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Managerial interpretation and innovation in the context of
climate change

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Keywords climate change, dynamic managerial capability, innovation, interpretation, environmental strategy

JEL Classification M10, M14, L80

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Abstract

Firms have developed climate change strategies over the last decade in response to rising regulatory, social and competitive pressures. Increasingly, these strategies include the development of new products and services (P&S) to reduce the environmental impact of the firm and its customers. In this paper, I explore how managerial interpretation of climate change has evolved over time and how these changes in interpretation are associated with innovation outcomes. The existing literature suggests that interpreting environmental challenges as opportunities is more likely to lead to open and innovative strategies. Using qualitative survey data on 99 Global 500 firms over the period 2003 to 2009, I find that threat-based interpretation can in fact lead to positive innovation outcomes at early stages of new P&S development. I identify three main mechanisms through which the detailed identification of threats encourages innovation in response to climate change. Furthermore, I develop a temporal dimension to the relationship between interpretation and stages of P&S development. I find that at advanced stages of P&S development, a balanced and opportunity-focused interpretation becomes more important. The results imply that managerial interpretation can provide firms with added flexibility to provide innovative responses to social and environmental challenges. But the relationship between interpretation and innovation is not static, nor is it a question of threat or opportunity interpretation but a combination of the two at different times that provides flexibility.

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Introduction

Climate change is a challenge that has attracted varying degrees of attention from firms in different sectors over the last decade. As public awareness and regulatory pressure increased during the 2000s for firms to develop strategic responses, so too has the overall attention afforded the issue by senior managers. This offers management researchers a window into the varying interpretations of what is a complex, global, long-term and dynamic environmental challenge facing firms.

Some firms have publicly declared that climate change is not a threat to their business. Others have focused mainly on the threat that climate change and associated policies present. And others still have a much more balanced approach in accepting that climate change poses a threat to society and potentially to the firm, but that it is also an opportunity for the firm to become “part of the solution”.ⁱ In the food and drinks sector in 2003, for instance, these three different perspectives are evident among the largest multinationals in the sector. Pepsico, for instance, states that “we are monitoring the ongoing discussion regarding climate change but do not currently see this as a direct threat”. Nestle, on the other hand, focuses exclusively on the risks associated with climate change including “shortages in agricultural raw materials, shortages in water, floods, cyclones, ..., which may disrupt the supply chain, including means of transport”. And finally, Unilever discusses the potential threats but ultimately suggests that “a strategic response is possible, by being well-prepared in the nature of our portfolio and in our capability to adapt products and supply chains in a very practical way”.ⁱⁱ

This variety of interpretations and attention to the issue does not just depend on how carbon-intensive or heavily regulated a firm is. There are examples of firms

such as Marks and Spencer embracing their role in being part of the solution from traditionally low-impact sectors like retail. And there are examples of high-impact firms like ExxonMobil that position themselves and society as not being in any immediate danger.ⁱⁱⁱ These interpretations at the top of organisations are shaped by senior decision-makers. They change over time, are influenced by new information on climate change, the actions of other firms and regulators, as well as fluctuations in public sentiment.

In the management literature, the question of how interpretation of events in the external environment as either threats or opportunities impacts strategic outcomes leads to different conclusions. On the one hand, there are positive aspects associated with interpreting events as threats, for example high commitment and wider search (Daft and Weick 1984; Dutton and Jackson 1987; George et al. 2006). On the other hand, threats may also lead to rigidity and a restriction of control at the top of the organisation (Staw et al. 1981; Gilbert 2006). Although recent literature has provided initial explanations for this contradiction, there has been a tendency to overlook the question of whether this relationship between interpretation and strategic outcomes such as innovation change over time.

As a result, I focus in this paper firstly on how interpretation of environmental issues such as climate change has evolved and secondly on how these changes affect innovation outcomes. In particular, I examine whether the relationship between managerial interpretation of external challenges and associated new product and service (P&S) development changes over time. By adopting a managerial cognition perspective to strategic responses, I assume that the external environment is not exogenous (Eggers and Kaplan 2013). Instead, the interpretations of senior managers (and in some cases potentially their moral judgements) shape the way that

organisations develop an understanding of, and the way in which they respond to, challenges in the external environment.

I use the capabilities literature to develop measures of new P&S development, drawing on Teece's dynamic capabilities framework (2007) and the founding, development and maturity stages of capability development from the work of Helfat and Peteraf (2003). I then examine, using cluster analysis, whether the climate change interpretations of senior management are associated with the development of product and service capabilities at different points in time. I find that more senior management attention to climate change is positively associated with actions to develop new P&S. In particular, more attention to threats is associated with innovation in new products and services in non-carbon-intensive sectors. Over time, however, there is a greater focus on balanced and opportunity-focused interpretation among all firms. I explore the relationship between threat identification and new P&S in two sectors in more detail, in order to develop a set of propositions about the relationship between attention, interpretation and new P&S. There are two main contributions of the paper. Firstly, I identify additional mechanisms that enable threat-based interpretations to lead to innovative outcomes. Secondly, I add a temporal dimension to the relationship between threat/opportunity interpretation and stages of new P&S development.

