRtoCC is represented by CDP's questionnaires, and that carbon disclosure

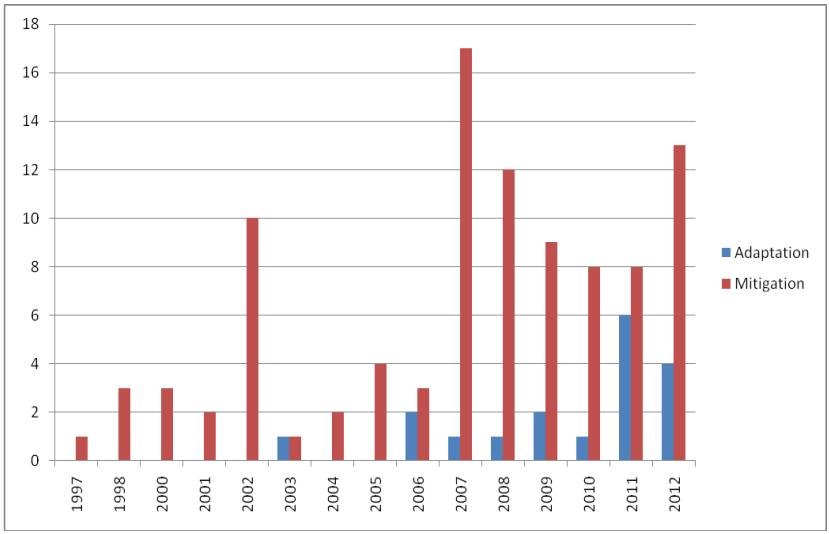
depends on corporate size (Freedman and Jaggi, 2005; Prado-Lorenzo et al., 2009), market capitalization (Prado-Lorenzo et al., 2009) and the threat of state regulation (Reid and Toffel, 2009; Freedman and Jaggi, 2005). On the other hand, these gaps represent a stimulus to collect different data and an opportunity to explain the dynamics of CRtoCC in other industries, for companies operating at national level and for small and medium enterprises, for companies based in different countries and in developing countries. By filling these gaps scholars would integrate and complete the present literature.

## 2.5. Classification of CRtoCC based on the problem context

I classified the existing CRtoCC literature into two broad categories based on the aim of corporate response to climate change such as mitigation, i.e. how businesses act to address the causes of climate change, that is reducing greenhouse gas emissions; and adaptation, i.e. how businesses deal with the physical consequences of climate change. This distinction reflects the actions needed by societal actors in relation to climate change, as identified by the Intergovernmental Panel on Climate Change (IPCC, 2007) and confirmed by some scholars for business strategies (Wittneben and Kiyar, 2009; Okereke et al., 2012). I further classified the papers into five narrower categories on the basis of the problem context: a) risks and opportunities; b) carbon accounting; c) business responses to climate change with the aim of emission reduction; d) carbon disclosure; and finally e) corporate adaptation. While the literature about risks and opportunities concerns both mitigation and adaptation, the literature regarding categories b, c, and d is mainly focused on mitigation. Finally, the literature about corporate adaptation to climate-induced physical changes still seems to be limited to being divided into narrower categories (Figure 2). I purposely do not consider literature and practices related either to the impact of specific climate change-related regulation such as the EU-ETS, or to technological responses. This classification is for the purpose of simplifying the understanding of different business problems linked to climate change, identified to date by peer-reviewed studies. It could provide a clear picture for

further studies and research. Moreover, it is not rigid. In fact, some research studies analyze more than one topic in the same paper, while a few papers cannot be included in this classification.

**Figure 2. No. of articles per year and per broad category**




### *2.5.1. Climate-related risks and opportunities*

Climate change can affect organizations directly and indirectly in the many aspects they have to deal with: from regulation compliance to competitiveness, from assets and resource availability to public relations, from innovation to financial aspects, and also threatening physical security. Climate change can represent both a risk and an opportunity for organizations. Scholars have mainly identified the risks driving corporate responses to climate change rather than the opportunities (e.g. Lash and Wellington, 2007; Romilly, 2007; Wittneben and Kiyar, 2009; Kolk and Pinkse, 2004; Porter and Reinhardt, 2007; Hoffman, 2005; Packard and Reinhardt, 2000). However, business exposure to such risks and opportunities could represent a driver for coping with climate change (Kolk and Pinkse, 2004), because, often, the identification of climate-related risks and opportunities is considered to be one of the first steps for designing and implementing climate-related strategies (Hoffman, 2006; Busch

and Hoffmann, 2007). The main climate-related risks and opportunities mentioned by the scholars are:

- *Regulation*. Regulation can have a profound impact on business growth and profitability. Regulatory risk can take the form of regulating emissions of products (e.g. car emissions) or processes, and can be implemented in different ways. Examples of carbon emission regulation are carbon taxes, emissions reduction requirement, cap and trade systems such as the EU ETS, the Canadian Regulatory framework, the Australian Climate Exchange (ACX); the Chicago Climate Exchange (CCX); the California Global Warming Solutions Act (Lash and Wellington, 2007). Regulation aimed at limiting GHGs emissions could represent an additional cost for companies if not well managed (Wittneben and Kiyar, 2009) or an opportunity, e.g. though the anticipation of emission reduction compared to ill-prepared competitors (Packard and Reinhardt, 2000; Hoffman, 2004; 2005; Boiral, 2006). Considering regulation as a business risk or opportunity may depend on the type of industry. For example, oil and gas, mining, metals and utilities generally perceive regulation as a risk, instead financial companies may assist customers affected by such regulation through facilitating their emission trading or financing offset projects for them (Kolk and Pinkse, 2004). Furthermore, companies could gain expertise in GHGs emission reduction and then influence policy makers to make sure that rules fall in their favor (Hoffman, 2005), or just benefit from new carbon market of allowances (Hoffman, 2004).
- *Physical risks*. Physical impacts from climate change can pose major challenges to business companies. Particularly sensitive are those sectors relying on particular temperature and seasonal conditions such as agriculture, forestry, tourism etc. (Alcamo et al., 2007; Lash and Wellington, 2007), those with industrial facilities located in climate-sensitive areas (such as coasts and floodplains) and with long-lived capital assets (Wilbanks, et al., 2007), industrial sectors dependent on

climate-sensitive inputs such as food processing (Beermann, 2011), and finally those relying on large scale infrastructure (Handmer, et al., 2012), such as energy, automotive and transportation sectors (Winn, et al., 2011). Physical risks are distributed differently across the globe with many implications for international business and the insurance market (Romilly, 2007). Linnenluecke and Griffiths (2010) also highlight the importance of other contingent variables in the assessment of business impacts of extreme weather events. They argue that the impacts of climate related events also depend on the vulnerability of the affected firm, as reflected in the relative firm size and previous experiences with similar events.

- *Supply chain risks*. This kind of risk is connected to the vulnerability and the geographical distribution of the suppliers, which could lead to higher material and energy costs (Lash and Wellington, 2007). Beermann (2011) highlights that the complexity of supply chains plays an important role regarding the degree of vulnerability of the German food industry.
- *Product and technology innovation.* A world with carbon constraints can start off new markets such as renewable energies, low carbon products, green building, new financial services and so on. Companies can achieve financial gains by introducing new goods or production process and an innovative action could result in monetary benefits, following the idea of Schumpeter's pioneer profit (Wittneben and Kiyar, 2009). A company can fare better than others if it identifies and exploits new market opportunities for climate friendly products and services (Porter and Reinhardt, 2007; Kolk and Pinkse, 2004; Wittneben and Kiyar, 2009; Lash and Wellington, 2007; Hoffman, 2005; Cook and Barclay, 2002). But choosing or adopting an innovative technology or product under environmental incertitude could also be risky.
- *Changes in customer needs*. Climate change could have an impact on customer demand, not only for climate friendly

products and for product and technology innovation, but also by causing changes in economies, related for example to weather, resource availability and so on (Schultz and Williamson, 2005). In fact, climate-related physical changes could also affect demand for some products in a positive way, representing a risk or opportunities for a variety of industries, 'for example, if tropical diseases migrate into more industrialized nations – which is likely as temperatures become warmer at higher latitudes – pharmaceutical companies may see their market expand' (Packard and Reinhardt, 2000).

- *Operational effectiveness improvement.* Companies could introduce process or energy efficiency improvements and cost savings, for example, together with the opportunity of benefiting from government financial incentives (Porter and Reinhardt, 2007; Kolk and Pinkse, 2004; Hoffman, 2005; Cook and Barclay, 2002).
- *Litigation risks.* Companies can create personal liabilities for directors and officers who become vulnerable to shareholder litigations by not changing emissions patterns (Lash and Wellington, 2007).
- *Reputation*. Industries or companies, where brand loyalty is an important component of corporate value, can be exposed to reputational risks if they continue to use products, processes or practices that have a negative impact on the climate (Lash and Wellington, 2007). This behavior can also affect the reputation with respect to employees and institutions (Wittneben and Kiyar, 2009). On the contrary, implementing a strategy to cope with climate change or accepting responsibilities can lead a company to improve its public relations in terms of brand, image and reputation improvements and with regards to better relations with customers, financial markets, institutions, stakeholders and employees (Wittneben and Kiyar, 2009; Kolk and Pinkse, 2004; Hoffman, 2005; Cook and Barclay, 2002).

- *Financial impacts*. Wittneben and Kiyar (2009) also identified the financial risk that occurs when rating societies take into account environmental and sustainability performance in their investment decisions, for example in case of economic losses due to natural disasters. It also seems that financial markets are starting to incorporate climate change in order to determine risk premium rates for companies (Busch and Hoffmann, 2007). In addition, Hoffman A. (2005) argues that the availability of capital is directly related to the issue of GHGs trading schemes. For example, many governments are introducing financial incentives to reduce GHGs (Hoffman, 2005), and financial companies may assist customers affected by GHGs regulation (Kolk and Pinkse, 2004). That is why climate change can open up new ways of accessing new sources of capital for businesses.

Each company is affected differently by climate-related risks and opportunities. This is why Busch and Hoffmann (2007) propose considering a company's carbon constraint profile as determined by: *(a) the company's asset mix, (b) the dependency on and intensity of carbon-based input factors and energy production, (c) the possibility for substitution and technological alternatives, (d) the technological trajectory and industry specific innovation patterns, (e) the company's position in the value chain, and (f) the location of its operational activities and sales.* Moreover, Bledaa and Shackley (2008) presented a simulation model of the dynamics of the belief of a business organization in climate change and its risks.

### *2.5.2. Carbon accounting*

Porter and Reinhardt (2007) argued that carbon emissions need to be considered as costly, because some countries already implemented taxes on carbon emissions, and because it is a matter of operational effectiveness. Adopting the GHGs emissions measurement is considered one of the first steps of businesses' responses to climate change aimed at mitigation (Hoffman, 2002, 2005, 2006; Kolk and Pinkse, 2004; Boiral, 2006; Lash and Wellington, 2007; Porter and Reinhardt, 2007; Wittneben and Kiyar, 2009). In fact, potentially,

quantifying carbon emissions allows firms to better evaluate some risks and opportunities, for example those deriving from carbon regulation, and therefore to make informed decisions on GHGs emission reduction targets. Hoffman (2005) maintained that GHGs measurements are often connected to the objective of cost reduction, but becoming familiar with GHG emissions measurement, reduction strategies and external trading schemes, represents a new area of expertise. As a result, some companies have created internal GHG trading systems to prepare themselves for potential future regulations. Boiral (2006) proposes the implementation of a GHGs emission inventory, firstly to gain a better understanding of the main source of emissions and to determine more precisely the priority of environmental initiatives, and secondly if companies want to participate in the GHG trading systems. Lash and Wellington (2007) suggested that quantifying the carbon footprint over time has the aim of identifying and prioritizing emission reduction opportunities and establishing strategies for participating in the GHG trading market. Furthermore, quantifying the carbon footprint also represents a strong signal that a company has recognized the importance of climate change. As far as I am aware, only a few research studies on carbon accounting implementation have been published in peer-reviewed journals. Among these, Kolk and Pinkse (2004) and Hoffman (2006) studied in depth the limitations and ambiguities of the current measurement systems implemented by companies at the time of the research. In fact, Kolk and Pinkse found that many companies had not yet implemented the GHGs emissions inventories so far, while for others who did, considerable differences existed with regard to the type of greenhouse gases monitored. Furthermore, the time frames and the baseline years were very different. Then, if GHGs emissions were measured, the majority of companies used this information to draw up environmental programs including targets for emission reduction or stabilization. However, climate change targets were sometimes part of broader environmental programs that were already in place. Controlling GHG emissions was not always limited to monitoring and target-setting. A number of companies used the resulting climate change indicators for internal control purposes, for investment

decisions or for credit-making process. A few companies implemented an internal emissions trading scheme for internal compensation purposes. But these findings partially differ from those of Hoffman. Indeed this scholar found that many companies implemented carbon emission accounting differently from the aforementioned research, but only some companies measured the actual emissions, while the majority estimated emissions using fuel-based calculations. This difference depends, in part, on the complexity of the task. There was no homogeneity in the emission metrics. There was also differences in the GHGs accounted. In addition, Hoffman identified other ambiguities both in direct and in indirect emissions. Besides, Kolk et al. (2008) pointed out three difficult aspects of carbon accounting: firstly, the decision about which emissions firms are responsible for, i.e. the problem of organizational boundaries. A result of the different ways of setting organizational boundaries is that emissions may be double counted by more than one firm or not counted at all. But when the commensuration takes place within the framework of an emissions trading scheme these boundary issues are settled. Secondly, some multinationals only account or report the emissions of specific locations. Thirdly, such problems related to the commensuration also have an impact on the auditing of emissions. In fact, the auditing process is conducted internally and the external verification is often only partial. Yet, the lack of external verification compromises the credibility of carbon accounting. The unreliability of the GHG emissions data provided by leading companies is also highlighted by a longitudinal study of sustainability reports carried out by Dragomir (2012), who pointed out unexplained figures and methodological inconsistencies. The difference among the findings of the aforementioned research could be attributed to the different samples, the information collection process and timing. A couple of studies provide an overview of the carbon accounting issue. In particular, Bebbington and Larrinaga-Gonzàlez (2008) focused on financial and non-financial GHG accounting, while Schaltegger and Csutora (2012) clarified the two main functions of carbon accounting: on the one hand creating transparency by accounting for the un-sustainability of current and past operations and forecasting future emissions; on the

other hand accounting for sustainability improvements by the identification and evaluation of reduction measures and by supporting carbon management decisions. Rietbergen and Blok (2010) developed a taxonomy for categorizing SMART industrial energy use or the greenhouse gas emission reduction targets arising from carbon accounting. Hoffmann and Busch (2008) defined four corporate carbon performance indicators: carbon intensity; carbon dependency; carbon exposure and finally carbon risk. They propose these indicators to distinguish between the physical and monetary dimensions and between current and future performances.

### *2.5.3. Mitigation responses*

The main part of the literature is focused on corporate strategies in response to climate change with the aim of mitigation. Some of these studies try to define a framework and to describe the current status, whereas others attempt to analyze how certain endogenous or exogenous variables influence the definition and the implementation of such strategies. Researchers agree on the need for companies to design and implement strategies for the management of climate-related challenges because of the risks and opportunities linked to the issue. Some scholars focus their attention on the necessity of assuming a leadership (Dunn, 2002), catching the first mover advantage (Wittneben and Kiyar, 2009; Hoffman, 2004, Hofman, 2002), doing better than others (Lash and Wellington, 2007), of having a proactive strategy (Hoffman, 2002) and implementing innovation (Hall and Vredenburg, 2003). Some research studies point out a strategy design (Hoffman, 2006; Lash and Wellington, 2007; Linnenluecke et al., 2011), and some barriers to the implementation of such strategies (Okereke, 2007), as an example of the political uncertainty (Hoffman, 2006; Kolk and Pinkse, 2005; Engau and Hoffmann, 2009). Some others try to characterize the firm's profile according to business strategies (Boiral, 2006; Kolk and Pinkse, 2005; Pinkse and Kolk, 2007; Sprengel and Busch, 2011). There are attempts to analyze the relationship between competitiveness and internal or external factors (Hoffman, 2002; Kolk and Pinkse, 2008); and to understand the role of geographical factors (Kolk and Pinkse, 2008); the size scale and the

public vs. private dimension (Kaya, 2008). Okereke and Russel (2010) investigate the competitive dynamics. While, some research studies focus on corporate responses to the carbon market (Pinkse, 2007; Haigh, 2008); some studies investigate the implementation of emission reduction practices and business strategies (Sullivan, 2009, 2010), with a focus on specific countries (Park, 2008; Eberlein and Matten, 2009; Jones and Levy, 2007; Reyers et al. 2011) or on specific industries, such as the insurance industry (Dlugolecki and Keykhah, 2002; Mills, 2009; Thistlethwaite J, 2012), bank (Furrer et al, 2012), the oil industry (Lowe and Harris, 1998; Rowlands, 2000; Skjærseth and Skodvin, 2001; Kolk and Levy, 2001; van den Hove et al., 2002; Le Menestrel et al., 2002; Levy and Kolk, 2002; Pulver, 2007), and the cement industry (Nordqvist et al., 2002). Other studies try to identify factors explaining the differences in responses to climate change (Levy and Newell, 2000; Jeswani et al., 2008; Okereke, 2007; Galbreath, 2010; Weinhofer and Hoffmann, 2010), while others focus on the influence of companies in an institutional context (Kolk and Pinkse, 2007a; Martin and Rice, 2010) or vice versa on the regulatory influence on corporate responses (Engau and Hoffmann, 2009, 2011a,b; Okereke and Russel, 2010; Elliot and Pye, 1998) or the mutual relationship (Sprengel and Busch, 2011). According to scholars, a company needs to follow some steps for the development of climate strategy (Hoffman, 2006; Lash and Wellington, 2007): carbon accounting, risks and opportunities assessment, and finally strategy development. Hoffman (2006) points out some difficulties in the development of a climate-related strategy. First the strategic timing, i.e. acting too early or too late. Second, establishing an appropriate level of commitment. Third the need to influence the policy development. Finally, there is the importance of creating business opportunities. The question about the timing has also been highlighted by Boiral (2006). Boiral's study represents an attempt to identify the pros and cons, and the drivers of a proactive strategy vs. reactive or wait and see strategies. He finally suggests adopting a proactive strategy. Some scholars also make an attempt to classify climate-related strategies. Kolk and Pinkse (2004) propose a typology based on two dimensions: the aim (strategic intent) and the