In the next section, I discuss the literature on managerial cognition, the relationship between cognition and new P&S, and I introduce a temporal dimension to interpretation and the development of new P&S. The methods section provides an overview of the data, coding framework and cluster analysis. The results section describes the evolution of attention, interpretation and P&S over time, introduces the cluster analysis results based on attention and interpretation, and illustrates the connections between interpretation and new P&S using examples from the financial

and telecommunications sectors. In the discussion section, I summarise the main implications of the results and identify the limitations of the study. Finally, I conclude by summarising the main contributions of the study, as well as the implications for policymakers and managers.

Theoretical background

Managerial cognition: Attention and interpretation of strategic issues

There is a rich and varied literature on how the actions of senior decision-makers affect how organisations respond to changes in the external environment. This literature has its roots in the behavioural theory of the firm, which assumes that there are limits to an organisation's capacity for attention. Because of this, attention must be allocated within organisations (Cyert and March 1963). This process of allocating attention has implications for strategic actions and outcomes. The concept of attention has been used in different ways by different subsequent streams of organisational theory (Ocasio 2011). In the managerial cognition literature, organisations are viewed as interpretation systems. So, for instance, in the tradition of Daft and Weick (1984), scanning of the external environment leads to an interpretation process where a shared understanding of challenges is developed. This shared understanding shapes the types of actions taken. Attention and awareness of challenges is the first step. Once attention is given to a challenge, the process of organisational interpretation begins. According to Ocasio's (2011) categorisation of attention constructs, this is referred to as the "attentional perspective", which is based on "top-down cognitive (and motivational) structures that generate heightened awareness and focus over time to relevant stimuli and responses" (Ocasio 2011, 1288).

Once there is awareness in the organisation of an issue in the external environment, the issue can be interpreted. Different interpretations shape organisational responses in different ways. The two labels of threat and opportunity are often applied to strategic issues. These labels affect the cognition and motivations of senior decision-makers, which in turn affect the process and the focus of organisational actions (Dutton and Jackson 1987).

Two main perspectives have guided the literature on interpretation of threats and opportunities and subsequent organisational response. The first is prospect theory which suggests that organisations are more likely to exhibit risk-seeking behaviour when changes in the external environment are interpreted as threats rather than opportunities (Kahneman and Tversky 1979; Daft and Weick 1984; Dutton and Jackson 1987; George et al. 2006). The second is the threat-rigidity hypothesis which suggests the opposite. That is, when organisations perceive changes in the external environment as threats, they are likely to respond rigidly due to a restriction in the level of information processing and a concentration of control at the top (Staw et al. 1981; Gilbert 2006). The apparent contradiction between the two perspectives has been resolved by recent empirical work that shows prospect theory is applicable when the loss/gain relates to tangible resources. The threat-rigidity hypothesis on the other hand is more appropriate when a reduction or enhancement of control is at stake (Chattopadhyay et al. 2001; George et al. 2006).

In general, in the empirical literature, however, opportunity interpretation is associated with more open and innovative approaches and threat-based interpretation with more closed and narrow approaches (see for example Sharma 2000).

Managerial cognition and capabilities for new P&S

A firm may have developed appropriate capabilities but until managers are able to connect these capabilities with challenges in the external environment, there may be inertia. Linking the capabilities and cognition literatures, as has started to happen in the last decade, brings a managerial perspective and an underlying assumption that the external environment is not exogenous (Eggers and Kaplan 2013). Managerial cognition is related to various stages of capability development, for example in influencing search processes, in evaluating experience, and in developing an understanding of what actually constitutes an organisation's capabilities.

Many scholars have tried to explain why firms, particularly incumbents, have difficulty responding to technological changes. Capabilities are part of the answer. When a technological change is competence-destroying, in that it requires a completely new set of capabilities, incumbents are more likely to fail (Tushman and Anderson 1986). In the face of this kind of technological change, firms that try to make incremental adjustments to existing products and services will suffer, due to the need to move to completely new ways of thinking about products and services in the industry. The transition from analog to digital imaging is an example of this kind of technological change that required fundamental shifts across the entire business. The razor/blade model was profitable during the analog phase, where companies made more money from blades (the film) than from hardware (the camera). This changed completely with the advent of the digital market. The story of Polaroid during this transition as illustrated by Tripsas and Gavetti (2000), shows that developing new technological capabilities is not enough. In fact, Polaroid was able to develop technological capabilities but senior managers' belief constrained the organisation's ability to deploy these capabilities effectively.

In this sense, managerial cognition can act as a dynamic capability. It can give firms the flexibility to reconfigure other capabilities (Adner and Helfat 2003) that might be necessary in responding to changes in the external environment. The ability of senior managers to balance efficiency and flexibility has been identified in the recent dynamic capabilities literature as an essential foundation for superior performance (Eisenhardt et al. 2010). In order to develop this ability, managers need to first develop an awareness of challenges in the external environment. Those that are more aware of environmental issues are more likely to direct resources to developing environmental product and service capabilities.