degree of cooperation (form of organization). Companies can focus on innovation or on compensation. Furthermore, companies can implement strategies at an individual level, through their own supply chain, or together with others such as competitors, companies in different sectors and Non Governmental Organizations (NGOs). These scholars found that high energy intensive industries such as chemical, mining, utilities, and oil and gas generally implement strategies with an innovation aim, while low energy intensive industries such as telecommunications, and finance and insurance, generally implement compensation strategies. Another research field in the climate-related strategy is the definition of firm behaviour. Kolk and Pinkse (2005) identified six profiles: Cautious Planners; Emergent Planners; Internal Explorers; Vertical Explorers; Horizontal Explorers; and Emissions Traders. The majority of companies fall in the first two clusters. The other four profiles include companies that have a more proactive stance and that are in a more advanced stage of exploring the market opportunities related to climate change. The uncertainty about climate policy is considered a barrier to a more proactive approach. Lash and Wellington (2007) propose a theoretical model where the actions taken to reduce vulnerability to climate risks and the ability of a firm to seize climate-related opportunities are considered related. Hoffman (2002) links climate-related strategies and the competitiveness through strategic factors, such as 1) capital asset management; 2) market competencies; 3) global competitiveness; and finally 4) the institutional change management. A further attempt to find a relationship between competitiveness in terms of firm-specific advantage (FSA) and climate change was made by Kolk and Pinkse (2008). These authors suggest that there is a significant difference in climate change impacts on corporate upstream or downstream activities, or on the complete value chain. They show that responses to climate change are related to the industry and that most efforts are still evolutionary and focused on downstream activities in particular. An additional element analyzed in relation to FSAs is the geographical factor. Kolk and Pinkse (2008) develop a framework composed of six possible strategies of climate induced FSAs development linked to the geography of multinationals. They studied the origin of FSA

development (corporate headquarters, regional centre or national subsidiaries) and its transferability. According to this exploratory research many multinationals still focus on their home regions. Transferability is more likely to occur in the latest stages of the FSA development chain, such as in the sale stages. Scholars also investigated the relationship between climate-related strategies and public policies (Levy and Kolk, 2002; Boiral, 2006; Engau and Hoffmann, 2009; Hoffman, 2006). Levy and Kolk (2002) classified the climate change responses of US and European oil multinationals considering two dimensions: whether companies follow public policies or not and whether they are assertive or not with public positions. According to this model, companies' responses can be labelled as resistant, proactive, avoidant or compliant. An important issue that is strictly related to climate change are climate policies and the international regulation (Levy, 1997). In fact, the uncertainty associated with a regulation succeeding the Kyoto protocol represents a risk and influences business responses (Kolk and Pinkse, 2005; Engau and Hoffmann, 2009, 2011a,b). Engau and Hoffmann (2009) remark on a positive relationship firstly between lobbying and participation in the policy making process and uncertainty associated with post-Kyoto regulation, and secondly between flexibility, which means preparing for a different outcome of the treaty and uncertainty associated with post-Kyoto regulation. Sprengel and Busch (2011) found that response strategies are influenced by the combination of the overall level of perceived stakeholder pressures and GHG intensity of the company. Okereke et al. (2012) propose to consider corporate climate strategies in two dimensions: 1) whether the firms' actions addressed arise from the causes or the consequences of climate change (mitigation vs. adaptation), and 2) the system that corporate activities are intended to influence (biophysical vs. socio-economic).

### *2.5.4. Carbon disclosure*

In correspondence with the emergence of climate-related risks, at the beginning of the last decade, several initiatives have emerged with the attempt to leverage the influence of institutional investors to create demand for carbon disclosure as an adjunct to conventional financial

systems, with implications for asset valuations. Two of the most prominent are the Carbon Disclosure Project (CDP) and the Investor Network on Climate Risk (INCR). Some studies try to analyze the current situation on corporate climate-related disclosure by considering information published through CDP or environmental reports and organization websites, whereas others attempt to analyze how certain corporate variables influence the divulgation of these kinds of environmental information. According to Kolk et al. (2008) carbon disclosure contains information on a wide range of climate-related activities, including measurement emissions, organizational preparations, technological investments, and trading and offsets. These scholars analyze the utility and limitations of CDP, finding a growing response rate in term of the number of disclosing firms, but the information provided is not as valuable for investors, NGOs or policy makers. The CDP response data thus suggests that shareholder pressure can have an impact on disclosure, and that firms with a high share ownership by CDP signatories are more likely to feel pressured to disclose information about their carbon mitigation activities. Another research study provides similar findings about the relationship between shareholder actions and corporate disclosure of climate change strategies. In fact, Reid and Toffel (2009) show that firms that have been targeted, and firms in industries in which other firms have been targeted by shareholder actions on environmental issues, are more likely to publicly disclose information to the CDP. They further found that firms with headquarters in countries with proposed GHGs regulations are more likely than other firms to publicly disclose information to CDP, such as those that share an institutional field with firms under threat of regulation. They also show that firms in environmentally sensitive industries (e.g., electric utilities) appear to be particularly responsive to shareholder resolutions. Cotter and Najah (2012) also found that institutional investors have influence on the extent and the quality of climate change disclosure practices in terms of the completion and publication of CDP's questionnaire on CDP's website, indicators in corporate communication, and the extent and the quality of climate information. Prado-Lorenzo et al. (2009) show a direct relationship between

corporate size, the market capitalization and the disclosure of information. Conversely, an inverse relationship between return on equity (ROE) and disclosure has been detected. These scholars also found that the volume of information disclosed on GHGs emissions significantly depends on the activity sectors in which the company operates. These results are aligned with those of Freedman and Jaggi (2005). In fact these scholars discovered a direct association between firm size and greenhouse gas emissions disclosure. Similarly, they also identified a positive association between the index of disclosure regarding greenhouse gas emissions and companies from nations that have ratified the Kyoto protocol. This finding has also been confirmed by Gallego-Alvarez et al. (2011). These authors pointed out that companies with higher environmental performance disclose more information on opportunities on climate change. Haque and Deegan (2010) developed a climate change related governance disclosure classification scheme and examined its implementation in major Australian companies. Stanny and Ely (2008) confirmed the association between the propensity to respond to the CDP questionnaire and the company size, and also found that the former is related to previous disclosure and foreign sales. Ihlen (2009) investigates how the climate change issue is treated rhetorically in non-financial reports. He found that organizations acknowledge that the environmental situation is grave, accept the science of climate change and the need for mitigation, and recognize that climate challenge represents an opportunity. He also identified differences in regional bases (the US, Europe or China), industries (oil industries are more sensitive to the topic), and finally business (business to business companies or business to consumer). Finally, Ziegler et al. (2011) investigate the influence of corporate responses disclosure and stock performance, finding that a trading strategy of buying stocks of corporations with disclosure practices and selling stocks of corporations without disclosing practices have become more worthwhile over time in Europe, while the relationship between disclosure practices and stock performance is positive for energy companies in the USA.

### *2.5.5. Adaptation*

Scientific discourse is no longer only focused on providing evidence about climate change and on the need for mitigation, but also on the requirement for adaptation. In the same way, in organizational studies companies are no longer only seen as the cause of climate change but also as victims of physical impacts (Linnenluecke et al. 2012) and the main actors in societal responses to them (Berkhout, 2012). However, the issue seems to be very complex, due not only to its novelty but also to the number of variables to be considered, both related to the weather and climate-related events and their dimensions (e.g. time, magnitude, location, predictability, and so on, for all dimensions see Winn *et al*., 2011), and related to business characteristics, such as the size, the previous experience, awareness, business impacts (sector and company specific vulnerabilities), and so on. Adaptive behaviour seems to be organized by specific internal resources and by external conditions, implying a certain difficulty in prediction and generalization (Berkhout et al., 2006). In addition, according to some authors, climate change could be assimilated to periodical new forces reshaping the business world such as globalization and information technology revolution cause of its complexity and the potential impact (Porter and Reinhardt, 2007). Therefore, the complexity of the phenomena emerges from previous studies and consequently only certain aspects have been investigated up to now. On the one hand, some studies try to observe the dimensions of climate-related physical changes by highlighting the novelty compared to other environmental jolts, and suggest the need to interpret the phenomena with a new conceptual framework for studying organizational responses to extreme weather events. In fact, Winn *et al*. (2011) suggested the idea that physical climate impacts are not isolated phenomena, such as environmental jolts, but they constitute a threat of *massive discontinuous change* (MDC). MDC is defined as a 'significant, sudden, disruptive change in the broader ecological or social systems of which organizations and economic systems are part', and differs from other kind of environmental changes by a greater scope and scale both in spatial and temporal terms, by its impacts and systemic origin, its non linearity and related unpredictability, which implies difficulty

in controllability and manageability, and finally by its irreversible and destructive characteristics. Based on the peculiarity of the characteristics of the weather and climate events, some research studies argue for the need to incorporate the following into the theory of organizational adaptation: the physical effects of climate-related physical changes through a resilience framework (Linnenluecke and Griffiths, 2010), to consider the natural environment as a primary stakeholder (Haigh and Griffiths, 2009) and to include anticipatory adaptation and organizational resilience capacities in strategic decision making (Linnenluecke et al., 2012; Wilby and Vaughan, 2011). On the other hand, some studies focus on the identification of business variables influencing corporate adaptation behaviour and strategies, such as awareness (e.g. Arnell and Delaney, 2006), vulnerability (Hertin et al. 2003; Hoffmann et al. 2009), uncertainty (Hertin et al., 2003; Berkhout et al., 2006), ability to adapt and dependency on the affected business (Hoffmann et al., 2009), organizational capabilities (Busch, 2011), or external factors such as market and institutional policies (Berkhout et al., 2006). Awareness of the potential threat of climate change is widely recognized as an important factor influencing corporate adaptation strategies (Hertin et al., 2003; Berkhout et al., 2006; Arnell and Delaney, 2006; Bleda and Shackley, 2008; Hoffmann et al., 2009). For example, Arnell and Delaney (2006) maintained that 'before an organisation embarks on adaptation it must first be *aware* of the potential threat of climate change, and second be *concerned* about the potential impacts on its business. Without awareness there will be no concern, and without concern there will be no adaptation'. Hoffmann *et al.* (2009) found that awareness has a positive impact on corporate adaptation, while they cannot confirm the same for vulnerability. However, Haigh and Griffiths (2012) suggested that adaptation is mainly implemented as a reaction to climate surprise rather than an anticipatory response to increasing awareness, perceived uncertainty and risks. In particular, the surprise of the climate becoming unpredictable, directly affecting operations, and challenging the ability to predict weather trends on the basis of past data. These findings seem to confirm the previous insights of Bazerman (2006), who considered climate change as a

"predictable surprise", i.e. 'an event that leads an organization or nation to react with surprise, despite the fact that the information necessary to anticipate the event and its consequences was available'. The role of uncertainty is still unclear, in fact, while Hoffmann *et al.* (2009) did not find a significant influence of this variable on the adaptation strategy, Winn *et al*. (2011) considered uncertainty as a typical component of the organization's perception of the future state of their relevant environment in relation to climate change, and Hertin *et al.* (2003) found that uncertainty about the best way to respond to risks related to physical climate events lead companies to a satisfying behaviour instead of an optimizing behaviour. Furthermore, Linnenluecke and Griffiths (2010) highlighted the importance of contingent variables in the assessment of business impacts of extreme weather events, for example the extremity of an event depends on both the characteristics of the event and the vulnerability of the affected company related to some variables, such as the company size, and the previous experiences of the organization with such events. Many economic sectors are affected by physical climate-related impacts but potential adaptation responses are usually seen as specific to place and context, the cause of fragmented climate events over time and space, and of varying exposure and vulnerability of different actors (Berkhout, 2012). As far as we know, those investigated were: winter tourism (Scott and McBoyle, 2007; Hoffmann et al., 2009); public water supply (Arnell and Delaney, 2006); the food industry (Beermann, 2011), with a particular focus on the wine sub-industry (Galbreath, 2011); the building industry (Hertin, et al. 2003); the pastoral industry (Linnenluecke et al., 2011); and finally the electricity industry (Linnenluecke et al., 2011; Busch, 2011; Haigh and Griffiths, 2012). Finally, some research attempted to develop some typologies of adaptation behaviours: based on the intent in respect to a climate stimulus can be *autonomous* or *planned* (Fankhauser et al., 1999; Smit et al. 2000) and *proactive* adaptation (i.e. also considering mitigation measures while implementing adaptation and resilience) (Beermann, 2011); based on the occurrence of climate stimulus adaptation can be *reactive*, *anticipatory* (Fankhauser et al., 1999; Smit et al. 2000) or *concurrent* (Smit et al. 2000); based on the temporal scale adaptation

can be *short term* or *long term* (Smit et al. 2000); and finally, based on the spatial range adaptation can be *localized* or *widespread* (Smit et al. 2000).

## 2.6. Conclusion

In this article I provided a review of academic literature on how companies respond to challenges related to climate change. I identified the main research topics, such as the main object of investigation in terms of firm and industry, and the main research areas. Such analysis enabled me to first propose a classification into two broad categories based on the aim of the corporate response to climate change such as mitigation, i.e. how businesses act to address the causes of climate change that is reducing greenhouse gas emissions, and adaptation, i.e. how businesses deal with the physical consequences of climate change; and secondly a classification on the basis of the problem context into five main areas of research of business climate-related issues: a) risks and opportunities; b) carbon accounting; c) business responses to climate change with the aim of emission reduction; d) carbon disclosure; and finally e) corporate adaptation. My classification will help academics and researchers to understand CRtoCC from a more complete perspective. In addition, following the approach of Srivastava (2007), a timeline with relevant papers has been prepared (Figure 3).

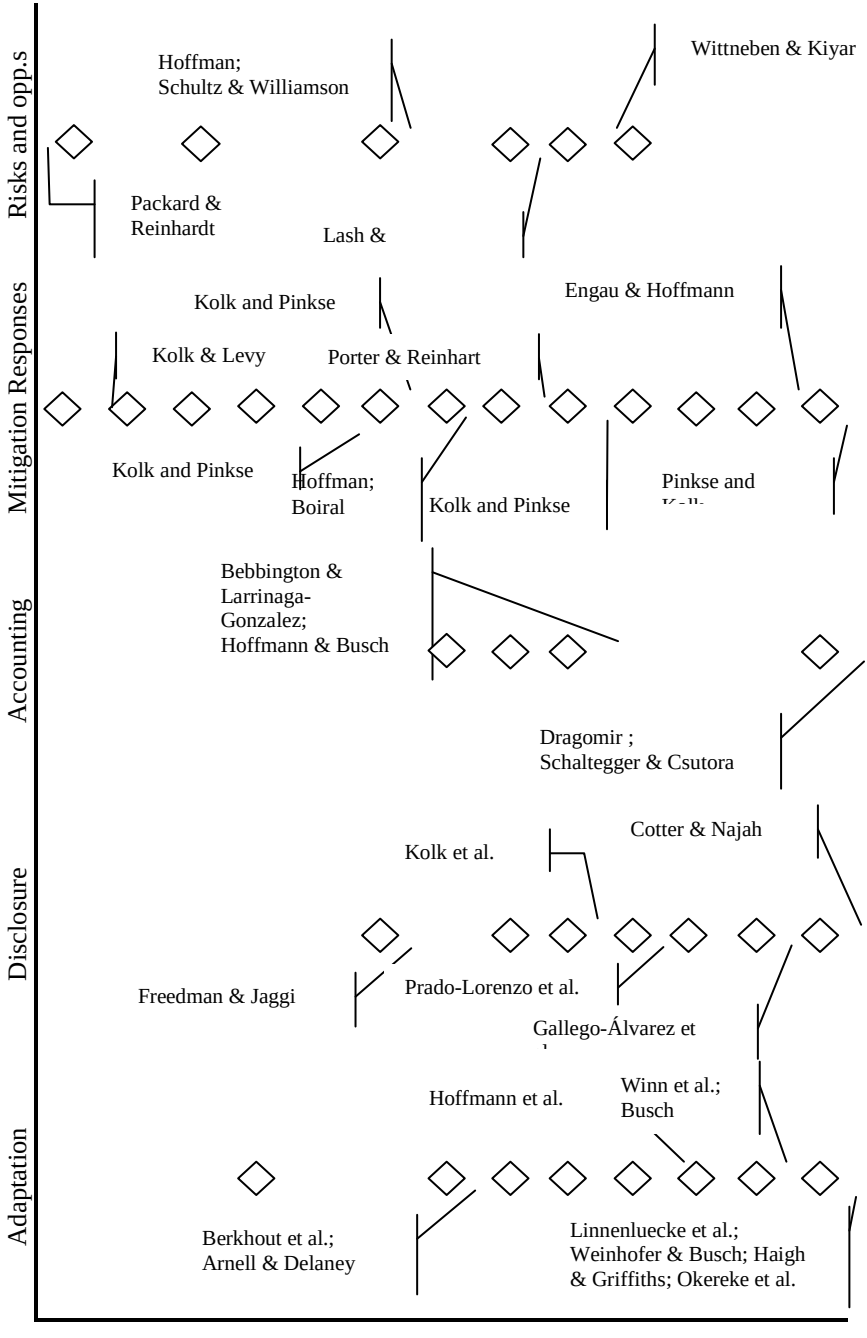
I reported the main findings and highlighted limits and the further fields of investigation. In particular, since 2007 the number of academic publications has increased per year, however not as much as we expected considering the novelty of the topic and the implications for business. So far the existing literature has shown how firms have mainly focused on their role with respect to mitigation. Corporate adaptation and resilience strategies to climate-induced physical changes are less well understood, in part because firms have not (yet) addressed adaptation to the same extent as policymakers and scientists (Linnenluecke and Griffiths 2010; Sussman and Freed 2008). Furthermore, I pointed out the methodologies employed to carry out these studies and the sources of data. I found that there is a limited use of quantitative analysis, which could be explained both by the lack of

data sources and by the necessity of highlighting the importance of the new problem, defining the meaning of various terms and the context, delimiting research boundaries, and suggesting further research areas, as in any emerging research area (Srivastava, 2007). Articles with a prescriptive tone are still fewer in number than descriptive and investigative studies. Apart from the novelty of the topic, this could be due to the incertitude linked to possible ways for coping with climate change for the achievement of a competitive advantage or for dealing with its physical impacts.