In responding to environmental challenges, firms are likely to reconfigure capabilities in different ways. Lavie (2006) identifies three means of reconfiguring capabilities in response to changes in the external environment. The first is capability evolution. This is an incremental form of change where existing capabilities are adapted over time through internal processes. Second, capability transformation is a more directed form of adaptation. A completely new capability is not developed because it still serves the same function as before. But the capability is transformed through a combination of internal learning and external search, for example through working with complementary partners active in the same area. Finally, capability substitution is the most extreme form of change in a firm's portfolio of capabilities. It occurs when there is a competence-destroying technological change that destroys the value of a firm's existing capabilities. Merging with or acquiring other firms, or in some other way acquiring new capabilities from outside the firm, are the main means of capability substitution.

In the short-term, there are unlikely to be complete substitutions of capabilities by firms in response to environmental issues. This is certainly possible in the medium

to long-term, particularly for firms that use highly carbon-intensive processes. For most firms, the choice is between evolution which involves incremental improvements to existing P&S and transformation, which is a more radical development of new P&S. The role of managerial interpretation is likely to differ depending on the extent of reconfiguration. In this paper, I focus on the development of new P&S.

For firms to invest in reconfiguring capabilities that will lead to the introduction of new products and services, managers need to examine a broad range of alternatives. Managers are more likely to search widely when faced with threats rather than opportunities (George et al. 2006). On the other hand, approaches are likely to be broader, more entrepreneurial and flexible if managers are able to identify opportunities (Sharma 2000). At the same time, a focus purely on environmental issues as opportunities may encourage firms to commit less resources and to be less risk-seeking. This may lead managers to focus on short-term and incremental improvements rather than considering long-term changes and entry into new markets.

Changes over time in interpretation and new P&S

The external environment is complex and subject to frequent changes. As a result, firms need to be prepared to reconsider prior interpretations and to adapt strategies based on new interpretations of challenges in the external environment. This process of change in interpretations started to be explored in the literature, beginning with the work of Barr (1998).

Of course, on the capabilities side, it takes time for the capabilities associated with new P&S to be developed. Routines and practices have to reach a certain level of routinisation in order to actually become capabilities. They go through processes of founding, development and maturity in reaching this point (Helfat and Peteraf 2003).

The identification of threats and opportunities is implicit in Teece's dynamic capabilities framework (Teece 2007). Opportunities and/or threats are first identified, before being realised or managed through the development of appropriate capabilities. Managerial interpretation of challenges as threats or opportunities, however, is likely to have different impacts on various stages of capability development.

Based on Teece (2007) and Helfat and Peteraf (2003), I identify three main stages of development for new P&S development. The first is identification, where the firm recognises that there may be an improvement to an existing product or an entirely new product or service that has the potential to reduce or facilitate a reduction in environmental impacts. The second is research and development, where the firm engages in activities to explore, develop and test the improvements or new products/services. The third is action, where the firm introduces the improved or new product/service to the market. Of course, underlying all of these stages are complex sets of routines and processes that firms perform in different and unique ways.

One of the assumptions of the managerial interpretation literature is that the initial categorisation of issues as threat or opportunities persists over time because these interpretations become embedded in systems and processes within the organisation (Dutton and Jackson 1987). But in the case where information on the external challenge is still evolving and capabilities are in the process of being reconfigured, managers are likely to revise their interpretations over time. These interpretations are in turn likely to be associated with different stages of capability development.

In the case of new P&S capabilities, for example, a threat-based interpretation may initially encourage broad search and high levels of commitment. Once the founding process of capability development is under way, a shift to interpreting

environmental issues as opportunities may lead to more innovative and flexible approaches to innovation. The ability to balance threat and opportunity interpretations has been found to lead to more innovative responses (Plambeck and Weber 2009). This recent focus in the literature on simultaneous applications of both threat and opportunity interpretation by senior managers does not engage with the temporal dimension (Gilbert 2006; Plambeck and Weber 2009). As a result, it remains unclear whether and how different interpretations of challenges in the external environment may be associated with different stages of capability development.

Methods and Data

Data sources

To explore the development of new P&S and the changing interpretation of climate change over time, I use survey data from the Carbon Disclosure Project (CDP) from 2003 to 2009. The CDP is a non-profit NGO that aims to improve the quality of information available globally on corporate carbon emissions and climate change strategies. The initiative now represents 665 institutional investors holding US\$78 trillion in assets.^{iv} The annual survey is sent to senior management executives in the largest firms globally (Reid and Toffel 2009). In this paper, I focus on the Global 500 firms in the sample. These are the largest multinational firms by market capitalisation and the sample includes a mixture of carbon-intensive and non-carbon-intensive firms.

The CDP survey between 2003 and 2005 focused exclusively on surveying the Global 500 firms. From 2006 onwards, the sample was significantly expanded. The first part of the survey is on the risks and opportunities of climate change. One of the

most consistent features across years in the CDP survey is an open-ended question on the risks and opportunities that climate change presents to firms. From 2003 to 2006, the question is as follows:

Do you believe climate change, the policy responses to climate change and/or adaptation to climate change represent commercial risks and/or opportunities to your company? Please provide information to explain your answer.

From 2007 onwards, this question is broken into sub-sections. Firms are asked whether there are regulatory risks, physical risks and/or general risks posed by climate change to their company. They are then asked to comment on the general opportunities that climate change presents and are asked whether they invest in any products or services that are designed to minimise or adapt to the effects of climate change. All of these questions allow open-ended responses.

The other main source of data for the analysis is data on firm-level carbon emissions from Trucost. I use data on scope 1 (direct) and scope 2 (indirect, mainly electricity-related) carbon emissions, which corresponds to the total operational carbon footprint of a firm. Trucost data is a mixture of reported and estimated carbon emissions based on a proprietary input-out model (Trucost, 2011). I use the firm-level data on emissions as a means of controlling for the environmental impacts of firms in the sample.

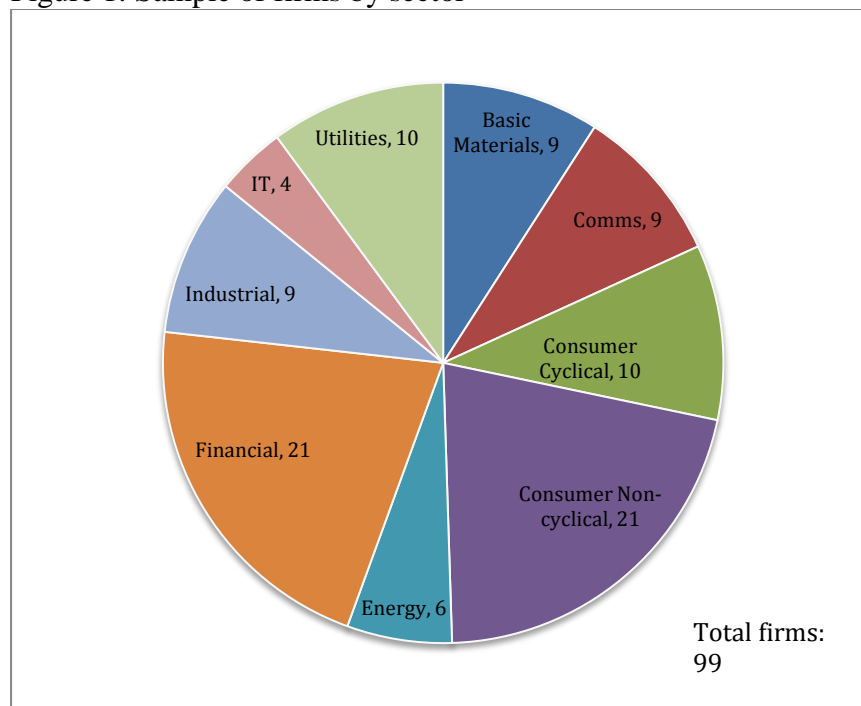
Sample

I restrict the sample to firms that answer the CDP survey in 2003, 2006 and 2009. This allows me to focus on a subset of 99 large firms observed in each of the three periods. I choose these years of the survey for three reasons. Firstly, 2003 was the first year of the CDP survey and a good baseline against which to measure future developments. Secondly, I space out the analysis to improve the likelihood that there

are changes in products and services as well as interpretation between one period and the next. This is because from one year to the next in the data, there are many responses in the survey from companies explaining that things have remained the same as the previous year. Thirdly, I stop at 2009 because after this period, there was a shift in public and political sentiment in the aftermath of the financial crisis and the Copenhagen climate summit. The period from 2003 to 2009 gives me a relatively undistorted view at a time when pressures for firms to deal with climate change were on the rise.

In the sample of 99 firms, there is a wide coverage of sectors. Both carbon-intensive sectors such as Utilities and Basic Materials as well as non-carbon-intensive sectors like financial services are represented in the sample. Figure 1 summarises the number of firms in each sector. As these companies are drawn from the Global 500 list of the largest firms by market capitalisation, they can all be considered incumbents in their respective industries.

Figure 1: Sample of firms by sector



New P&S variable

I develop a measure for new products and services (new P&S), that is categorical and was developed using the coding structure summarised in Table 1. I identify three stages of capability development: identification, R&D and action (Teece 2007; Adner and Helfat 2003). In the second and third stages, I differentiate responses based on whether or not they include an external partnership. In each case, I have shown a sample quote from the data with a focus on the financial sector firms as this is one of the sectors from which illustrations are drawn later in the analysis.

Table 1: New product and service capabilities

Description	Stage of development	Samples quotes
General discussion of potential for new products or services but without specific examples	Identification	“Due to the political uncertainty associated with the Kyoto protocol or the EU emission trading scheme the market opportunities are very limited and at this point in time only taken up by niche players. We are however watching the scene and are ready to jump in if we see a business opportunity arising at a risk level that is acceptable to us”. (Credit Suisse, 2003)
Specific examples of new products or services under development	R&D	“ANZ is an active participant in providing financial services to the emerging renewable energy and alternative fuels market and is currently designing and piloting a number of new financial products and services that will encourage the uptake of energy efficiency technology and GHG abatement”. (ANZ, 2006)
Above plus external partnership	R&D with partnership	“The ClimateWise Principles is a collaboration of companies in the insurance sector that have come together to address and publicly report on how the insurance sector can help with the issue of climate change, from risk identification, public policy making, and embedding responses to climate change in the way we deal with and can encourage customers, suppliers and companies that we invest in.” (Aviva, 2009)
Specific examples of new products and/or services that have lower carbon footprints – specific mentions of product introduction rather than R&D	Action	“Barclays was the first UK Bank to set-up a carbon-trading desk and we helped shape the development of the EU ETS market (for example in helping create standard contracts and in sharing our own trading experiences with new players). We see the market as an important area of business for us and one where the investment banking skills of our investment banking division Barclays Capital can give clients new tools to manage their emissions risks”. (Barclays, 2006)
Above plus external partnership	Action with partnership	“Citi Commercial Lending has affiliated with the New York State Energy Research and Development Authority (NYSERDA) to offer businesses low-interest loans for financing energy-efficiency improvements and/or renewable technologies under the "New York Energy Smart Loans" program”. (Citigroup, 2009)