I identified the need for a more extensive and more specific set of data, and the need to extend and diversify analyses in different industries, countries, and beyond multinational companies. In fact, the present literature mainly focuses on MNCs and on USA and EU boundaries, and also on carbon intensive industries, in particular the oil and gas industry. This may be due to its role in emissions (Patenaude, 2011). These limits could be due to the lack of data availability, considering that the only database on CRtoCC is represented by CDP's questionnaires and that in general carbon disclosure depends on corporate size (Freedman and Jaggi, 2005; Prado-Lorenzo et al., 2009), market capitalization (Prado-Lorenzo et al., 2009) and the threat of state regulation (Reid and Toffel, 2009; Freedman and Jaggi, 2005). These gaps could represent a stimulus to collect different data and opportunities to explain the dynamics of CRtoCC in other industries, for companies operating at national level and for small and medium enterprises, for companies based in different countries and in developing countries. I found that this early literature on CRtoCC focuses on the necessity and the importance of climate change for business and defines the context, but it only suggests possible ways for the achievement of a competitive advantage or cost reduction while coping with climate change, without studying this issue in depth. In fact, the first four research areas indentified seem to follow the contents of the CDP questionnaire and social and environmental responsibility reports. This could be the reason why the relationship between competitiveness and climate-related action has not been analyzed with empirical study and

economic data, and not included in the CDP questionnaire. The analysis of the studies according to the problem context also shows a couple of discrepancies between some research, for example the relationship between strategic decisions and public policy uncertainty. In fact, while the shared statement is that public policy uncertainty slows down or limits a business climate-related strategy (Kolk and Pinkse, 2005; Boiral, 2006; Hoffman, 2005), Engau and Hoffmann, (2009, 2011a) pointed out that, in relation to post-Kyoto uncertainty, only a minority of firms postpones strategic decisions. This is the opposite of what firms officially claim, as companies mainly pursue reduction strategies. Furthermore, while Hoffman (2006) found that nearly all the companies investigated had implemented GHGs emission inventories, on the contrary, Kolk and Pinkse (2004) found that many companies had not already implemented GHG emission inventories. These kinds of discrepancy could be due to the different timeframe in which these research studies were carried out, considering the fast development of phenomenon, but, above all, it is likely to be due to the sample choice and the quality of data and its reliability. This is why it may be useful to carry out further research on these issues. Besides, the classification of climate-related company behaviour could be revised with further research about the current behaviour, since in recent years attention on climate change has increased all over the world, and has progressed from a mitigation to an adaptation perspective. In fact, the distinction of the papers according to the aim of companies' action (mitigation vs. adaptation) points out how earlier literature was focused on mitigation, while only in recent years scholars have also started to become engaged in understanding adaptation responses.

**Figure 3. CRtoCC evolutionary timeline**



| 20 00 | 20 01 | 20 02 | 20 03 | 20 04 | 20 05 | 20 06 | 20 07 | 20 08 | 20 09 | 20 10 | 20 11 | 20 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

The study of climate change in relation to business could be considered a new and evolving research field, which is already open and ready to be explored. This illustrates the interconnection in current years among businesses and governments, society, market and the natural environment, with all its complexity and relevance.

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# 3. Managing physical impacts of climate change: How awareness and vulnerability induce adaptation

*This paper was written together with Jonatan Pinkse*

## 3.1. Abstract

While business tends to be seen a substantial factor in causing climate change, climate-induced physical changes can also pose major challenges to firms in return. Firms can reduce their vulnerability to these changes by implementing anticipatory adjustments (adaptation) or by trying to absorb and recover from weather and climate events (resilience). Based on an empirical analysis of the oil and gas industry, this paper examines how the way firms make sense of climate stimuli in terms of awareness and vulnerability to these stimuli informs their strategic measures to adapt and become more resilient to climate-induced physical change. In the empirical analysis, the paper derives four main types of adaptation behaviour – pre-emptive, reactive, continuous and deferred adaptation – that correspond with different degrees of awareness and vulnerability. It also explores the relevant firm and context-specific features that affect awareness, vulnerability assessment, and subsequent adaptation measures. The findings suggest that the type of physical change, the sources of information used, the ecological embeddedness, and the potential financial implications have the most distinctive influence on the measures firms take to cope with physical impacts. The paper concludes with implications for research, management practice, and policymakers.

**Key words:** climate change; organizational sensemaking; corporate strategy; adaptation; oil and gas industry

## 3.2. Introduction

Although the international political debate on finding an agreement to reduce greenhouse gas (GHG) emissions has stalled considerably, scientific and political discourse on the need to adapt to climate change's physical impacts has advanced, nevertheless. In March 2012, for example, the IPCC published a special report on the relationship between climate change and extreme weather events, the impacts of such events, and general strategies to manage the associated risks (IPCC 2012). Climate-induced physical impacts can also pose major challenges to firms, as it could lead to changes in the business environment (Porter and Reinhardt 2007; Weinhofer and Busch 2012). Particularly vulnerable are sectors that rely on specific temperatures and seasonal conditions such as agriculture, forestry, and tourism, have industrial facilities located in climate-sensitive areas, such as coastal areas and floodplains (IPCC 2007), or depend on large-scale infrastructures (IPCC 2012), such as energy, automotive and transportation sectors (Winn et al. 2011). Vulnerability can be reduced, however, when firms prepare for an impact on their business by implementing anticipatory adjustments (adaptation) or by trying to absorb and recover from weather and climate events, thus becoming more resilient (Linnenluecke et al. 2012).

A perspective seeing firms as vulnerable to climate change instead of responsible for GHG emissions causing climate change is still fairly novel (Berkhout 2012; Linnenluecke and Griffiths 2010). As extant research has shown, so far firms have mainly focused on their role with respect to mitigation; that is, how firms reduce GHG emissions, respond to climate policy, and create business opportunities related to both (Eberlein and Matten 2009; Engau and Hoffmann 2011; Kolk and Pinkse 2005, 2008; Lash and Wellington 2007; Pinkse 2007). Corporate adaptation and resilience strategies to climate-induced physical changes are less well understood, in part because firms have not (yet) addressed adaptation to the same extent as policymakers and scientists have (Linnenluecke and Griffiths 2010; Sussman and Freed 2008). Recently a new stream of literature has emerged, however, that sheds light on corporate adaptation and resilience strategies through

conceptual frameworks based in organization theory (Linnenluecke and Griffiths 2010; Linnenluecke et al. 2012; Winn et al. 2011) and empirical work using case studies and surveys within specific industries (Beermann 2011; Busch 2011; Galbreath 2011; Haigh and Griffiths 2012; Hertin et al. 2003; Hoffmann et al. 2009; Linnenluecke et al. 2011; Scott and McBoyle 2007; Weinhofer and Busch 2012). This research has unearthed factors that influence adaptation and resilience strategies firms deploy, e.g. awareness of climate-related physical threats, degree of uncertainty, and risk management capabilities.

In this paper, we build on this emerging research by examining how the way firms make sense of climate stimuli informs their strategies to adapt and become more resilient to climate-induced physical change. It has been argued that adaptation is an organizational change process in response to direct and indirect climate stimuli (Berkhout et al. 2006; Winn et al. 2011). What remains ambiguous, however, is what firms perceive as relevant climate stimuli they might act upon. It has been argued that this is the outcome of a sensemaking process where firms first interpret how climate change will (or have come to) affect their organizations before they take action (Linnenluecke et al. 2012). Due to the discontinuous nature and futurity of climate change impacts (Winn et al. 2011; Yusoff and Gabrys 2011), the outcome of this sensemaking process is likely to vary considerably across firms. Therefore, we expect that firms' sensemaking of climate change will explain much of the variation in the adaptation and resilience activities of firms.

To empirically explore the influence of corporate sensemaking of climate stimuli on adaptation and resilience strategies, we focus on the global oil and gas industry. This industry is particularly sensitive to physical changes due to its reliance on natural resources such as water supply; the fact that operations are located in geographic areas exposed to extremes; a high dependence on large-scale infrastructures; and its long-lived and relatively immobile capital assets. Using data from the 2010 Carbon Disclosure Project survey, we analyse how oil and gas firms perceive and interpret their exposure and vulnerability

to weather and climate events in terms of business impacts and financial implications and how this has subsequently been translated into adaptation and resilience strategies.

## 3.3. Literature review

Scientific discourse is no longer focused only on providing evidence about climate change and the need for mitigation, but also on the need for adaptation to extreme weather events and climate-related disasters (IPCC 2012). Likewise, in the management literature firms have come to be seen as victims of climate change and not just as the ones causing the issue (Linnenluecke et al. 2012). They have also been pointed to as important actors that could mobilize society to adapt to physical impacts of climate change and become more resilient (Berkhout 2012). For most firms, adaptation to climate-induced physical change is a delicate issue, however, because it calls into question their relation with the ecosystems they are embedded in and depend on for (natural) resources (Whiteman et al. 2012). It is also highly complex, not only due to the novelty of the issue, but also to the great number of factors related to weather and climate events and their underlying dimensions (e.g. time, magnitude, location, predictability, etc.) that need consideration (Winn et al. 2011).

### *3.3.1. Corporate perceptions of climate-induced physical change*

While many economic sectors are affected by climate-related physical impacts, potential adaptation responses tend to be context-specific both in spatial and temporal terms, leading to different degrees of exposure and vulnerability of various firms (Berkhout 2012; Winn et al. 2011). The growing evidence on corporate adaptation and resilience behaviour is still fairly incongruent, however. This is not surprising as the few studies in the area were conducted in rather heterogeneous industries, including ski resorts (Hoffmann et al. 2009; Scott and McBoyle 2007), public water supply (Arnell and Delaney 2006), food production (Beermann 2011), wine production (Galbreath 2011), construction (Hertin et al. 2003), and electricity supply (Busch

2011; Haigh and Griffiths 2012). Questions driving the nascent literature on corporate adaptation and resilience include how firms could deal with the complexity of climate-induced physical impacts, which firm-specific variables determine whether they respond adequately and on time, and what the underlying logic is of the adaptation process.

Concerning the complexity of the phenomenon, studies have tried to capture the various dimensions of climate-related physical changes, arguing that climate change could be unique in its impact on business (Linnenluecke and Griffiths 2010; Linnenluecke et al. 2012; Linnenluecke et al. 2011; Winn et al. 2011). Winn et al. (2011) submit that physical climate impacts are not isolated phenomena, but constitute a threat of massive discontinuous change, defined as 'significant, sudden, disruptive change in the broader ecological or social systems of which organizations and economic systems are a part' (Winn et al. 2011: 161). Climate change is unlike other changes in the business environment, because of its much greater scale and scope, irreversibility, destructiveness and high uncertainty as the impacts are unpredictable and discontinuous. Linnenluecke and colleagues argue that due to the peculiarity of weather and climate events a business-as-usual response to changes in the business environment would not suffice (Linnenluecke and Griffiths 2010; Linnenluecke et al. 2012; Linnenluecke et al. 2011).

Regarding business responses to physical impacts, studies have focused on the identification of firm-specific variables that influence corporate adaptation behaviour and strategies, such as awareness (Arnell and Delaney 2006), vulnerability (Hertin et al. 2003; Hoffmann et al. 2009), perceived uncertainty (Berkhout et al. 2006; Hertin et al. 2003), ability to adapt and dependency on the affected business (Hoffmann et al. 2009), and organizational capabilities (Busch 2011). Awareness of the potential climate threat in particular has been widely recognized as an important factor influencing corporate adaptation strategies (Arnell and Delaney 2006; Berkhout et al. 2006; Bleda and Shackley 2008; Hertin et al. 2003; Hoffmann et al. 2009). Arnell and Delaney (2006: 229), for example, maintain that

'before an organisation embarks on adaptation it must be first aware of the potential threat of climate change, and second concerned about potential impacts on its business.' Hoffmann et al. (2009) found that awareness has a positive impact on corporate adaptation, while they could not confirm the same for vulnerability. Haigh and Griffiths (2012), on the other hand, found that adaptation measures were implemented mainly after firms had been taken by surprise by physical impacts rather than as an anticipatory response from increasing awareness.

Evidence on perceived uncertainty has been fairly ambiguous as well. While Winn et al. (2011) consider uncertainty a typical component of the corporate perception of the future state of their environment in relation to climate change; Hoffmann et al. (2009) were not able to find significant influence of this variable on adaptation strategy. Then again, Hertin et al. (2003) found that the multiple uncertainties firms face in relation to climate change led them to exhibit satisficing instead of optimizing behaviour. Put differently, there are so many future unknowns that firms will not be able to find out what the optimal solution would be in the first place. Linnenluecke and Griffiths (2010) also highlight the importance of other contingent variables in the assessment of business impacts of extreme weather events. They argue, for example, that the extremity of an event not only depends on the characteristics of the event, but also on the vulnerability of the affected firm as reflected in the relative firm size and previous experiences with similar events.

### *3.3.2. The corporate adaptation process*

Another question that has been addressed is how the adaptation process unfolds (Berkhout et al. 2006; Carter et al. 1994; Fankhauser et al. 1999; Smit et al. 2000). In the climate science literature scholars have identified various approaches towards adaptation and resilience, reflecting different underlying logics of adaptation behaviour. One of the main distinctions refers to the intent with respect to climate stimuli; that is, adaptation can be autonomous or planned (Carter et al. 1994). Autonomous adaptation implies that there will be 'some natural or spontaneous adjustments in the face of a changing climate' (Carter

et al. 1994: 32). Planned adaptation, on the other hand, refers to a certain degree of agency where actors strategically intervene to better cope with climate impacts (Fankhauser et al. 1999; Smit et al. 2000). Another key distinction refers to the timing of adaptation behaviour; that is, behaviour could be reactive, concurrent or anticipatory, which refer to actions after, during or before climate stimuli are experienced, respectively (Fankhauser et al. 1999; Smit et al. 2000).

With regard to intent, in the organizational literature the balance seems to tilt to the view that corporate adaptation is a relatively planned process. Scholars have emphasized the need for a strategic and proactive response towards climate impacts (Arnell and Delaney 2006; Berkhout et al. 2006; Busch 2011; Linnenluecke et al. 2011; Weinhofer and Busch 2012). Weinhofer and Busch (2012), for example, conceive of corporate adaptation as a process of corporate risk management, comprising three stages: identification, assessment and response. The underlying logic is that firms could manage physical climate impacts as any other risk a firm faces and could thus reduce, avoid or transfer climate risk. In terms of timing, all three could be used to either manage experienced, expected or not-yet fully anticipated impacts. Their approach is based on the assumption (also acknowledged by the authors) that climate impacts are viewed as negative impacts and acted upon as potential risks. As previous studies show, however, evidence on the level and impact of awareness and perceived uncertainty is mixed at best. This raises the question how firms would respond when they perceive physical impacts differently; that is, they are not aware of the impacts or, if they are, do not see it as something negative, they have no control over.

The organizational learning approach, Berkhout et al. (2006) propose, leaves more space for different readings firms might have of physical changes, because it puts less focus on strategic intent. Even though climate stimuli might be new and challenging, they argue that firms would try to adopt known routines and through a process of learning develop responses, similar to those to other changes in the market, technological or regulatory environment. The adaptation strategies they derived from a set of case studies – wait-and-see; risk

assessment and options appraisal; bearing and managing risks; sharing and shifting risks – corroborate Weinhofer and Busch (2012) that corporate adaptation bears close similarities with standard risk management. Nevertheless, since most firms face climate stimuli that are highly ambiguous and experienced indirectly only, they also found that most industries had difficulties assessing which standard operating routines would be adequate to respond to physical impacts. A limitation of organizational learning as theoretical lens, however, is the underlying assumption of environmental stability that presumes routines to develop autonomously. Moreover, reliance on previous experiences and routines does not catch the on-going and future environmental changes triggered by weather and climate related events (Winn et al. 2011). As Okereke et al. (2012: 25) argue, '[r]elying on old and pre-existing set of skills and capabilities to handle the new risks and challenges posed by climate change is bound to lead to suboptimal and ineffective response strategy.' Hence, we propose to further develop a sensemaking perspective instead.

### *3.3.3. Corporate adaptation through a sensemaking lens*

The discontinuity, ambiguity and uncertainty surrounding direct and indirect climate stimuli (Berkhout et al. 2006; Winn et al. 2011) call into question what firms perceive as relevant climate stimuli they might act upon. That is, climate stimuli might be perceived as risks (Weinhofer and Busch 2012) and responses might be based on a drive to use existing routines (Berkhout et al. 2006), but this is not a given, a priori. Instead we look on corporate adaptation and resilience strategies as the outcome of a sensemaking process. Sensemaking provides a lens to understand how a phenomenon becomes an event for a firm and what the event means for business practices (Weick et al. 2005) and thus highlights the interaction between cognition and action (Thomas et al. 1993). Sensemaking typically occurs explicitly when 'the current state of the world is perceived to be different from the expected state of the world, or when there is no obvious way to engage the world' (Weick et al. 2005: 409). Even though firms will be aware that climate change could cause them problems, the uncertainty and ambiguity about how the issue will bear out in the future, leads to

them to struggle how to cope with and rationalize the issue at present (Yusoff and Gabrys 2011). We consider sensemaking an appropriate theoretical lens, in particular in the early phases of climate-induced organizational change, when uncertainty is at its highest and firms have not yet been able to develop routines (Berkhout et al. 2006; Winn et al. 2011).

Since a sensemaking process entails three key processes – scanning, interpretation and action (Thomas et al. 1993) – corporate adaptation can be understood as a continuous process of scanning past, present and future climate stimuli (Berkhout et al. 2006), which, when interpreted, inform action (Linnenluecke et al. 2012). To the extent that awareness and vulnerability will rest on the interpretation and rationalization of weather and climate-related events, firms operating in the same business environment could thus hold different views on how climate change might destabilize their business environment and behave differently in response. In the remainder of the paper we investigate corporate adaptation behaviour by viewing it as a combination of the three main elements of the sensemaking process: awareness of climate-related physical changes, the subsequent vulnerability assessment, and ensuing corporate response. In addition, we explore the relevant firm and context-specific features that affect awareness, vulnerability assessment, and corporate adaptation behaviour. In fact, we expect adaptation behaviour not to be stable, but fluctuating over the development of the sensemaking process. Uncovering relevant features affecting the sensemaking process of climate stimuli could thus help shedding light on corporate adaptation in a dynamic sense.