Table 2 illustrates the scoring scheme I used for the different stages of capability development. Firms that are undergoing R&D efforts in partnership with a firm in another sector for instance are given a score (3) that is above R&D efforts that are only focused internally (2). This is because external search is an important part of the capability reconfiguration process (Lavie 2006). Partnering with organisations outside the firm is an indication of broader search efforts for opportunities and alternatives.

Table 2: Capability coding scores

Stage of capability development	Score
None	0
Identification	1
R&D	2
R&D with partnership	3
Action	4
Action with partnership	5

Attention, interpretation and control variables

I use computer-aided textual analysis to measure the overall attention to climate change, the extent to which firms have a positive and/or negative interpretation of climate change, and how tentative or certain they are in their responses. The positive and negative interpretations are the main measures of the extent to which senior managers interpret climate change as an opportunity or a threat.

These two labels, opportunities and threats, are often applied to strategic issues. When one or other is applied, this affects the cognitions and motivations of key decision-makers and in turn the types of actions undertaken (Dutton and Jackson 1987). From empirical evidence, there are three main characteristics that define threats and opportunities (Jackson and Dutton 1988):

1. Positive versus negative association
2. Gain versus loss

3. Controllable versus uncontrollable

The first two categories are highly correlated and are often collapsed into positive-gain versus negative-loss in the empirical literature (Thomas et al. 1993; Chattopadhyay et al. 2001).

To measure the overall *attention* to the risks and opportunities of climate change, I use a simple measure that counts the number of words in each firm's response to the specific questions on risks and opportunities. Although a relatively crude measure, I assume that the total word count reflects the centrality of the issue to senior managers. This is in line with previous content analysis research in management that suggests word frequency reflects cognitive centrality (Duriiau et al. 2007).

Linguistic Inquiry and Word Count (LIWC) is a text analysis software programme that calculates how people use different categories of words in written or spoken text. I use LIWC to analyse each firm's responses in 2003, 2005 and 2008. I choose to include the 2003 responses in looking at both capabilities and framing of climate change because I want to analyse the first year of firm responses. This is important in this context because 2003 is the first year of the CDP. As such firms are not influenced by others' prior responses or by their own prior responses to the survey. For later years, I measure interpretation in 2005 and 2008, i.e. a year before the measurement of capabilities. This accounts for the fact that there is likely to be some delay in the effect of interpretation and it also reduces the problem of common method bias.

I calculate an additional variable *positive – negative* that indicates the difference between positive and negative scores for a firm's response. Values that are close to zero indicate a balanced interpretation of threats and opportunities. Values that are negative indicate that a firm has a predominantly threat-based interpretation, whereas

values that are above zero indicate that a firm has a predominately opportunity-based interpretation.

I use the variables *tentative* and *certainity* as additional controls in the analysis. These are measures from LIWC. They measure the extent to which the language used is tentative or certain. They are not direct measures of the extent to which an issue is controllable. But when the response is more certain, I assume that the respondents interpret the challenge as more controllable. When the response is more tentative, I assume that the respondents interpret the challenge as more uncontrollable. Finally, I include a variable that measures the incremental changes to products and services (improved P&S), using a similar coding structure to the new P&S variable.^v

Data analysis

There are three main stages to the data analysis. The first is a qualitative phase where I take a deductive approach to the data analysis, similar to the coding approach advocated by Miles and Huberman (1994), to analyse the capability development of firms over time. In the first cycle, I use the coding structure outlined previously in Table 1 to analyse the survey responses of all Global 500 responding firms in 2003, 2006 and 2009, using a manual content analysis approach. The data are coded using analytic memos as well as descriptive and magnitude coding. This is based on my theoretical framework and research questions. I use the programme Nvivo 10 to manage the coding process and scoring system. I then use pattern coding to group the capabilities that emerge in different sectors (Saldana 2009).

The second phase of data analysis is quantitative. I use cluster analysis to group firms by their interpretation of climate change and their carbon impacts. I use a k-means optimisation clustering technique that assigns firms to clusters based on their dissimilarity from each other and from cluster means. The dissimilarity matrices are

based on Euclidean distance. This is one of the most commonly used measures of dissimilarity in cluster analysis and it allows for an interpretation based on the distance between two points. I use the Calinski and Harabasz stopping rule to assess clustering solutions with the best fit. The rule provides a pseudo-F index where larger values indicate more distinct differences between clusters (Everitt et al. 2011). In the third phase, I use the results of the cluster analysis to explore the details of the clustering in more detail using illustrations from the financial and telecommunications sectors. These sectors are chosen for two main reasons. Firstly, the issue of climate change was relatively new for firms in these sectors in 2003 compared to firms in carbon-intensive sectors. Secondly, many of these firms initially had threat-based interpretations of climate change at the beginning of the period but changed interpretations over time. This allows me to explore the evolution of their interpretations during a period when they were only beginning to develop strategic responses to climate change.

Results

In this section, I firstly present the summary statistics and descriptive analysis of the data. I then present the results of the cluster analysis and qualitative illustrations from two non-carbon-intensive sectors.

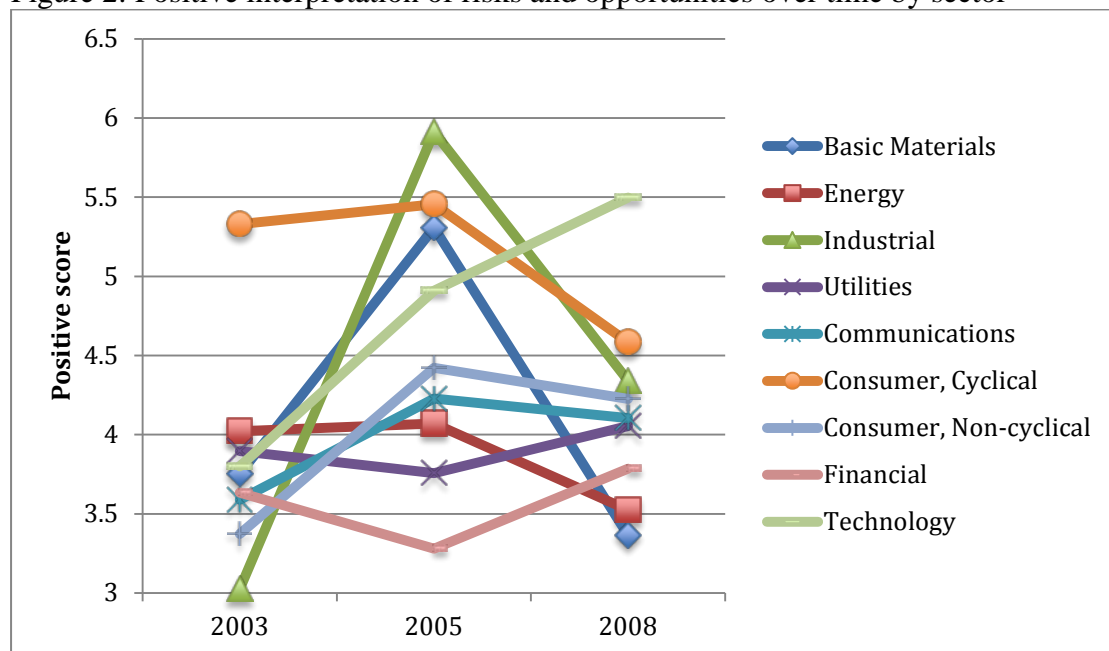
Summary statistics and descriptive analysis

Both the interpretation of the threats and opportunities of climate change and the development of capabilities change over time in the sample. Overall attention to the risks and opportunities of climate change grows across all sectors. On average, firms in carbon-intensive sectors (Basic Materials, Energy, Industrial, Utilities) have higher overall attention scores in each year compared to non-carbon-intensive sectors

(Communications, Consumer Goods, Financial, Technology). The financial sector has the highest attention score by 2008 of all non-carbon-intensive sectors, having experienced a steep rise between 2003 and 2005, as well as between 2005 and 2008.

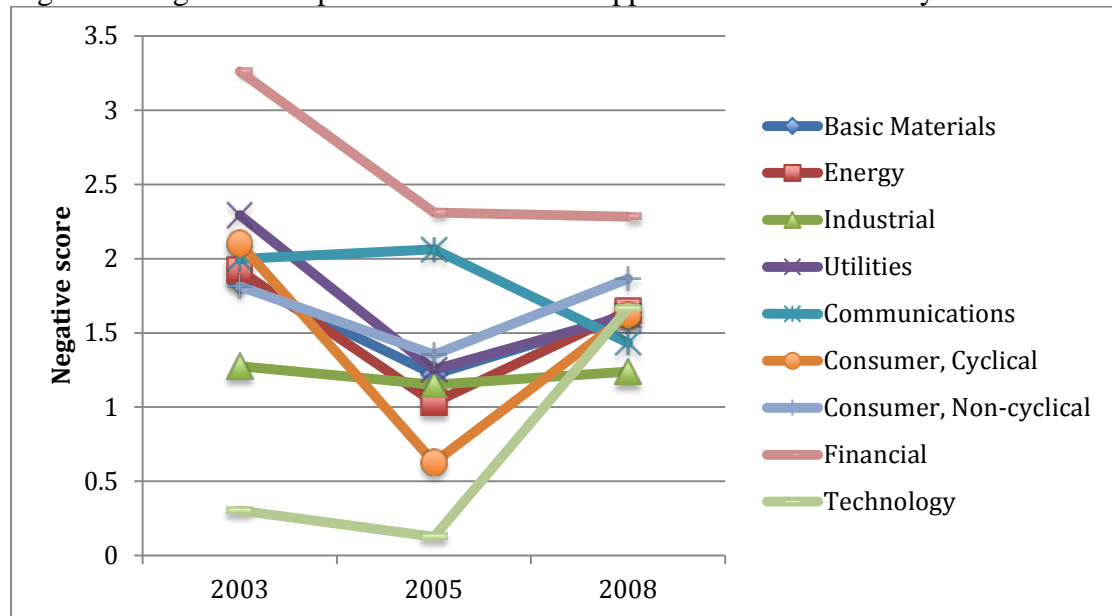
Changes in interpretation differ more across sectors. Figure 2 shows that only the technology sector has an increasingly positive interpretation of the risks and opportunities associated with climate change over time. The industrial and basic materials sectors, on the other hand, have a more positive interpretation in 2005 compared to 2003 but this subsequently returns to a lower positive score by 2008. The utilities and financial sectors experience the least amount of change during the period. Both see a small decline in the extent of positive interpretation between 2003 and 2005, and then a subsequent increase between 2005 and 2008. By the end of the period, the energy and basic materials sectors have the least positive interpretation and the technology sector has the most positive interpretation.