### 3.4. Data and methods

This study investigates corporate sensemaking of climate-induced physical change, addressing the phenomenon through an inductive analysis of awareness of climate-related physical changes, vulnerability assessment and subsequent responses. For this research we used data from the Carbon Disclosure Project (CDP), which gathers information on the climate profile of firms. To date, CDP

represents the most important database about business climate-related responses in term of risks, climate-related strategies and carbon accounting from thousands of the world's largest firms. For our analysis we chose the CDP 2010 questionnaire, even though this was not the most recent database when the analysis was conducted. We made this choice because of the exploratory nature of our research. In fact, in the most recent CDP 2011 questionnaire, questions about corporate adaptation to climate change had been merged and reduced. By contrast, CDP 2010 encompasses open questions, more adequate for our research objective.

CDP 2010 includes information of 1499 firms. We targeted the oil and gas industry group (energy industry group according to CDP classification) for our analysis. We selected this industry because of its saliency with regard to the climate change issue. It is a salient issue due to the industry's geographic location of facilities in climate sensitive areas, its reliance on particular temperatures and seasonal conditions for operations, its dependence on climate-sensitive inputs such as water, ownership of long-lived capital assets and its reliance on a large-scale infrastructure (IPCC 2012). Besides, this industry already suffered negative impacts of extreme events in terms of physical damages and financial losses, such as in the hurricane seasons of 2005 and 2008 in the Gulf of Mexico. While this industry has already been investigated in terms of responses to climate regulation, mitigation (Levy and Kolk 2002; Pulver 2007; Rowlands 2000; Sæverud and Skjærseth 2007) and ethics (Le Menestrel et al. 2002), adaptation strategies have not yet been investigated, up till now. In the CDP 2010 questionnaire, 91 firms in the oil and gas industry group responded. Compared to other industries, this is a relatively high rate of respondents, recognizing that current and/or anticipated physical impacts of climate change represent significant risks to them (68%).

For the purpose of this study, of the entire questionnaire we considered a selected number of questions with useful information about adaptation to climate change. The questions selected represent 444 pages of text. Three firms did not provide answers for the selected

questions, thus reducing our final sample to 88 firms. Our sample included firms operating at each level of the oil and gas supply chain (upstream, midstream, downstream, providers of equipment and services); thus not only with a portfolio of oil and natural gas products, but also including coal, chemicals and renewables.

The contents of the questionnaires were coded and analysed using NVIVO, which enables comparing large amounts of qualitative data. The coding procedure was run twice: we first conducted an exploratory coding procedure to find the main issues emerging from firms' statements, followed by more detailed coding, also considering variables that had emerged from previous research about firms' awareness (e.g. uncertainty), vulnerability assessment (e.g. direct and indirect impacts) and actions (e.g. risk sharing). We thus used a combination of pre-defined codes from extant research and codes emerging from the data to identify the main features of sensemaking in response to climate-related physical changes. Regarding firms' awareness of climate-related physical changes, we used the following dimensions for coding: the kinds of physical changes ranging from gradual changes (e.g. increase in air and sea temperature, sea rising level, melting snow and ice covers, etc.) to the frequency and intensity of more extreme weather events (e.g. hurricanes, floods, etc.); the perception, uncertainty, ecological embeddedness, and geographic exposure, using a coding scheme ranging from high to low; the timeline, ranging from current, medium, to long-term; the source of information ranging from internal – i.e. experience of climate-related physical change, output of risk management, research and monitoring – and external – i.e. institutional reports, previous experience of other firms, and supply chain. Concerning vulnerability assessment we considered the following dimensions: physical impact in terms of assets, operations and productivity; business impact in and beyond the market; and, financial implications, controllability and sense of urgency.

Subsequently, we developed themes by matching codes and assigning an overall awareness and vulnerability level to each firm, ranging from high to low. This allowed us to develop a matrix with on one

side the dimensions of awareness and vulnerability and on the other side adaptation behaviour. Such cross-tabulation helped identifying adaptation behaviour in relation to firms' awareness and interpretation of direct and indirect climate stimuli. The emerging adaptation behaviours were interpreted, where possible, by making reference to the existing typologies of corporate adaptation and resilience strategies (Berkhout et al. 2006; Haigh and Griffiths 2012; Hertin et al. 2003; Hoffmann et al. 2009; Linnenluecke et al. 2012; Whiteman and Cooper 2011). Finally, we performed a cross-tabulation to explore how specific adaptation and resilience measures were related to each of the four adaptation behaviours we identified previously.

## 3.5. Findings

In this section, we present our findings on the sensemaking process of climate-induced physical changes in the global oil and gas industry. We first identify measures firms in the sample have taken to adapt or become more resilient to climate change. Next, we derive firms' main types of adaptation behaviour based on how they seem to have made sense of climate stimuli in terms of awareness and vulnerability to climate-related physical changes. Finally, we compare and contrast the four types of adaptation behaviour and discuss how they could change over time.

### *3.5.1. Corporate measures for adaptation and resilience*

Our data indicated that firms plan and implement different measures in response to climate-related physical change; that is, they either recognize their exposure and vulnerability to physical risks and take action purposely to anticipate potential negative impacts or they respond after ecological events have already occurred. Regarding adaptation and resilience measures of firms in the sample, we identified the following: (1) wait-and-see, (2) risk assessment, (3) technical solutions, (4) reduction of exposure through geographical decisions, (5) shift and share risks, (6) resilience, (7) portfolio diversification, and (8) cooperation. In part, this corroborates previous

research making the distinction between do nothing, assess, reduce risk, share risk and diversify (Berkhout 2012; Berkhout et al. 2006; Hoffmann et al. 2009; Weinhofer and Busch 2012). We also found oil and gas firms to engage in measures to improve corporate resilience (Linnenluecke et al. 2012) and reduce geographic exposure (Linnenluecke et al. 2011). In addition, we identified new forms of cooperation with competitors and other stakeholders.

On the whole, the issue of climate-induced physical changes has become fairly salient in the oil and gas industry in the sense that firms have implemented a wide variety of measures over the past years. In fact, only firms adopting a wait-and-see strategy failed to pursue any real action although these firms do not always exclude the possibility to change their behaviour in the future. Firms at a relatively early stage in their sensemaking process of climate-related physical change mostly turn to conducting a risk assessment, as SBM Offshore explains:

> Besides the insurance activities, SBM does not plan to manage or adapt to the risks identified as physical risks other than keeping a close eye on the developments of the risk (and the identification of possible new risks) through the Risk Management Process.

Risk assessment can be related to monitoring scientific developments from major research institutes specialized in climate science or to monitoring short-term weather forecasts and longer-term weather scenarios. For example, Premier Oil states that '[m]eteorological and oceanographic studies are carried out for all new projects. These include hindcasting and analysis of data on wind, currents and wave height over 1,000 years. These studies will now include forecasting to include anticipated variations brought about by climate change.' Risk assessment also plays an important role in the identification of risk mitigation strategies, such as procedures, technical solutions, resilience strategies – including emergency, contingency and business continuity plans – crisis management, and financial solutions such as insurance opportunities. In fact, climate-related physical risk is not

considered only from an operational point of view, but also from a financial, strategic and legal perspective.

However, while some firms are still in the early phase of monitoring and interpreting risks, others have already defined and implemented dedicated adaptation measures. Technical adaptation measures range from developing standards and respecting mandatory requirements, to designing improvements for maintenance, materials, facilities, assets, and process engineering to endure climate-related physical impacts. Some firms identified operational alternatives to overcome climate-related physical impacts such as constructing an all-weather road to access upstream facilities. Sometimes the objective of an intervention is to reduce the dependency on affected natural resources through consumption reduction, re-use and recycling, in particular to deal with limited water availability.

For some firms, climate-related physical changes have become as salient to affect production volume decisions when the cost of upgrading facilities exceeds economic viability (e.g. Penn West Energy Trust) or to influence geographical siting decisions (e.g. Chevron). In fact, reducing exposure through geographical siting decisions is one of the more radical responses that some oil and gas firms have been contemplating or implemented in certain cases and is considered in particular in siting decisions for new investments. As Anadarko Petroleum Corporation notes, having a well-balanced portfolio from a geographical point of view is considered a risk mitigation strategy:

> Anadarko believes that supply risks generated by extreme weather events and other physical impacts that reduce or cease operation may be mitigated by enhancing production from unaffected regions.

Geographical siting decisions have also been made with regard to older facilities when firms operate in particularly risky areas or after experiencing extreme weather events. Although oil and gas firms may sustain large costs for repairs, in some cases it is considered not possible to do anything other than write-off and decommission assets

(e.g. Apache), or to make a strategic repositioning to less risky locations (e.g. Halliburton).

Many firms in the sample highlight a resilience strategy, when they expect weather extremes. They have defined all kinds of emergency, contingency and restoration plans to secure assets, personnel and operations and set up crisis management teams. In addition, many firms rely on instruments to share and shift risks, such as insurance, consideration of physical risks in contract negotiations, economic evaluation of new projects, and a more widespread tendency to pass increased costs to costumers. A well-diversified portfolio – not only in terms of geographic location, but also of products and assets – is often mentioned as a way to mitigate climate risks. In the words of Arrow Energy:

> Extreme weather – hot and cold temperatures – directly affects the demand for gas and electricity, increasing volatility in energy demand and in certain circumstances increases risks to energy supply capacity and reliability. [...] Ensuring that our portfolio of plant and derivative contracts matches our exposure is critical in covering off those risks.

Finally, cooperation is also a response emerging from our data and has occurred both at industry level and stakeholder levels. Some firms have contributed to developing reference industry plans; Chevron, for example, supported the efforts of the American Petroleum Institute in developing industry's plans for storm preparation and return after storms. The objective of this kind of cooperation differs from risk sharing, as it aims at sharing lessons-learned as well as resources to prepare for emergencies in case of extreme weather events. Risk related to steady changes such as water availability often leads firms to participate in regional initiatives as well as involvement in policy and regulatory developments (e.g. Hess). Besides, firms collaborate with local industries to reduce impact on local water resources and prevent conflicts with local communities for access to resources (e.g. BG Group).

### *3.5.2. Adaptation behaviour in the oil and gas industry*

In the following, we explore how firms' sensemaking of climate stimuli relates to the variation in the adaptation and resilience measures of firms in the oil and gas industry, as outlined in the previous section. In part reflecting existing typologies of corporate adaptation and resilience strategies (Berkhout et al. 2006; Linnenluecke et al. 2012), our data revealed that based on their awareness and vulnerability profile, firms exhibited four types of adaptation behaviour: pre-emptive, reactive, continuous and deferred adaptation (see Figure 1).

Firms that have a high awareness of climate-related physical changes and assess their vulnerability as high tend to adopt *pre-emptive adaptation*. These firms are embedded in locations with high weather and climate extremes and have thus come to recognize the risks of changing ecosystem conditions (Whiteman and Cooper 2011). Hence, they show the kind of anticipatory attitude, scholars have identified previously as the first stage of the adaptation process of firms with high exposure (Hertin et al. 2003; Hoffmann et al. 2009; Linnenluecke et al. 2012). In contrast, firms that have found to be highly vulnerable (ex-post assessment), but until they experienced an extreme climate event had low risk awareness (ex ante), are the ones caught by surprise (Haigh and Griffiths 2012). Their adaptation behaviour is thus a response after-the-fact and is referred to as *reactive adaptation*. Firms with high risk awareness, but assess their vulnerability as low tend to undertake *continuous adaptation*. While their 'ecological embeddedness' is high due to the unstable climatic conditions of the locations in which they operate (Whiteman and Cooper 2011), either their own operations are not of the kind that makes them particularly vulnerable to these conditions, or they feel relatively secure due to the adaptation measures that they have already adopted. Finally, there are those for whom climate-induced physical changes are not a salient issue because they have low awareness and assess their vulnerability as low. Therefore, they opt for *deferred adaptation*. Their attitude is to wait and see what might happen in the future and until then either do not to take any actions or postpone decisions (Berkhout et al. 2006).

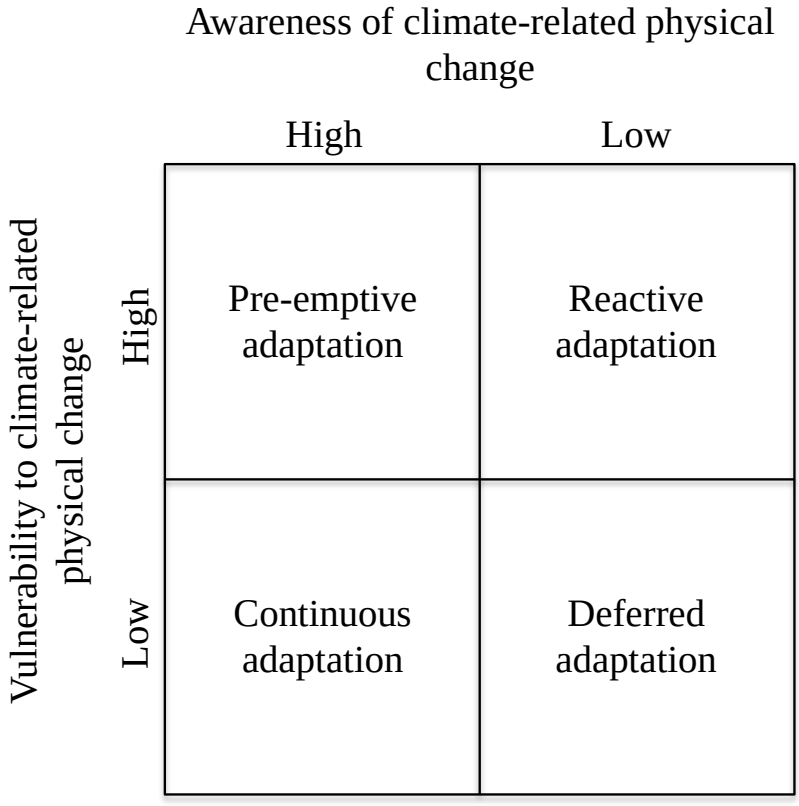


**Figure 1 Corporate adaptation behaviour: a typology**

In subsequent sections we set forth how each of the four main adaptation behaviours that we derived, differs in terms of the sensemaking processes that have led them to adopt the behaviour. We highlight the intervening role of awareness and vulnerability assessment processes in bringing a firm to change behaviour towards changing climate conditions (or not). Table 1 summarizes the main features of each type of adaptation behaviour as they emerged from our research.

**Table 1 Corporate adaptation behaviour compared**

| | Pre-emptive adaptation | Reactive adaptation | Continuous adaptation | Deferred adaptation |
|---|---|---|---|---|
| **AWARENESS** | **HIGH** | **LOW** | **HIGH** | **LOW** |
| Kind of physical change | Steady changes and Extremes | Extremes | Extremes | Steady changes and Extremes |
| Risk perception | High | High | Low | Low |
| Uncertainty | Low | Low | Low | Low |
| Timeline of ecological changes | Current | Anytime | Current | Long term |
| Information source | Internal and External | Internal and External | Internal | External |
| Ecological embeddedness | High | High (post-event) | High | Low |
| Geographic exposure | High | High | High | Low |
| **VULNERABILITY** | **HIGH** | **HIGH** | **LOW** | **LOW** |
| Physical impacts on the firm | Facilities; Operations; Production; Ability to supply; Personnel safety; Investment decisions | Facilities; Operations; Production; Ability to supply; Personnel safety | Facilities; Operations; Production; Ability to supply | - |
| Market business impacts | Supply chain; Demand | Supply chain; Demand | Commodity prices; Supply | - |

| | | | | |
|---|---|---|---|---|
| | | | chain | |
| Beyond market business impacts | Local communities; Local industries; Increasing regulation; Reputation | Local industries | - | - |
| Financial implications | Estimate | Quantification | Estimate | - |
| Controllability | Low | Moderate | High | High |
| Sense of urgency | Moderate | High | Low | Low |

### *3.5.3. Pre-emptive adaptation*

Firms in the sample exhibiting pre-emptive adaptation behaviour are well aware of climate-related physical changes and assess their vulnerability as relatively high, and thus consider the business impacts and financial implications for their organization. The risk perception is fairly high and uncertainty is mainly related to the severity and the timeline – i.e. how extreme physical changes will be and when they take place – rather than to the occurrence of such changes. However, there are firms with pre-emptive behaviour that seem able to indicate the timeline of weather and climate-related events. Firms in this group not only identify the ecological changes, but also the geographical location of such changes in relation to their assets. In other words, they have a clear view on their geographic exposure, which they consider as quite high. Besides, in addition to the fact that they view weather and climate extremes as salient, they also consider the more steady changes in the ecosystem. One important concern in view of gradual changes is water availability. Water shortage could involve

negative consequences by changing the economic preconditions of operations, as exemplified by Penn West:

> Penn West's assets are, to a large extent, established facilities designed and constructed at a time when public and industry awareness of the risks of climate change was not as high as it is today. In many instances the cost of upgrading these facilities to accommodate the need to use less fresh water will be substantial and may exceed that of economic viability, which could lead to decreased production at certain assets.

The degree of ecological embeddedness of firms following a pre-emptive approach appears to be high (Whiteman and Cooper 2011); that is, they tend to disclose much information about their reliance on local ecosystems and related impacts. Furthermore, while they often cite the IPCC or other institutional reports as sources of information, they have elaborated on these by relating the more general models to the specific situation and characteristics of their own organization. Risk management plays an important role, both in terms of risk identification, assessment, and mitigation (Weinhofer and Busch 2012), related in particular to extreme weather events. Many firms have established specific functions or working groups to deal with climate change, which are often integrated in standard risk management procedures or in the overall risk management system. Employees with such dedicated functions focus on detecting signals of climate-related physical changes and climate science, conducting vulnerability assessments, and sometimes identifying the necessary adaptation measures. Many firms also rely on crisis management and contingency plans to deal with extremes.

Firms implementing pre-emptive adaptation measures have usually identified already the impacts of climate change on their business. This not only includes the operational dimension, such as damages to production facilities or infrastructure, but also the market dimensions, such as impacts on demand conditions. While these impacts could endanger revenues directly, firms also consider other, more indirect impacts such as reputational damages from difficulties to supply oil or oil spills or the fact that their relation with local communities might

deteriorate. BG Group states, for example, that '[t]here is potential for conflict with local communities near our operations for resources, such as water, when availability of the resources is affected by climate change or where our activities may be perceived to adversely influence local industries.' Origin Energy, on the other hand, warns for more government involvement; that is, the firm emphasizes the potential financial implications from 'increased government attention and regulations such as greater control on spatial planning, government charges for water in light of droughts, increased energy market regulation etc.'