Figure 2: Positive interpretation of risks and opportunities over time by sector



In terms of negative interpretation, the financial sector has the most negative score throughout the period although it reduces over time. Figure 3 shows that there is a generally decreasing trend in terms of negative interpretation between 2003 and 2005 which mirrors the increase in positive interpretation during the same time. This is followed by an increase in the negative score between 2005 and 2008 in most sectors, except for communications and financial.

Figure 3: Negative interpretation of risks and opportunities over time by sector



Scores for new product and service innovation are low on average across sectors in 2003, as shown in Figure 4. In all sectors, there is an increase in new P&S development between 2003 and 2006. Between 2006 and 2009, however, several sectors remain static (Consumer Goods) or decrease in their new P&S scores (Energy, Technology, Basic Materials). The industrial, utilities, financial and communications sectors all experience an increase in new P&S both between 2003 and 2006, and between 2006 and 2009. Among non-carbon-intensive sectors, there is more variation in the extent to which capabilities are developed. Firms in the financial and technology sectors have the highest average new P&S scores by 2009. The consumer

non-cyclical sector lags behind. The communications sector makes a jump between 2006 and 2009 in new P&S development. Table 3 provides an overview of the summary statistics for the sample of 99 firms.

Figure 4: New P&S innovation over time by sector

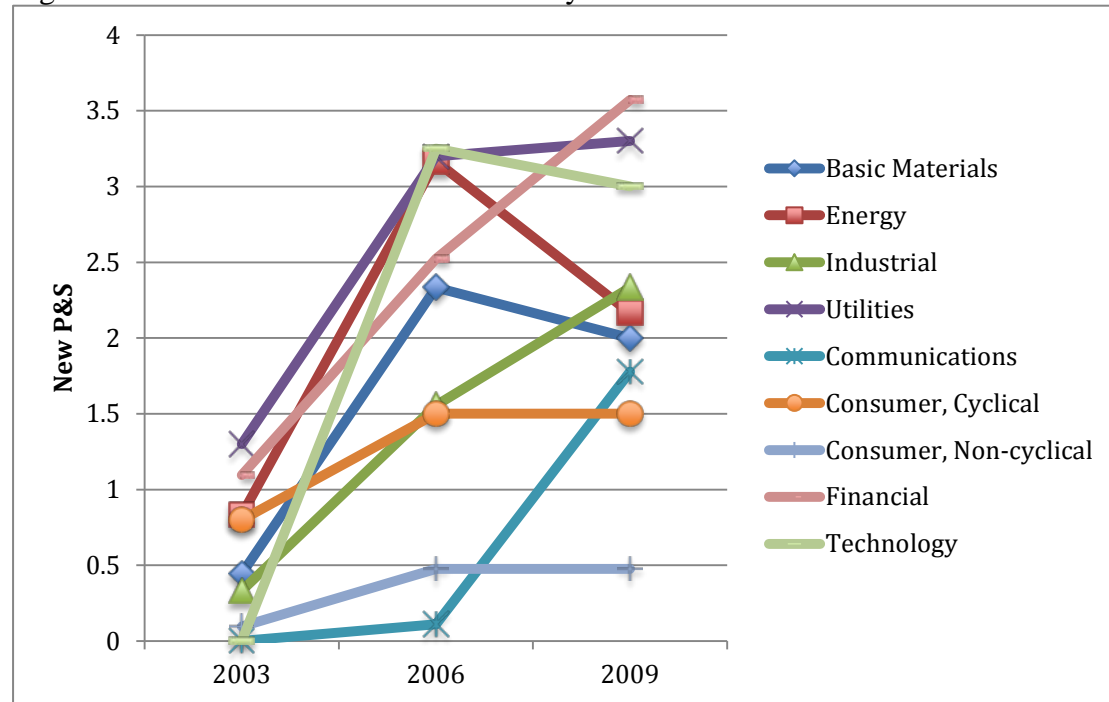


Table 3: Summary statistics

Variable	Source (units)	Firm-year obs.	Mean	Std. Dev.	Min	Max
<i>Improved P&S</i>	Coded from CDP data	297	1.66	1.80	0	5
<i>New P&S attention</i>	Coded from CDP data	297	1.62	1.85	0	5
<i>positive</i>	LIWC word count	254	487.90	493.07	14	2717
<i>negative</i>	LIWC scale	254	4.04	1.84	0	12
<i>positive - negative</i>	LIWC scale	254	1.80	1.42	0	10.2
<i>positive - negative</i>	Positive minus negative - LIWC scale	254	2.24	2.40	-6.67	12
<i>tentative certainty</i>	LIWC scale	255	1.73	1.63	0	13.33
<i>certainty</i>	LIWC scale	255	0.64	0.63	0	4.08
<i>Total CO2 emissions (Scope 1 and 2)</i>	Trucost (million tonnes)	285	15	33	0.01	172
<i>Log of total CO2 emissions</i>	Trucost	285	14.49	2.26	9.30	18.96