Furthermore, the sense of controllability tends to be low; particularly in relation to physical damages that are not fully covered by insurance and thus require specific agreements with contractors. Nevertheless, with regard to workers safety, firms show a relatively higher sense of controllability. The sense of urgency, on the other hand, varies widely. When firms are aware of climate change and consider themselves vulnerable, pre-emptive adaptation behaviour can be considered an evolving process, starting with signal detection, impacts assessment and action implementation, thus resulting in a cyclical sequence (Linnenluecke et al. 2012), giving rise to continuous adaptation over time.

### *3.5.4. Reactive adaptation*

Firms with reactive adaptation behaviour are those that have experienced the impacts of climate-related physical change directly, in particular weather extremes. Basically, crisis management and emergency plans appear not to have been sufficient to prevent great financial losses. Firms in this group have a high perception of climate-induced risk both in terms of the occurrence of more extreme and frequent weather events and of the resulting business impacts such as asset damages, delays and shutdowns of operations, personnel safety, supply chain disruptions, increased competition for supplies and services related to post-event recovery, and reduced demand for products. Uncertainty is low and seems not to have influence at all. When uncertainty does play a role, then it mainly concerns the

impossibility to predict the timeline of the occurrence of new extremes rather than the occurrence itself. Regarding the timeline, focus is on ecological changes that are prevalent in the present time, although the fact that firms have been affected induces them to start considering changes in the mid to long-term as well. Total states, for example, that 'the timescales over which these identified physical risks are expected to materialize are: Anytime'. The main source of information is direct experience of ecological changes and damages. After the experience, however, they also start to collect information from national and international institutions, such as the IPCC, as well as from industrial associations and other stakeholders.

Vulnerability assessment can be quite complex. That is, while reactive firms have a high sense of urgency, due to the interdependency of oil firms' operations, their sense of controllability can vary considerably. Vulnerability to extreme weather events can stem from damage to their own operations or from damage to operations of collaborators on which they depend. For example, Shell's Mars platform suffered damages 'above water, when massive clamps holding part of the rig's structure failed under sustained winds of 270 km per hour, while, under water, the anchor of another firm's mobile drilling unit that had gone adrift cracked the pipeline.' Furthermore, when there is a constant risk of physical changes, this could lead to a production reduction, which may result in increasing costs that are passed on to the customer through higher fuel prices. Due to the fact that firms with reactive behaviour have already experienced damages, they are able to quantify and report financial implications with great accuracy in terms of costs and losses instead of just providing an estimate. In fact, these financial calculations take in consideration not only the costs of reconstruction and decreased revenues due to refinery shutdowns and reduced production, but also the added costs to improve the design of facilities based on previous experiences.

Firms in the sample took actions to improve their technical design and to strengthen their assets' ability to withstand extreme weather and climate events, implemented dedicated risk management procedures, and hired specialized personnel. Interestingly, the evolving resilience

strategies not only comprise measures for crisis management, but also involve measures to ensure business continuity. While Shell decided to become 'part of a joint industry project to tighten specifications for anchoring mobile drilling rigs during the hurricane season,' the firm also engaged in developing alternative ways to get the oil from a rig to a refinery when pipelines are damaged. Besides, firms identified and implemented reactive adaptation actions not only to reduce vulnerability, but also to reduce exposure. For example, some firms sold facilities in affected areas to reduce exposure, as the case of Total illustrates:

> Until recently less than 2.5% of Total operated production was located in the Gulf of Mexico, so that the impact of Katrina and Rita in 2005 was far less than for other firms. The assets Total detained in Gulf of Mexico (Virgo and Matterhorn) have been sold in April 2010.

An important element of reactive adaptation behaviour is the lessons learned from previous experiences. The findings suggest that dealing with specific extreme weather events have become a routine. Halliburton states, for example, that it 'has adapted its facilities over many years of operations in order to sustain its presence in the Gulf of Mexico. Many facility design lessons have been learned through several hurricane events experienced in the last 10 years.' However, such learning usually refers only to a specific type of extreme event such as the increased intensity and frequency of hurricanes becoming a routine, and doubts could be raised whether they can be extended to other climate-related physical changes. That is to say, routines can be developed for known physical events such as hurricanes, but other events of a highly uncertain and discontinuous nature could still take reactive firms at a surprise (Winn et al. 2011). The occurrence of extreme weather events can also reach a threshold and become a real threat to organizational survival. Instead of triggering a process of learning it then leads to a relocation process, as many firms adopting a reactive behaviour affirm.

#### *3.5.5. Continuous adaptation*

Firms adopting continuous adaptation behaviour are those that are generally located in an area subject to extreme natural conditions. Due to a high ecological embeddedness, these firms have already implemented measures to deal with increased frequency and intensity of extreme weather events. In fact, they are used to dealing with weather variations and harsh conditions, so they usually have a risk perception of climate-related physical changes that is quite low and consider ecological changes as business as usual. Firms in this group argue having built resilient organizational structures, since they have already acquired the ability to bracket local ecosystem dynamics so as to anticipate risk, prevent crises and be prepared for ecological changes (Whiteman and Cooper 2011). This assumed ability is the reason why these firms do not perceive significant or additional risks for their assets and operations, be it from steady changes or from extreme weather events. In terms of timeline, they consider the occurrence of ecological changes in the present as well as those that might take place in the medium to long term. As Premier maintains:

> Premier operates in countries that may be impacted by climate change. In 2009, we included a review of the potential impact this might have on our operations. The process considered rising sea levels and the increased frequency of unpredictable weather events. The review found that given our facilities are already designed to withstand once in 100 years storm cases, a possible increase in the frequency of such storms would not present additional operational risks. Our offshore fixed facilities already include a contingency for rising sea levels.

Uncertainty about physical changes is not always relevant to these firms, because they are prepared to cope with extremes anyway. For example, Cenovus and Encana claim to be able to cope with temperatures ranging between -40°C and +30°C. In general, firms with continuous adaptation have a risk management strategy focused on the conditions of the natural environment, including risk monitoring, assessment and mitigation as well as emergency and business continuity plans. Moreover, the attention to ecosystem changes also allows these firms to proactively identify alternative

solutions to new ecological changes. Next to on-going anticipatory adjustments and resilience strategies to cope with extremes, these firms are also responsive to new challenges from more steady and gradual changes, such as water availability.

While the awareness of physical changes is high, continuously adapting firms assess their vulnerability as fairly low. This is not surprising, since their assumed ability to identify risks and implement corresponding actions to mitigate risks and reduce impacts on the business provides them with a sense of high controllability. Moreover, the business-as-usual character of physical changes reduces the sense of urgency. While ecological changes could still affect production facilities, the fact that these firms have implemented appropriate measures leads to the belief that they are able to withstand expected and unexpected changes. As Roc Oil Firm claims:

> Any weather-related disruptions that may occur at our operations are addressed through our existing management systems, including our emergency response procedures. Although our assets are already designed to withstand extreme weather conditions, ROC will continue to review applicable climate change research that may assist with future design and operating strategies.

Furthermore, in terms of business impacts, the major financial implications these firms mention are related to interrupted or reduced production, and, consequently, reduced corporate revenue. They also identify more indirect impacts such as the ability to supply products and problems in the supply chain from midstream and downstream operators. These indirect impacts could bring to some financial consequences such as increased costs of production, for example, due to increasing fuel prices required to operate in abnormally cold weather or rising commodity prices.

### *3.5.6. Deferred adaptation*

Firms with deferred adaptation behaviour have not implemented adaptation measures and do not intend to do so anytime soon. Typically, these firms have a low awareness of climate-related

physical changes and assess their vulnerability as low. This low awareness is due to a combination of factors. First of all, risk perception is low. In some instances, this perception that the organization will not be affected is based on the fact that operations are located in a relatively stable natural environment or on the nature of operations. Centennial Coal Firm notes, for example, that '[t]he nature of our operations and assets are such that things like extreme weather events, changes in weather patterns or rises in sea level do not pose a significant risk to these physical assets'. In other instances, this low risk perception and the deferred character of reactive firms' behaviour derives from a conviction that physical impacts are not likely to occur within a period relevant to its business activities. For example, Occidental Petroleum Corporation states that 'it is not aware of credible projections that significant changes in weather or climate that could result in immitigable impacts are probable within the anticipated operating life of its facilities.'

Besides, these firms tend to stress the uncertainty surrounding climate change, sometimes based on the belief that there is no clear relation between rising GHG emissions and climatic changes, as exemplified by Occidental, which states that even though their 'facilities face these physical risks, the involvement, if any, of GHG emissions or climate change is indeterminate.' In addition, the main source of information, such as the IPCC, used to gain insight seems predominantly to be taken at face value. What is still lacking is knowledge about how climate change impacts would have a direct bearing on their organization. This is further aggravated by the fact that the typical risk assessment these firms have conducted is based on historical data and when they look into the future they maintain a rather short-term perspective, as Talisman Energy notes:

> Talisman's assets are designed to withstand probable extreme weather events based on historical data. The Company has not undertaken a comprehensive assessment of physical risks that may be associated with potentially more extreme weather events and related phenomena.

It is worth noticing that even though firms with deferred adaptation behaviour mention some climate-related physical changes, they provide only a few lines on the topic, and on average much less than firms adopting other adaptation behaviours. This suggests that these firms were either not aware of complex weather and climate-related events at the time of the questionnaire, or at least had not yet conducted an in-depth risk and vulnerability assessment. For example, we could not identify any mention of the physical impacts on their business or business impacts such as those related to changes in resource availability or any financial implications, often recalled by firms adopting different adaptation behaviour. Since firms in this group emphasize the safety of their operations in the near future, their sense of controllability appears to be relatively high, but lack a real sense of urgency.

**Table 2 Corporate adaptation behaviour and associated adaptation measures**

| | **Pre-emptive adaptation** | **Reactive adaptation** | **Continuous adaptation** | **Deferred adaptation** |
|---|---|---|---|---|
| Wait-and-see | - | - | - | Wait and see |
| Risk assessment | Early and advanced assessment of climate-related physical risk | Advanced assessment of climate-related physical risk | Advanced assessment of climate-related physical risk | Traditional risk identification |
| Technical solutions | Operational and procedural; Engineering and design; Maintenance; Developing alternatives | Operational and procedural; Engineering and design; Investment in infrastructure; Supply diversification; Development of | Operational and procedural; Engineering and design; Investment in innovation; Maintenance; Development of alternatives | - |

| | | | | |
|---|---|---|---|---|
| | | alternatives | | |
| Geographical exposure | Regional diversification; Consideration of safe location for new investments | Divestiture of operations in affected areas; Strategic geographic repositioning | Decommissioning of old facilities | - |
| Risk sharing and shifting | Insurance; Shift increased costs to consumers; Consideration of physical risks in contracts and future acquisitions | Insurance; Shift increased costs to consumers | Insurance | - |
| Resilience | Emergency, contingency and business continuity plans; Development of crisis management for clients | Emergency, contingency and business continuity plans; Set-up of specific organizational department to deal with extremes | Emergency, contingency and business continuity plans | - |
| Portfolio diversification | Diversification by market segment | - | - | - |
| Cooperation | Stakeholder management to prevent conflicts; Involvement in regulatory developme | Sharing of lessons-learned in the industry; Support of local policies and | - | - |

| | | |
|---|---|---|
| | nt | industrial emergency plans;<br>Support of mitigation policies |

### *3.5.7. From sensemaking to adaptation measures*

Table 2 compares and contrasts the four different adaptation behaviours in terms of the main adaptation and resilience measures that correspond with each behavioural type. While firms adopting deferred behaviour mainly rely on traditional risk identification and assessment, those adopting other kinds of behaviour perform more dedicated assessments of climate-related physical risk. For all three active behaviours, we found operational and procedural measures and engineering interventions among the technical solutions. However, firms with a reactive stance also invest in infrastructure or consider supply diversification, while those with continuous adaptation behaviour invest more in innovation. Pre-emptive behaviour leads firms to consider the reduction of exposure through geographic diversification, looking for safe locations for new projects in particular. Reactive firms, on the other hand, divest operations in affected areas instead and go for a strategic repositioning. Finally, firms with continuous adaptation accelerate a decommissioning of old facilities. We found that diversification by market segment is implemented particularly by firms with pre-emptive behaviour, a stance which also triggers more risk sharing and shifting. Firms with pre-emptive and reactive behaviours are the ones most vigorously improving resilience and engaging in collaborative measures. While pre-emptive firms work with policymakers to contribute to regulatory development – e.g. about water use – and with local stakeholders to prevent conflicts, reactive firms are working together within the industry to share lessons learned and define industrial emergency plans. In general, we observed that firms with reactive behaviour take a more resolute stance in adaptation measures; firms with pre-emptive

behaviour plan for a more widespread set of measures; and those with continuous behaviour rely on fewer but more focused measures.

While we presented the four types of adaptation behaviour as fully distinct in the sense that a firm could adopt one type of behaviour only, the typology is somewhat stylized. To classify a firm in one cell of the typology only (see Figure 1) was not always possible, because large oil and gas multinationals do not behave in a unified manner. A firm could very well make sense of climate stimuli in different ways across installations, depending on location-specific weather and climate events, and thus adopt different types of adaptation behaviour simultaneously. For example, some firms take different kinds of adaptation and/or resilience measures consistent with the distinct sensemaking processes they apply towards on the one hand steady changes and on the other hand extreme events. They thus modulate their behaviour according to the different perceptions they hold of awareness and vulnerability to each type of physical change. The resulting priority of intervention is quite different, as the case of Sasol exemplifies. In fact, this firm explicitly made a distinction between various climate-related physical changes; while climate change was seen as just an additional factor with regard to water availability, the firm placed much greater attention on managing extreme weather events. In the end, Sasol was exhibiting pre-emptive adaptation behaviour towards gradual changes, but took a more reactive approach towards extreme events based on a past experience with heavy rainfalls which put pressure on some dams it relied on.

We argued that corporate adaptation behaviour seems to be driven mainly by a combination of awareness and vulnerability. However, a more fine-grained look at the factors underlying these two dimensions shows that firms often place different weights on each of these underlying factors with concomitant results for the implemented measures. In our analysis in particular the type of physical change, the sources of information used, the ecological embeddedness, and the potential financial implications emerged as having the most distinctive influence on the measures firms take. While uncertainty was found to be important in previous research (Berkhout et al. 2006; Hertin et al.

2003), in our sample high uncertainty in general did not keep firms from implementing adaptation measures.

Although we could discern a general pattern between the way firms make sense of climate stimuli in terms of awareness and vulnerability and the type of measures they take, there is also some counterfactual evidence. At times, other factors seemed to have played a more decisive role. Cairn Energy, for instance, despite being highly aware of physical changes and conceived of some of its operations as vulnerable, did not implement any adaptation measures. The reason was that the only installation that could experience climate stress was located in Bangladesh and at the tail end of its production life, so no additional precautions were considered necessary. In addition, the economic viability of certain measures has an important role not only influencing adaptation behaviours – e.g. adopting pre-emptive adaptation rather than deferred adaptation behaviour – but also adaptation measures, e.g. selling facilities or decreasing production rather than implementing technical solutions. We also identified some firms with high risk awareness of climate-related physical change and low vulnerability, nevertheless not adopting adaptation measures because they consider themselves to have already adapted. Finally, some firms showed high risk awareness but failed to disclose information from which their vulnerability profile or adaptation measures could be derived.

Furthermore, corporate behaviour is not stable; firms can change behaviour according to changes in the features that underlie their specific sensemaking process of climate stimuli. Some firms that currently have a deferred adaptation profile, postponing adaptation measures, seem inclined to change position on the issue in the (near) future. For instance, TransCanada Corporation intends to take on board the impact of climate change in future projects in the Arctic region; that is, if it 'builds new facilities in northern areas, the firm's facility designs will take into account the potential for changing permafrost levels.' What could induce such behavioural change is that firms come to realize their vulnerability after incurring damage from an extreme weather event. This could trigger reactive adaptation when

the damage surpasses a certain threshold (e.g. high financial implications). The opposite could happen as well, however. Since firms can actively reduce their vulnerability through adaptation measures, taking such measures could actually push them back in a deferred adaptation position, based on the belief that no further measures seem necessary.

This seems to have happened at Devon Energy Corporation:

> Furthermore, with the recent divestiture of Devon's Gulf of Mexico and international properties, Devon has repositioned itself for production growth with a balanced portfolio of onshore North American oil and gas assets. With this strategic repositioning, Devon has effectively mitigated the risk of facility damage from offshore storms.

## 3.6. Conclusions

Physical impacts from climate change can pose major challenges to firms, leading to a reconsideration of the relationship between organizations and the environment. Firms have come to be seen not only as one of the societal actors causing climate change, but also as victims of its impacts. Based on a qualitative analysis of CDP survey data for the oil and gas sector, this study identifies factors influencing corporate adaptation and resilience strategies in response to climate-induced physical changes. Building on previous research, the paper in particular argues that adaptation is the outcome of a sensemaking process where firms interpret how climate change will affect their organizations before they take action (Linnenluecke et al. 2012). Corporate adaptation behaviour is viewed as a combination of the three main elements of the sensemaking process: awareness of climate-related physical changes, the subsequent vulnerability assessment, and the ensuing adaptation measures. Four main types of adaptation behaviour emerged from the analysis: pre-emptive, reactive, continuous and deferred adaptation.

The study also identifies the relevant direct and indirect climate stimuli that affect awareness, vulnerability assessment, and

subsequent adaptation measures, which remained ambiguous in previous research. The findings suggest that the type of physical change, the sources of information used, the ecological embeddedness, and the potential financial implications seem to have the most distinctive influence on the measures firms take to cope with physical impacts. Furthermore, the study shows that adaptation strategies often still consist of a set of ad-hoc measures, rather than being based on the development of new routines through organizational learning, as previously proposed (Berkhout et al. 2006). Adaptation behaviour is not stable, however, but fluctuating over the course of the sensemaking process. That is, there is constant interaction between identification, interpretation and action (Thomas et al. 1993; Weick et al. 2005), which leads to different patterns of dynamic adaptation behaviour. However, while previous research argued that this would result in a cyclical process where firms learn to better cope with physical impacts over time (Berkhout et al. 2006; Linnenluecke et al. 2012), our findings suggest that the opposite might occur as well. Once firms with pre-emptive or continuous adaptation behaviour have taken measures to better cope with physical changes, they sometimes have the tendency to become complacent and move back to a reactive or a deferred stance instead.

The findings of the study and the typology could represent a useful tool for firms to understand their adaptation behaviour in relation to the sensemaking process of climate-induced physical change and possibly reconsider it. For example, firms with deferred behaviour could start to improve their awareness relying on more and more adequate sources of information, such as internal inquiries, and assess their vulnerability including financial implications of potential physical impacts. In addition, firms with pre-emptive behaviour could accelerate the formulation and implementation of their adaptation strategies, thus jumpstarting more substantive adaptation measures. Besides, the study suggests that knowledge about the likelihood of physical impacts and the vulnerability of the organization are important prerequisites for subsequent action. Policymakers could therefore provide small and medium-sized firms with information to guide their sensemaking process and compensate their limited ability

to adapt. They could commission studies on climate-induced physical changes, the projected impacts on infrastructure, and the financial implications for particular economic sectors. Furthermore, policymakers could provide training sessions to make firms aware of their ecological embeddedness and fund private research initiatives and subsequent dissemination activities.

To conclude, then, this study is not without limitations. The CDP survey, for example, does not allow interacting directly with the firms involved. Relating adaptation measures to the way in which firms make sense of climate stimuli in terms of awareness and vulnerability was an outcome of our analysis, but we were not in the position to ask firms directly whether and/or how this process took place. Besides, the oil and gas industry, which we singled out for our analysis, could be a frontrunner in implementing adaptation measures, given its particular awareness of climate change being one of the major emitters, its vulnerability and its ability to adapt. Other industries might not have advanced as much and thus show less variety in their adaptation behaviour, as a consequence. While the body of research on corporate adaptation to climate-induced physical impacts is growing, there are still many questions remaining. As a follow-up to this paper, future studies could investigate the more comprehensive sensemaking process of climate change and not only consider climate stimuli from physical impacts, but also how these interact with stimuli related to competitive or regulatory forces related to mitigation.

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# 4. The mutual influence of Environmental Management Systems and the EU ETS: findings for the Italian pulp and paper industry

*This paper was written together with Francesco Rizzi and Marco Frey and has been published in European Management journal, (2013) 31, 16– 26.*

## 4.1. Abstract

The European Emissions Trading Scheme (EU ETS) is designed to be a flexible and efficient mechanism to encourage carbon-intensive industries to reduce $CO_2$ emissions cost-effectively. Similarly, Environmental Management Systems (EMSs) are well-established tools designed to improve the efficiency of the environmental performance of companies. Up to now, knowledge of the mutual influences of strategic planning, ETS management and EMSs is still incomplete, and their implications are not fully understood. This study tries to identify whether the involvement of a firm in the ETS with the adoption of an EMS favours the generation of corporate strategic synergies in terms of organizational management and environmental planning. Due to a relatively short time frame and the need for exploratory research, a multiple case study emerged as the most suitable approach. Hence various Italian pulp and paper companies involved in the EU ETS were interviewed and analyzed. We found that organizations that integrate ETS management and EMS tend to establish satisfactory standards and procedures that are relevant for environmental monitoring and compliance. However not all ETS-related activities are integrated into EMSs. In addition, despite some mutual synergies, these are not sufficient for determining corporate environmental planning.

Keywords: Emissions Trading Scheme; Environmental Management Systems; allowance management; organizational change; environmental planning; pulp and paper industry.

## 4.2. Introduction

The European Emissions Trading Scheme (EU ETS) is considered a flexible policy instrument to cut greenhouse gas (GHG) emissions in order to achieve Kyoto's reduction targets. The ETS is a market-based policy instrument based on the cap-and-trade system which offers, in theory, the opportunity to meet environmental targets in the most cost-effective way. In other words, setting a cap on the permitted amount of emissions, corresponding to allocated allowances, and introducing a market for allowances grant flexibilities to companies to define their strategy (Rogge *et al.*, 2011a). Then, in equilibrium, the market price of carbon is supposed to reflect the scarcity of allowances and the marginal abatement costs which are equalised across companies. Therefore, overall abatement costs are minimized (Tietenberg, 2006).

This possibility of tailoring a cost-effective strategy to meet the carbon emission targets implies at the same time the opportunity for a company to protect competitiveness and shareholder value. But developing such a strategy and day-to-day business decisions requires a rethinking of information flows, capital expenditure and organizational changes (Sandoff and Schaad, 2009). In fact, on the one hand, a successful implementation of a carbon market implies multiple challenges (e.g. to improve monitoring, control and planning skills, to achieve long-term predictability of carbon prices, etc.). On the other hand, it would allow a predictability of investments, which would result in an efficient participants' management of investments, i.e. to manage resources, roles and responsibilities to define whether to invest in new equipment to reduce carbon emissions, or to buy additional allowances (Egenhofer, 2007). In fact, the price for allowances also sets monetary incentives to adopt new solutions for energy-efficient and carbon-efficient improvements. But the price of allowances is practically influenced by the ETS design, e.g. rules of allowance allocations, cap definition, and use of credits from other Kyoto Mechanisms (Schleich *et al.* 2009). In other words, by avoiding

its distorted implementation (e.g. the potential effects of the allocation of allowances for free to new entrants, banning banking between different trading phases, etc.) and price volatility, the ETS is expected to provide incentives to innovation (European Commission, 2005; Schleich *et al.* 2009; Rogge *et al.*, 2011a).

Hence, in order to effectively manage this system, companies are expected to implement cross-functional activities (Sandoff and Schaad, 2009), or develop useful and specific interdisciplinary functions.

Correspondently, an Environmental Management System (EMS) is considered a beneficial tool for organizations that wish to integrate environmental management in the overall corporate management system, not only to comply with existing regulations but also to take into account and eventually respond to changing knowledge and technology (Bansal and Bogner, 2002). Additionally, it is beneficial in order to implement better organization and documentation of environmental activities and procedures (Morrow and Rondinelli, 2002). Even though the relationship between the implementation of an EMS and environmental innovation is still unclear (Ziegler and Nogareda, 2009), some authors reported a positive influence of an EMS on environmental innovation (Radonjic and Tominc, 2006; 2007), together with environmental regulation and organizational changes, and on detecting cost- saving potential by reducing information deficit (Horbach, 2008), especially in the case of EMSs in maturity stage (Rennings *et al.*, 2006).

Against this background, this paper aims to analyze the mutual influence of environmental voluntary regulation and the ETS in terms of organizational management and environmental planning.

In fact, it is still unclear whether ETS-related activities are allocated to existent departments and functions; for example, to those involved in EMSs, or companies setting up new ones. To this end, we provide an analysis of how ETS management has been implemented in companies adopting an EMS. In detail, the analysis focuses on the identification of the persons in charge of ETS-related activities within companies having EMSs. Another objective of the research is

understanding whether the ETS is able to influence corporate organization and to trigger investment planning to a greater extent than a pre-existing EMS program.

We addressed these questions by carrying out a multiple case study of the Italian pulp and paper industry. This industry has been very receptive to environmental voluntary regulations (see, as an example, the project Life PIONEER "Paper Industry Operating in Network: an Experiment for Emas Revision", 2003-2006), and features organizations with installations representing the most important European emitters in terms of emission size. In fact, installations according to the Community Independent Transaction Log's classification are classified in five categories: zero emitters (0 kt $CO_2$-eq), mini (<25 kt $CO_2$-eq), small (25-50 kt $CO_2$-eq), medium (50-500 kt $CO_2$-eq) and large (>500 kt $CO_2$-eq). While mini installations under 10,000 $tCO^2$/year (about 3400 participants) represent 32% of the total number of installations covered by the EU ETS, their emissions amount to nearly 1% of the emissions covered by the ETS; installations under 25,000 $tCO_2$/year represent 55% of the total but emit only 2.4% of all the EU ETS emissions (Egenhofer, 2007). Italian pulp and paper installations feature mini, small and medium sized installations.

Because the aim of our research was to explore the generation of synergies at corporate strategic level in terms of organizational management and environmental planning between the ETS and EMSs, and to explain causal relationships, a qualitative approach seemed appropriate (Yin, 2002).

This paper is structured as follows: the following section presents a critical review of the literature on the EU ETS and on the environmental voluntary regulation; grounding on the resulting open research questions, the next two sections introduce the case study methodology and present our findings respectively; finally, the last section discusses these findings and concludes with research and policy recommendations.

## 4.3. Literature review and research framework

Compared to EMS, which has become widespread among organizations since 1996, the ETS is a relatively new concept in environmental management. In fact, the EU ETS came into force in 2005. The Scheme, introduced by the Directive 2003/87/EC, is a crucial tool in EU carbon policy to achieve the emission reduction targets of the Kyoto Protocol. It applies to the largest carbon-intensive industry sectors of EU member states (e.g. fuel combustion and oil refining, mineral/cement, steel, pulp and paper, etc.). The Scheme is based on a cap-and-trade system that is organized in trading phases. The first was a pilot phase between 2005 and 2007), while the current phase coincides with the Kyoto commitment period (2008-2012). The third trading period (phase 3) will last from 2013 to 2020. According to the EU ETS, during phases 1 and 2 each member state is assigned to national installations that are, subject to the Directive, a number of allowances corresponding to emission targets adopted in a specific National Allocation Plan (NAP). These companies have to surrender as many allowances as emitted. If a company emits more allowances that what have been allocated, it can buy extra allowances on the carbon market to avoid fines. If it emits less than the allowances allocated, it can sell exceeding allowances on the carbon market. European companies can also fulfill their emission reduction obligations in part by using two other flexible mechanisms of the Kyoto Protocol generating certificates: the Clean Development Mechanism (CDM), and the Joint Implementation (JI).

### *4.3.1. Literature review on ETS impacts on corporate management and innovation*

To date, it is possible to classify the existing literature on the EU ETS in two groups: studies trying to foresee the Scheme's impacts (i.e. policy-design orientated), and those carrying out ex-post impact assessment (i.e. effectiveness-evaluation orientated). In particular, there is a growing number of the former and a shrinking number of the latter due to the recent EU ETS introduction (for an overview of an empirical study on the ETS operating mechanism and economic effects, see Zhang and Wei, 2010). Memorable ex ante studies include

Laurikka and Koljonen (2006) and Kara *et al.* (2008). The former scholars showed with real option- pricing models that the uncertainty regarding the allocation of emission allowances is critical in a quantitative investment appraisal of fossil fuel-fired power plants. However, the latter study highlighted the different positions of energy-intensive industry branches in Finland with regard to emissions trading. For example, whereas the pulp and paper industry owns most of the power plants required for satisfying their electricity and heat demand, other industries rely on the market. Referring to the ex-post impact assessment approach, a growing set of studies have considered the effect of the Scheme on competitiveness. Oberndorfer and Rennings (2007) compared differing theoretical studies and concluded that the fears of the majority of sectors regarding strong negative impacts on competitiveness are not justified. Demailly and Quirion (2008) focused on the iron and steel industries and concluded that competitiveness losses are small, while Lund (2007), investigating carbon-intensive manufacturing industries, found that the influence of ETS on costs is quite heterogeneous in different industry sectors. In fact, the total impact remains below 2% of the production value, with the exception of highly electricity-intensive industries such as steel and cement. To this end, Egenhofer (2007) provided a broader analysis of the economic implications of the EU ETS design.

A second set of studies analyzed the relationship between the ETS and investment decisions. Hoffmann (2007) suggested with a case study on the German electricity industry that the EU ETS represents a prominent driver for small-scale investments with a short payback period, while its impact on large-scale investments or R&D is limited. Furthermore, Hoffmann *et al.* (2009) found that the uncertainties regarding the future of EU ETS do not necessarily lead to investment decisions being postponed.

As far as we know, comparatively few studies analyzed the impact of the ETS on corporate management and organizational change, and only two of them refer to the pulp and paper industry. Studying the German power sector, Rogge *et al.* (2011a) differentiated innovation components into the research of development and demonstration

(RD&D), innovation adoption, and organizational change. They found that the EU ETS, until now, has had a limited impact in terms of fundamental changes in adopting corporate innovations, while it has had some impacts for RD&D on carbon capture technologies, and for organizational changes. Rogge *et al.* (2011b) carried out similar research on the German pulp and paper sector, confirming that EU ETS barely affected innovation activities, with the exception of organizational change. Pontoglio (2010), in an analysis of the reaction to EU ETS of the Italian pulp and paper companies after phase 1, pointed out that companies adopted a "wait and see" strategy. Additionally, Sandoff and Schaad (2009), describing the function of allowance management and decision-making in response to the ETS, suggested the involvement of top management as a proxy for the importance given to the ETS and, thus, the willingness to take ETS-related actions that are not driven only by compliance strategies. Despite this, the impact of the ETS on wider corporate environmental management has not been investigated in detail.

### *4.3.2. Literature review on EMS impacts on corporate management and innovation*

As companies began to invest in pollution prevention techniques, and started integrating their environmental management practices into traditional management systems, two main standards for EMS design and certification were developed and are now internationally recognized: ISO 14001 and EMAS (Morrow and Rondinelli, 2002). According to these standards, an EMS consists of a structure of roles and responsibilities, and a related set of procedures for managing the organization's environmental policy. These include direct and indirect environmental aspects (such as compliance with legal and other requirements), environmental management programs (to ensure a continuous environmental improvement, as well as efficient training, awareness and competence), plus relevant documentation, records and communication, operational control, emergency procedures and response, monitoring and measurement, non-conformance, corrective and preventive actions, periodical audits, and management reviews. Morrow and Rondinelli (2002) figured out the main benefits for companies implementing such a standard (i.e. better organization and

documentation of their environmental activities and procedures, increased legal certainty and regulatory compliance, improved image), but they also found that investment decisions are made on the basis of economic and regulatory issues rather than environmental considerations.

In their overview of the costs/benefits of ISO 14001 implementation, Bansal and Bogner (2002) argued that an effective EMS allows firms to integrate environmental management into overall corporate management systems, not only to comply with existing regulations but also to take into account – and eventually respond to – changing knowledge and technology. Gavronski *et al.* (2008) found four dimensions characterizing the benefits of the adoption of ISO 14001: operational changes, financial impacts, and relationships with business stakeholders and societal stakeholders. Barla (2007) investigated the relationship between the implementation of ISO 14001 and environmental performances in the pulp and paper industry, with inconclusive results. However, Iraldo *et al.* (2009) found that organizations with the ability to plan their environmental targets effectively, such as those implementing an EMS, have a better chance of improving environmental performances.

Reviewing the literature on the relationship between environmental innovation and EMSs, Horbach (2008) claimed that environmental regulation, environmental management tools, and organizational changes are important drivers for environmental innovation. In particular, environmental management tools reduce information deficit to detect cost-saving potential, which is another important driver of environmental innovation. Rennings *et al.* (2006) reported that EMSs have a positive influence on environmental process innovation, in particular in its maturity stage. Similarly, Radonjic and Tominc (2006; 2007) pointed out a positive relationship between the implementation of an EMS and the acceleration of technological innovation, while Ziegler and Nogareda (2009) revealed that an EMS could be reversely affected by environmental product or process innovations.

With reference to the Spanish pulp and paper industry, del Río González (2005) found that the main obstacles to adopting clean technologies are related to the long payback periods on the investment in these technologies. This is due to the large amounts of initial capital investment required, and the difficulty of recovering such investments by increasing sales.

### *4.3.3. Research gap*

Given this framework, as far as we know, only a couple of studies have investigated the integration of Energy Management and Kyoto-related activities into an EMS, finding conflicting results (Amundsen, 2000; Wagner, 2008). In fact, while Amundsen (2000) noted that such activities had not already been integrated in Norwegian energy-intensive companies despite being desirable for achieving energy and resource efficiency, Wagner (2008) found a significant positive relationship between the implementation of an EMS and energy management. However, both carried out their research when EU ETS was not in force. As a consequence, the analysis of the implications and relationships occurring between ETS management, EMSs, and strategic planning is still incomplete.

In particular, it is relevant to shed light on the synergies and mutual relationships that are theoretically and practically possible when implementing environmental voluntary regulation and carbon management in response to more and more challenging "green policies". These policies require an integration of environmental and corporate operation management. In fact, as an example, the objectives in terms of the reduction of $CO_2$ emissions introduced with the EU ETS Directive have impacts on the determinants of corporate know-how.

Continuous improvements are required, e.g. in terms of performance monitoring and control, compliance, technology and carbon market, etc., which means investing in cross-functional competences and in research and development activities. Impacts on risk and opportunity evaluation, strategy development and corporate procedures are unavoidable.

To undertake actions and take advantage of opportunities from the ETS market suggests developing an ETS management and, arguably, integrating it in the overall environmental management system. In fact, on the one hand GHG emissions are environmental aspects already considered by an EMS. On the other, an EMS represents a suitable system to manage an important part of ETS-related activities. For example, the European Commission requires installations to have an approved monitoring plan, according to which they need to monitor, report and verify (MRV) their $CO_2$ emissions during the year (2007/589/EC), and EMS are already in charge of monitoring, reporting and verifying activities for environmental aspects. Furthermore, if an EMS provides a company with better organization and documentation of environmental activities and procedures (Morrow and Rondinelli, 2002), it allows firms to integrate environmental management into overall corporate management systems (Bansal and Bogner, 2002). Since this implies increasing legal and regulatory compliance, a company that integrates ETS management with an EMS would theoretically lead to establishing satisfactory standards and procedures for GHG emissions compliance. Additionally, the activation of integrated competences could lead to profit from the opportunities that a GHG flexible market offers. According to this, in our research we investigated whether, and if yes how, carbon management can be integrated into an environmental management system; and if no, who is in charge of ETS-related activities not assigned to EMSs.

With specific reference to planning activities, on the one hand the EU ETS has been designed to provide an incentive for innovation; on the other hand, the above research reveals some influence of EMSs on technological environmental innovation. Thus, it is reasonable to expect that the contextual implementation of an ETS and an EMS would trigger investments in technological change and innovation. In particular, according to the nature of the emissions trading scheme, it is also reasonable to expect that the EU ETS could be able to trigger higher investments in innovation than those embedded in traditional EMS programs. The findings on this are discussed below.

## 4.4. Methodology

We addressed the aforementioned questions by carrying out a multiple case study of the Italian pulp and paper industry. We chose a qualitative methodological approach because of the complexity of the phenomena, and the current lack of meaningful theoretical models to be tested for generalization among different ETS sectors. The explorative aim of our research seemed consistent with such approach (Yin, 2002). We chose the Italian pulp and paper industry because it has been very receptive to environmental voluntary regulations. According to *Assocarta* (2009), in December 2008 there were 62 certified installations ISO 14001 and/or EMAS, with an overall production of more than six million tons of paper. This is more than 60% of the national production, and 450,000 tons of wood pulp for paper. Finally, this sector, as previously stated, is an interesting investigation field due to the presence of companies that belong – in terms of emissions per year – to the most representative classes of European installations. We selected our cases in order to allow an analytical generalization of findings through a literal and theoretical replication, ensuring the possibility of discovering similarities among the cases, and to predict contrasting results for predictable reasons (Yin, 2002). With the former, we included comparable companies and, to allow the latter, we selected companies with different characteristics. In terms of details, companies were chosen on the basis of the number of allowances allocated by the Italian National Allocation Plan, and of the achievement of an environmental certification such as an EMAS or ISO 14001, which implies the implementation of an EMS. In doing so, we included, in a first step, 14 out of 15 of the companies having more than 60,000 $tCO_2$ allowances according to the Italian NAP of phase 2 (only one had no environmental certification such as an ISO 14001 or EMAS). Afterwards, we discarded one company that had gone out of business, and two companies due to difficulties in obtaining an adequate commitment from environmental managers for participating in the research. We contacted the remaining 11 companies. Finally, seven

companies gave their commitment to providing research with detailed information. Two of these companies belong to the same holding, and have the same Environmental Manager, which is why we considered six cases in this paper. Since each company owns one or more installations, the set includes mini, small and medium installation size according to the definition of the Community Independent Transaction Log (CITL) of the European Commission (Table 1).

The numbers of case study replication have been considered sufficient for the objective of our research for the following reasons: firstly, we have case studies with installations in all of the main European and Italian classes of the pulp and paper industry (Table 1); secondly, we have more than one installation per size class (Table 1); thirdly, we have companies owning from one to five or more installations (Table 2); and finally, we have more than one company owning only one plant, two plants, or five or more plants (Table 2). The final set of companies represents around 41% of GHG emissions of the overall Italian pulp and paper industry. These case studies comply with the requirements of both literal and theoretical replication (Yin, 2002).

Due to the nature of the multiple case study methodology, the degree to which the sample is representative of the population is considered secondary here.

**Table 1. Overview of installations and allocated allowances of case studies and of Italian and European pulp and paper industry. Year 2009**[3]

| **Pulp, Paper and Board** ***Year 2009*** | **Large (kt $CO_2$-eq> 500)** | **Medium (50 <kt $CO_2$-eq< 500)** | **Small (25 <kt $CO_2$-eq< 50)** | **Mini (0 <kt $CO_2$-eq< 25)** | **Zero (kt $CO_2$-eq= 0)** | **Total** |
|---|---|---|---|---|---|---|
| *Number of installations* | | | | | | |
| Case studies | 0 | 16 | 4 | 4 | 0 | 24 |
| Italy | 0 | 31 | 33 | 99 | 0 | 163 |
| EU 25 | 0 | 201 | 158 | 418 | 5 | 782 |
| *Number of installations - % of the total* | | | | | | |
| Case studies | 0 | 66.67 | 16.67 | 16.67 | 0.00 | 100 |
| Italy | 0 | 19.02 | 20.25 | 60.74 | 0.00 | 100 |
| EU 25 | 0 | 25.70 | 20.20 | 53.45 | 0.64 | 100 |
| *Allocated allowances - Emission unit - t $CO_2$-eq* | | | | | | |
| Case studies | 0 | 1,886,108 | 167,836 | 52,804 | 0 | 2,106,748 |

[3]The number of installations covered by the Scheme and allowances allocated may differ between years, due to installation closures or new installations.

| | | | | | | |
|---|---|---|---|---|---|---|
| Italy | 0 | 3,002,228 | 1,185,772 | 951,702 | 0 | 5,139,702 |
| EU 25 | 0 | 26,573,969 | 6,093,866 | 4,901,174 | 113,435 | 37,682,444 |
| *Allocated allowances - % of the total* | | | | | | |
| Case studies | 0 | 89.53 | 7.97 | 2.51 | 0.00 | 100.00 |
| Italy | 0 | 58.41 | 23.07 | 18.52 | 0.00 | 100.00 |
| EU 25 | 0 | 70.52 | 16.17 | 13.01 | 0.30 | 100.00 |

It is worth mentioning that five of the six selected companies also have installations in other European countries, or have links with foreign companies. This aspect allows us to avoid distortions related to potential national peculiarities in terms of ETS implementation at installation level.

We conducted our case studies between December 2010 and March 2011. Firstly, we contacted the Environmental Managers by phone, explaining the objectives of the research, and then sent a questionnaire by email for familiarization. After that, we conducted phone or face-to-face interviews at the company site where possible. Once we collected the information, we contacted the Environmental Managers again by phone to clarify any issues that arose. Additional generic information was collected from companies' websites and BVD Amadeus Financials Data. We completed our database with ETS data of the Community Independent Transaction Log (CITL) from the European Commission.

### 4.5. Results

Below we present our findings regarding the main effects of the EU ETS and EMSs on organizational management and environmental

planning, which we have correlated with the most important characteristics of firms. We support our findings with exemplary quotes in the text.

### *4.5.1. ETS, EMS and organizational management*

All the cases analyzed have one or more installation that achieved certification, either in the same period in which the EU ETS (phase 1) came into force, or before (Table 2). In these installations, ISO 14001 certification is more frequent than EMAS registration. Companies with these certifications allocated some of the activities necessary for dealing with the ETS to the existing EMS, with the exception of one installation (owned by C4) that had no environmental certification. In this case, the company has certifications for some installations but does not extend – either formally or informally – the EMS to its non-certified installations. Excluding this exception, although a certification only applies to one installation, companies with more installations tend to coordinate environmental management systems between certified and non-certified installations. In this case, some ETS-related activities are managed both at an installation level and a corporate level. The situation is explained well by one company (C1), who stated: '*When ETS legislation first came into force in 2005, our Corporate Environmental System became responsible for ETS-related activities. This involved Corporate General Management, Plant Management and EMSs operating at installation level. The aim was to ensure adequate compliance, a systematic collection of all necessary information and timely monitoring*.'

**Table 2. Overview of case studies**

| *Cases* | *No. of Italian installations* | *ISO 14001* | *First Year of Certification* | *EMAS* | *First Year of Registration* |
|---|---|---|---|---|---|
| **C1** | 13 | 13 | 2009 | 2 | 2005, 2011 |
| **C2** | 2 | 1 | 2005 | 1 | 2006 |
| **C3** | 1 | 1 | 2000 | 1 | 2005 |
| **C4** | 5 | 3 | 2006 | | |
| **C5** | 2 | 1 | 2006 | | |
| **C6** | 1 | 1 | 2000 | 1 | 2006 |
| **Total** | **24** | **20** | | **5** | |

The complexity of ETS management depends on the number, and on the dimension of installations managed by a company. Indeed, corporate EMSs seem ineffective in decoupling the human resources involved in managing ETS from the number and dimension of the installations. In fact, the two companies with five or more installations (C1 and C4) developed a complex management system to manage ETS-related activities. They have become involved in new activities regarding the ETS, both in personnel in staff to the Direction and key persons in the environmental management system with different functions – some dedicated – both at corporate and at plant level. These two companies spend 117 and 586 man-hours/year per installation respectively in ETS management, while the others spend equal or less than 110 man-hours/year per installation (Table 3). Such evidence suggests that it is not possible to conclude that the less companies are involved in ETS, the less they employ human resources in ETS management. The difference among average man-hours/year per installation could be due to different approaches in task allocation.

**Table 3. Personnel allocation per installation**

| Cases | N of installations | Average emissions/year per installation | Average man hours/year per installation | Average human resources per installation |
|---|---|---|---|---|
| **C1** | 13 | 107,537 | 117 | 2.46 |
| **C2** | 2 | 73,618 | 14 | 2 |
| **C3** | 1 | 160,280 | 110 | 6 |
| **C4** | 5 | 44,161 | 586 | 2.2 |
| **C5** | 2 | 59,518 | 42 | 1 |
| **C6** | 1 | 61,416 | 96 | 2 |

C1 and C4 are the only two companies that employed new ETS-dedicated staff, although in different functions. C1 employed 10 new production installation employees to deal with carbon monitoring, and one employee at a corporate level to coordinate ETS-based activities and online operations (such as compliance and National Emission Trading Register activities). These new functions work together with the EMS personnel. C4 employed one Energy Manager to deal with allowance trading at a corporate level.

The two companies also differ from the others in terms of allowance trading. C4 created a specific function to deal with allowance trading. With the same aim, C1 assigned all activities related to carbon market monitoring and allowance trading to a 100% controlled company involved in energy services, whose executive manager takes decisions concerning allowance operations.

All companies extended the EMS to ETS-related activities, with the exception of C5, which externalized a consulting service for regulatory updating in order to support the compliance management implemented within the EMS, for annual emission communication, for relationships with the Authority, and for the calibration of instruments. C1, C2, and C4 regularly outsource the calibration of instruments, while C3 and C6 stated that they do not acquire consultancy services for ETS-related activities.

Administrative and financial staff are also involved in the management of allowances, but, once again, their exact role tends to depend on the number of installations. For companies with five or more installations, administration and finance mostly involve administrative tasks and are not in charge of trading activities, while companies with less than five installations also often rely on administration and finance for trading activities, as explained by one company (C2): '*The EMS informs administration and finance about allowances. After an internal allowance exchange between Italian and foreign corporate installations for cases where plants have a surplus of units, EMS notifies the administration and finance office about surpluses or shortages to trade on the market*.'

Generally speaking, ETS-related activities assigned to EMSs concern carbon emission monitoring, compliance procedures, regulation monitoring, documentation and verification, while allowance price monitoring and trading allowances are assigned to administrative and finance departments, or more specific staff.

The involvement of executive management in trading decisions varies greatly among companies. C1 claims to have an internal rule for allowance trading, i.e. selling only exceeding allowances, thus no other decisions are needed; C2 relies on trading decisions taken by their administration and finance departments, while for C5 and C6, these decisions are taken by the owner or at a corporate level. Although C1, C2, C3 and C4 reported that executive management boards are informed about ETS-related activities but decisions are delegated to subordinates, executive management involvement seemed more flexible in C3 and C4. Both C3 and C4 informed us that the executive management boards can sometimes take crucial decisions regarding trading.

To summarize, in four companies (C3, C4, C5 and C6), executive management is actively involved in allowance trading decisions.

To understand the level of administrative and financial involvement, we noticed that only in two cases (C2 and C3) were strategies or options to deal with allowance management actively proposed by this department.

The managerial aspects considered in this paper suggest that, having set up an EMS, a company would make it an important part of ETS-related activities, in particular carbon emission monitoring, compliance procedures, regulation monitoring, documentation and verification. Despite this, the tendency to take decisions on the ETS only during yearly management reviews suggests the prevailing attention to regulation compliance. This can impact negatively on the corporate capability to exploit the potential advantages of trade allowances at the best prices, as well as to have a larger number of investment options.

In order to understand the attitude of companies towards the integration of EMSs and the ETS, it is important to note that the presence of an EMS in a company was generally perceived as very beneficial to ETS management, with the exception of C4.[4] The internal and external audits introduced by EMSs are considered an added value for ETS compliance; in the words of C1: '*The constant collaboration between different managers (i.e. between those responsible for carbon monitoring and EMS) operating within the Environmental Management Systems of the Group, and the interrelation with those in charge of coordination has led to the optimization of data collection and monitoring, with clear advantages during third-party audits for validation of annual emissions. Observations arising from internal audits and external audits have undoubtedly improved the awareness of the Process Owner regarding an appropriate and timely management of the EU ETS*.' C3 reported that the presence of an EMS is fundamental for allowance management. C2 commented: '*An integrated system certainly makes it easier to monitor and manage data as well as to draft final accounting and to report on performances. The presence of an environmental management system has certainly enabled the rapid integration of ETS-compliance in corporate procedures*.' Such declarations reveal a higher orientation towards compliance with ETS rules than towards its trading opportunities.

The integration of ETS-related activities in an EMS entails the implementation of specific ETS requirements in existing procedures that, most of the time, regard structure and responsibilities, supply, non-compliance management, audit, controlling, monitoring and reporting, or other technical aspects even more specifically related to the EU ETS regulation. The integration within the EMS of financial procedures related to trading activities is usually overlooked.

As a consequence, rules are often unclear about market-oriented activities (e.g. scouting of external opportunities, real options

[4]The Energy manager of this company does not cooperate systematically with those responsible for EMS; similarly, the EMS implemented in three installations is not extended to the other two.

valuations, etc.). On the contrary, carbon emission monitoring is carried out periodically (often monthly), even if it is worth mentioning that only one company has set up a specific procedure to communicate GHG emission performances to the company's top management board (C1).

The above findings seem to indicate that companies integrating ETS management in an EMS tend to give priority to adapting and integrating standards and procedures for GHG emission monitoring and compliance within the existing organization. The following paragraph aims to investigate to what extent this is also reflected in a lack of integration between technical and financial metrics in "more than short-term compliance perspectives."

### *4.5.2. ETS, EMS and environmental planning*

To better understand the impact of the ETS on environmental strategies and planning, we attempted to explore EMS modifications in response to the EU ETS and allowances allocation.

From a theoretical point of view, the higher the deficit of allowances, the stronger the interest of the company in considering far-seeing investments in technology innovation, or in external projects.

For the first phase, C2, C3, C4 and C6 received fewer allowances than carbon emissions, and the other companies (C1 and C5) received more allowances than carbon emissions. For the second phase, C2, C4 and C6 received fewer allowances than carbon emissions, and C1, C5 and C3 received more allowances than carbon emissions (Table 4).

**Table 4. Allowances allocation of case studies**

| *Allowances per phase* | *Phase 1 (2005-2007)* | *Phase 2 (2008-2012)* |
|---|---|---|
| Fewer allowances than carbon emissions | C2, C3, C4, C6 | C2, C4, C6 |
| More allowances than carbon emissions | C1, C5 | C1, C3, C5 |

Within this framework, internal emission reduction (i.e. interventions on the core industrial process) emerges as the most cited strategy to deal with the ETS, often coupled with trading and the internal reallocation of allowances between installations located in different EU ETS countries. In fact, every company, with the exception of C5, stated that internal emission reduction is the main strategy to respond to the ETS, while internal reallocation of allowances is considered a good option for those companies (C1, C2 and C4) that can internally compensate for differences between allowances and emissions among installations.

Only C5, who did not respond to any questions concerning environmental planning, claimed that since the main strategy driver is profit maximization, its prevailing strategy is to trade in the short run without diverting attention from core activities. This could mean that those companies strongly focused on the core market attribute a marginal role in strategy development to the ETS, and tend to implement only indirect measures for carbon reduction in the long run. Of course, this attitude could also be explained by the number of allocated allowances. The fact that C5 received more allowances than carbon emissions in both periods could have weakened the stimulus to improve environmental performance. On the contrary, for the other companies, the main driver for developing a strategy in response to the ETS is the need to improve internal performances. In particular, the driver is the reduction of compliance risks for C1, C2, C3 and C6,

which is significant if compared with the fact that cost reduction opportunities related to the ETS were only considered important by C4.

By analyzing the potential interventions for reducing emissions, five companies (C1, C2, C3, C4 and C6) aim to improve production efficiency. Despite that, only C2 and C4 intended to implement new production processes based on new fuel substitution technologies. None of the companies, other than C2, appear to take into account the opportunity to invest in foreign non-EU ETS countries by accessing CDM and JI systems. Generally speaking, companies are weakly stimulated to invest beyond the incremental innovation of core processes. As a consequence, compared with the intrinsic goals of EMSs and the ETS, the influence of allowance costs on strategy development is still unclear.

The gap between real and perceived impacts of EMS and ETS integration is witnessed by the fact that four companies (C1, C2, C3 and C4) recognize the ETS as a determinant of strategic decision development, although in practice they gave priority to other variables (e.g. product improvements, financial burdens, etc.) through a non-integrated approach.

When the first balance of the experience of ETS is asked, the introduction of ETS is perceived as a cost by C2, C3 and C6. Only the companies that invested more in internal (C4) or external (C1) trading functions tend to consider the access to $CO_2$ market as a potential opportunity. It is clear that the same opinion is shared by those receiving more allowances than carbon emissions in both phases (C5). These differing perceptions seem to depend not only on the balances between allocated allowances and emissions but also on the marginal cost of emission reduction and the price of allowances in the market.

According to our data regarding environmental planning and investment decisions, no specific procedures aimed at performing a systemic management of emission reduction opportunities have been implemented. Hence, proposals or initiatives to invest in emission reduction generally came directly from executive management boards on the basis of the periodic review.

The development of this initiative to invest in emission reduction is explained by C2: '*No specific procedure for planning carbon emission reductions has been established at a company level but there is a general procedure for managing investments that includes environmental aspects. Furthermore, the plan to reduce emissions is set on an annual basis as an indirect consequence of the planning of technical interventions*.' Similar practices are present in all the other companies. Only C1 added that the R&D department, titled "Technology, Investment & Energy", is also systematically engaged in ETS-oriented investment planning.

In general terms, in all companies, when an initiative comes from the staff involved in a EMS, or from technical divisions, it is submitted to the executive management board. Similarly, when an initiative comes from the executive management board, technical managers, including production managers, and EMS staff are consulted.

Companies usually favor investments that are integrated in the productive process and in energy production (C1, C2, C3, C4 and C5), such as the installation/enhancement of combined heat and power systems, the replacement of existing engines with more efficient ones, and fuel substitution. Only in two cases (C1 and C2) did companies claim that they implemented both innovative and market-available technologies, while in other cases only market-available technologies have been implemented.

We tried to understand the barriers to adopting innovations in carbon emission reduction, beginning with the barriers identified by del Río González for the pulp and paper industry (2005). According to the interviewee's responses, the most common barrier is the high initial investment, but only one company also focused attention on the long payback period of the investment, which is not in complete agreement with del Río González's findings. Furthermore, we attempted to understand the role of EMSs in carbon reduction planning. We found that the most recent investments with impacts also on internal carbon reduction (C1, C2, C3 and C4) had been planned before the EU ETS came into force, and only in two cases (C1, which reports more interventions, and C6) after 2005. Of these, the investments were part

of environmental planning regardless of the ETS (C1, C2, C3 and C6). In fact, the main drivers for environmental planning with effects also on carbon emission reductions, with the exception of C1 and C2, are not carbon emission reductions but cost reductions and wider EMS requirements in terms of the continuous improvements of resource efficiency (C1, C2, C3 and C6). To confirm this, we asked what role the ETS plays on investment choices. C1, C2, C3 and C6 answered that the ETS was one among other variables not having more importance than others, while the influence of allowance prices on investment choices is still unclear.

## 4.6. Discussion and conclusions

We tried to analyze the mutual influence of EMS and the ETS in terms of the impact on organizational management and environmental planning. Thus, we highlighted how ETS management has been implemented in some companies adopting an EMS, and if/how the ETS has been able to trigger more investment planning than in a pre-existing EMS program.

Firstly, we found that the theoretically predicted integration of ETS-related activities into corporate EMS is essentially confirmed by the experiences we investigated. We learned that it is possible to distinguish different axes of integration. These axes mainly refer to carbon emission monitoring, compliance procedures, regulation monitoring, and documentation.

Our findings confirm and extend Amundsen's insights (2000) of the joint management of energy with the environment, and Wagner's findings (2008) about a positive relationship between energy management and EMSs.

Sandoff and Shaad (2009) recognized the role of environmental departments in various ETS-related activities, but their work does not explicitly include an analysis on EMSs. Our study reveals that the interaction between the ETS and EMSs in setting corporate roles and responsibilities cannot be neglected.

We discovered that allowance trading and related market monitoring are basically assigned to qualified personnel for companies with many installations, or to administrative and finance personnel for companies with few installations. This distinction in the assignation of ETS-related activities highlighted the distribution of roles and responsibilities, and enabled us to make a classification between the different sets of ETS-related activities included in overall ETS management. According to this classification, activities of ETS management can refer to financial allowance management (FAM) and physical $CO_2$-emission management (PEM). Indeed, FAM includes trading strategy, allowance trading and allowance market monitoring, which are activities generally assigned to administrative and finance departments, or to specific personnel. Similarly, PEM includes carbon emission monitoring, compliance procedures, regulation monitoring, documentation reporting, and verification, which are generally assigned to technicians within an EMS.

Our findings would seem to indicate that, even under EMS and ETS integration, FAM and PEM tend to reflect independent corporate dynamics and, thus, should not be considered as a unique field of organizational investigation. This distinction, which serves to gain further insights into organizational changes in respect of the investigation made by Sandoff and Schaad (2009), derives from the analysis of companies with an EMS. However, further research may be necessary to verify its validity for companies without an EMS.

Furthermore, if management involvement, in our cases executive management, can be considered as a proxy of the importance of the ETS and the willingness to take related actions (Sandoff and Schaad, 2009), transferring activities to (internal or external) qualified personnel, such as transferring FAM to qualified personnel with multidisciplinary competences, can be a sign of the willingness of the board to use informed decisions (e.g. about allowance prices) for tailoring a cost-effective strategy. This would mean not only complying with environmental regulations, but also seizing the opportunity that the carbon market offers.

Another important insight arising from our study is that companies integrating PEM in an EMS would establish satisfactory standards and procedures for GHG emission monitoring and compliance. In fact, the integration of PEM in an EMS reflects the priority that companies tend to give to technical and organizational aspects rather than to financial opportunities, which are often considered uncertain. As a consequence, one of the most frequently implemented items is the establishment of specific procedures (i.e. the definition of roles, responsibilities and operational instructions) such as those regarding non-compliance management, audit implementation, controlling, monitoring and reporting, or items even more specifically related to the EU ETS regulation (e.g. communications to third party auditors, etc.).

On the cost determinants, the integration of PEM in an EMS appears not to imply additional costs, with the exception of firms that decide to employ additional personnel, because these costs are generally absorbed by, and integrated in, other environmental activities. This is mainly due to the fact that often the implementation of an EMS already implies investments in terms of control and monitoring. From a contrasting point of view, with the relationship between EMS implementation and trade investments being weak, enhancing FAM capabilities so as to manage new tasks linked to allowance market tends to imply additional costs in terms of personnel re-qualification and/or new recruitment of administrative, finance or other qualified staff.

Further insights are provided by our exploration into the mutual effects of the ETS and EMSs on environmental planning. In accordance with previous research, we would expect that, on the one hand, the involvement of a company in the EU ETS, plus the implementation of an EMS, would trigger investments in technological change and innovations. On the other, the EU ETS would trigger investment planning on carbon reduction to a greater extent than a pre-existing EMS program. However, we found that investments in technological innovation to reduce carbon emissions are still limited, and investments tend to be mainly focused on market-

available technologies for core processes. This is due to the innovation risks and the related high initial investment costs of technological boundaries. From this perspective, the volatility of $CO_2$ prices is still a critical issue in ETS implementation, since financial uncertainties usually deter from both technical and organizational innovation.

In addition, the most frequent actions within environmental planning regarding the improvement of production processes, and energy efficiency or energy production, are considered as the safest ways to achieve cost reductions. These investments already appear to be typical components of EMS programs. In fact, they had often been planned before the EU ETS came into force. This is why we can conclude that until now the EU ETS has not been able to trigger additional investment in technological innovation, despite the presence of an EMS. This is because in environmental planning, other variables (e.g. entity of investment and focus on core markets) appear to prevail over seizing opportunities from the ETS market. A possible reason for that could reside in the fact that allowance prices in the first two phases have been volatile and sometimes very low, therefore resulting in a weak incentive to implement energy efficiency and innovation (Schleich *et al.*, 2009; Mansanet-Bataller *et al.*, 2011).

We believe our findings have some important implications for business management and policy makers. In fact, we found that companies involved in the EU ETS benefit from the presence of an EMS, both in terms of organizational and technological investment oriented to carbon reduction. Regarding the latter, it is worth noting that the commitment to continuously improving environmental performances often implies $CO_2$ emissions reductions. Accordingly, although not mandatory, industries that are expected to manage the EU ETS could count on EMS implementations to acquire knowledge and skills to boost ETS-PE activities in phase 3 (2013-2020), and to set satisfactory procedures and monitoring systems. However, since synergies between ETS and EMSs in terms of FAM to date are not significantly developed, companies should count on qualified personnel typically not covered in the implementation of an EMS to catch the opportunities offered by the carbon market.

In terms of policy implications, given that the stimulus to invest in innovation can be easily achieved through regulation enforcements (e.g. reducing the carbon cap, auctioning allowances, etc.), this would potentially affect the international competitiveness of pulp and paper companies. A good complementary policy could be the improvement of the efficiency of ETS management through the promotion of EMSs in these companies. In so doing, special attention has to be paid to spreading awareness towards the financial opportunities that arise from the implementation of market-based mechanisms. Policy makers, therefore, have to consider the design and planning of ad-hoc training courses as mandatory and not optional.

However, this study is not without its limitations. In fact, our analysis of the selected case studies enabled us to define a conceptual model that could be further improved by focusing on other sectors. Furthermore, the fact that our case installations are based in Italy, even though five companies also manage installations in other countries, means that it would be useful to investigate whether companies from other countries experience the same dynamics. Finally, while our qualitative approach helped us to shed light on an unexplored research field, the causal relationships that we formulated could be usefully considered for further validation and generalization through statistical surveys.

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# 5. Conclusions and directions for further research

This dissertation aimed to address several research gaps about corporate responses to climate change. In particular, I attempted to shed light on three issues. First, the state-of-the-art literature in relation to how companies respond to challenges related to climate change. Second, how companies perceive and interpret their exposure and vulnerability to weather and climate events in terms of business impacts and financial implications and how this has subsequently been translated into adaptation and resilience strategies and third, how carbon regulation such as the European ETS impacts on companies with an environmental management system in terms of organizational management and environmental planning. These issues have been addressed in three papers (one of which has already been accepted for publication).

The analysis of the main research topics and areas about corporate responses to climate change through a literature review enabled me to first propose a classification into two broad categories based on the aim of the corporate response to climate change such as mitigation, i.e. how businesses act to address the causes of climate change that is reducing greenhouse gas emissions, and adaptation, i.e. how businesses deal with the physical consequences of climate change; and secondly a classification on the basis of the problem context into five main areas of research of business climate-related issues:

a) risks and opportunities;
b) carbon accounting;
c) business responses to climate change with the aim of emission reduction;
d) carbon disclosure;
e) corporate adaptation.

I reported the main findings and highlighted limits and the further fields of investigation. In particular, since 2007 the number of academic publications has increased per year, however not as much as

we expected considering the novelty of the topic and the implications for business. So far the existing literature has shown how firms have mainly focused on their role with respect to mitigation. Corporate adaptation and resilience strategies to climate-induced physical changes are less well understood, in part because firms have not (yet) addressed adaptation to the same extent as policymakers and scientists (Linnenluecke and Griffiths 2010; Sussman and Freed 2008).

I identified the need for a more extensive and more specific set of data, and the need to extend and diversify analyses in different industries, countries, and beyond multinational companies. In fact, the present literature mainly focuses on MNCs and on USA and EU boundaries, and also on carbon intensive industries, in particular the oil and gas industry. This may be due to its role in emissions (Patenaude, 2011). These limits could be due to the lack of data availability, considering that the only database on CRtoCC is represented by CDP's questionnaires and that in general carbon disclosure depends on corporate size (Freedman and Jaggi, 2005; Prado-Lorenzo et al., 2009), market capitalization (Prado-Lorenzo et al., 2009) and the threat of state regulation (Reid and Toffel, 2009; Freedman and Jaggi, 2005). These gaps could represent a stimulus to collect different data and opportunities to explain the dynamics of CRtoCC in other industries, for companies operating at national level and for small and medium enterprises, for companies based in different countries and in developing countries. I found that this early literature on CRtoCC focuses on the necessity and the importance of climate change for business and defines the context, but it only suggests possible ways for the achievement of a competitive advantage or cost reduction while coping with climate change, without studying this issue in depth.

The analysis of the studies according to the problem context also shows a couple of discrepancies between some research, for example the relationship between strategic decisions and public policy uncertainty. and the implementation of carbon accounting and GHG emission inventories. In fact, it is still unclear the influence of public policy uncertainty about carbon emissions limitation on strategic decisions regarding climate-related actions and whether companies

have already implemented carbon emission inventories or not. These kinds of discrepancy could be due to the different timeframe in which these research studies were carried out, considering the fast development of phenomenon, but, above all, it is likely to be due to the sample choice and the quality of data and its reliability. This is why it may be useful to carry out further research on these issues. Besides, the classification of climate-related company behaviour needed to be revised with further research about the current behaviour, since in recent years attention on climate change has increased all over the world, and has progressed from a mitigation to an adaptation perspective. In fact, the distinction of the papers according to the aim of companies' action (mitigation vs. adaptation) points out how earlier literature was focused on mitigation, while only in recent years scholars have also started to become engaged in understanding adaptation responses.

The second study identifies factors influencing corporate adaptation and resilience strategies in response to climate-induced physical changes through a qualitative analysis of CDP survey data for the oil and gas sector. Building on previous research, the paper in particular argues that adaptation is the outcome of a sensemaking process where firms interpret how climate change will affect their organizations before they take action (Linnenluecke et al. 2012). Corporate adaptation behaviour is viewed as a combination of the three main elements of the sensemaking process: awareness of climate-related physical changes, the subsequent vulnerability assessment, and the ensuing adaptation measures. Four main types of adaptation behaviour emerged from the analysis: pre-emptive, reactive, continuous and deferred adaptation. Firms that have a high awareness of climate-related physical changes and assess their vulnerability as high tend to adopt *pre-emptive adaptation*. In contrast, firms that have found to be highly vulnerable (ex-post assessment), but until they experienced an extreme climate event had low risk awareness (ex ante), are the ones caught by surprise. Their adaptation behaviour is thus a response after-the-fact and is referred to as *reactive adaptation*. Firms with high risk awareness, but assess their vulnerability as low tend to undertake

*continuous adaptation*. Finally, there are those for whom climate-induced physical changes are not a salient issue because they have low awareness and assess their vulnerability as low. Therefore, they opt for *deferred adaptation*. Their attitude is to wait and see what might happen in the future and until then either do not to take any actions or postpone decisions. The study also identifies the relevant direct and indirect climate stimuli that affect awareness, vulnerability assessment, and subsequent adaptation measures, which remained ambiguous in previous research. The findings suggest that the type of physical change, the sources of information used, the ecological embeddedness, and the potential financial implications seem to have the most distinctive influence on the measures firms take to cope with physical impacts. Furthermore, the study shows that adaptation strategies often still consist of a set of ad-hoc measures, rather than being based on the development of new routines through organizational learning, as previously proposed (Berkhout et al. 2006). Adaptation behaviour is not stable, however, but fluctuating over the course of the sensemaking process. That is, there is constant interaction between identification, interpretation and action (Thomas et al. 1993; Weick et al. 2005), which leads to different patterns of dynamic adaptation behaviour. However, while previous research argued that this would result in a cyclical process where firms learn to better cope with physical impacts over time (Berkhout et al. 2006; Linnenluecke et al. 2012), our findings suggest that the opposite might occur as well. Once firms with pre-emptive or continuous adaptation behaviour have taken measures to better cope with physical changes, they sometimes have the tendency to become complacent and move back to a reactive or a deferred stance instead. While the body of research on corporate adaptation to climate-induced physical impacts is growing, there are still many questions remaining. As a follow-up to this paper, future studies could investigate the more comprehensive sensemaking process of climate change and not only consider climate stimuli from physical impacts, but also how these interact with stimuli related to competitive or regulatory forces related to mitigation.

The third research, tries to analyze the mutual influence of EMS and the ETS in terms of the impact on organizational management and environmental planning. Thus, the paper highlights how ETS management has been implemented in some companies adopting an EMS, and if/how the ETS has been able to trigger more investment planning than in a pre-existing EMS program. Firstly, the paper argues that the theoretically predicted integration of ETS-related activities into corporate EMS is essentially confirmed by the experiences we investigated. However, it is possible to distinguish different axes of integration. These axes mainly refer to carbon emission monitoring, compliance procedures, regulation monitoring, and documentation. The study reveals that allowance trading and related market monitoring are basically assigned to qualified personnel for companies with many installations, or to administrative and finance personnel for companies with few installations. This distinction in the assignation of ETS-related activities highlighted the distribution of roles and responsibilities, and enabled to make a classification between the different sets of ETS-related activities included in overall ETS management. According to this classification, activities of ETS management can refer to financial allowance management (FAM) and physical $CO_2$-emission management (PEM). Indeed, FAM includes trading strategy, allowance trading and allowance market monitoring, which are activities generally assigned to administrative and finance departments, or to specific personnel. Similarly, PEM includes carbon emission monitoring, compliance procedures, regulation monitoring, documentation reporting, and verification, which are generally assigned to technicians within an EMS. These findings would seem to indicate that, even under EMS and ETS integration, FAM and PEM tend to reflect independent corporate dynamics and, thus, should not be considered as a unique field of organizational investigation. However, further research may be necessary to verify its validity for companies without an EMS. Furthermore, transferring activities to (internal or external) qualified personnel, such as transferring FAM to qualified personnel with multidisciplinary competences, can be a sign of the willingness of the board to use informed decisions (e.g. about allowance prices) for tailoring a cost-effective strategy. This would

mean not only complying with environmental regulations, but also seizing the opportunity that the carbon market offers. What is more, companies integrating PEM in an EMS would establish satisfactory standards and procedures for GHG emission monitoring and compliance. In fact, the integration of PEM in an EMS reflects the priority that companies tend to give to technical and organizational aspects rather than to financial opportunities, which are often considered uncertain. As a consequence, one of the most frequently implemented items is the establishment of specific procedures (i.e. the definition of roles, responsibilities and operational instructions) such as those regarding non-compliance management, audit implementation, controlling, monitoring and reporting, or items even more specifically related to the EU ETS regulation (e.g. communications to third party auditors, etc.). Further insights are provided by the exploration into the mutual effects of the ETS and EMSs on environmental planning. The analysis shows that investments in technological innovation to reduce carbon emissions are still limited, and investments tend to be mainly focused on market-available technologies for core processes. This is due to the innovation risks and the related high initial investment costs of technological boundaries. From this perspective, the volatility of $CO_2$ prices is still a critical issue in ETS implementation, since financial uncertainties usually deter from both technical and organizational innovation. In addition, the most frequent actions within environmental planning regarding the improvement of production processes, and energy efficiency or energy production, are considered as the safest ways to achieve cost reductions. These investments already appear to be typical components of EMS programs. In fact, they had often been planned before the EU ETS came into force. This is why the paper concludes that until now the EU ETS has not been able to trigger additional investment in technological innovation, despite the presence of an EMS. This is because in environmental planning, other variables (e.g. entity of investment and focus on core markets) appear to prevail over seizing opportunities from the ETS market. A possible reason for that could reside in the fact that allowance prices in the first two phases have been volatile and sometimes very low, therefore

resulting in a weak incentive to implement energy efficiency and innovation (Schleich *et al.*, 2009; Mansanet-Bataller *et al.*, 2011). However, since this research is focused on Italian installations, it would be useful to investigate whether companies from other countries experience the same dynamics. Finally, the causal relationships formulated could be usefully considered for further validation and generalization through statistical surveys.

To conclude, there are still many issues regarding corporate responses to climate change that are worth examining. In fact, while this dissertation has shown that companies are becoming increasingly involved in developing and implementing responses to market, policy and physical impacts related to climate change, until now these responses have been considered as disconnected by scholars. However, considering the increased frequency and intensity of weather and climate events both in the present and future, the development of European and international policies on carbon emissions reduction, e.g. the European climate and energy package 20-20-20, and on climate adaptation, the growing attention of shareholders towards multinationals' carbon disclosure and the market changes, the corporate responses to all these challenges are expected to gain strategic importance at corporate level. Some questions are still open, for example: the management procedures and processes of companies dealing with climate-related challenges, as well as the key roles in charge of the definition of a climate strategy; the overall responsibility within the company for the implementation of this strategy; then the organizational implications in terms of structural and managerial changes. Furthermore, while mitigation and adaptation are often considered to be two distinguished responses to climate change, from a strategic management perspective mitigation could be considered as a profound element of long term adaptation strategies (Beerman, 2010), therefore further studies could try to understand business strategies in terms of both mitigation and adaptation. Another important issue is the opportunities arising from climate challenges. In fact, to date, scholars have mainly focused on climate related risks rather than on opportunities, but is unclear the influence of both risks and opportunities on corporate strategies. Finally, it is worth

highlighting the need to investigate the relationship between competitiveness and climate-related action.

## 5.1. References


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