The association between new P&S on the one hand, and threat and opportunity interpretation on the other, changes over the course of the period. Most of the firms with more negative than positive interpretations of climate change had the lowest levels of new P&S activity. Across all categories of new P&S, interpretation of climate change first becomes more opportunity-focused and then more balanced by 2009.

Attention, interpretation and new P&S – cluster analysis results

In this section, I investigate how firms are clustered firstly according to their attention to the risks and opportunities of climate change and secondly according to their interpretation of these risks and opportunities.^{vi} I develop a set of propositions about the relationship between attention, interpretation and new P&S using the results of the cluster analysis and qualitative illustrations from the data.

Attention

Table 4 summarises the cluster analysis results based on attention to climate change risks and opportunities in each year. In 2003, there are four main clusters: Low, Medium, High (low CO₂) and High (high CO₂). There are significant differences between the clusters based only on improved P&S but not on new P&S. Relatively speaking, most of the firms in the sample have high attention to climate change risks and opportunities. The two clusters with similarly high attention scores differ mainly based on their total carbon impacts. The smallest number of firms is in the low attention group and the total carbon impact of this group is above the sample average. In 2006, there are again 4 main clusters: Low, Medium (low CO₂), Medium (high CO₂) and High. This time, most firms are clustered around a medium level of attention relative to others in the same year. There is a similar number of firms with

low attention compared to 2003. Differences between the groups are significant at the 10% level for new P&S (Kruskal-Wallis test: $p = 0.1$). The group with the highest attention from 2005 has the highest new P&S score in 2006.

Table 4: K-means clustering for all firms 2003 to 2009 – attention

2003	Low <i>n=5</i>	Medium <i>n=27</i>	High (low CO2) <i>n=15</i>	High (high CO2) <i>n=31</i>	<i>Mean</i> <i>n=78</i>
Improved P&S	0.20	0.26	0.27	1.29	0.67
New P&S		0.67	0.80	0.90	0.74
Attention	62.20	140.30	206.33	209.32	175.42
Tentative	8.45	1.42	2.43	1.11	1.94
Certainty	0.00	0.18	2.03	0.62	0.70
Log(CO2)	15.65	12.50	13.18	16.50	14.42
2006	Low <i>n=6</i>	Medium (low CO2) <i>n=35</i>	Medium (high CO2) <i>n=19</i>	High <i>n=21</i>	<i>Mean</i> <i>n=81</i>
Improved P&S	1.17	2.26	2.32	3.00	2.38
New P&S	1.00	1.60	1.58	2.81	1.86
Attention	137.50	274.31	248.79	645.43	354.41
Tentative	5.54	1.01	0.84	1.06	1.32
Certainty	0.73	0.33	1.36	0.48	0.64
Log(CO2)	14.44	13.05	15.39	16.86	14.69
2009	Low <i>n=32</i>	Medium <i>n=27</i>	High <i>n=26</i>		<i>Mean</i> <i>n=85</i>
Improved P&S	1.63	2.52	3.69		2.54
New P&S	1.44	2.41	3.69		2.44
Attention	516.69	850.41	1556.27		941.00
Tentative	2.25	2.03	1.52		1.96
Certainty	0.49	0.60	0.70		0.59
Log(CO2)	12.92	17.10	13.94		14.56

In 2009, the best clustering solution has 3 clusters: Low, Medium and High. On average, overall attention to risks and opportunities is more than 3 times what it was in 2003. There is a more even grouping of firms into the 3 clusters in this year

compared to previous years, with the smallest number of firms in the High cluster. The Medium cluster has the highest total carbon impact compared to the others, whereas the Low cluster has the lowest average total carbon impact. There are highly significant differences between the groups in terms of both improved (Kruskal-Wallis test: $p=0.0003$) and new P&S scores (Kruskal-Wallis test: $p=0.0001$). The group with the highest attention has the highest new P&S score, and the group with the lowest attention has the lowest new P&S score. These results suggest that the positive association between attention to climate change risks and opportunities and new P&S development becomes stronger over time.

Although the overall relationship between attention and new P&S development is positive, there are several examples in both 2006 and 2009 of mismatches between attention and new P&S activity. In 2009 for example, three pharmaceutical firms have attention scores greater than 1000 but new P&S scores of either 0 or 1 (Baxter, Novo Nordisk and AstraZeneca). This is mainly due to the focus in this sector on improving energy efficiency rather than on the identification of any new products and services specifically in response to climate change. On the other hand, there are also several examples of firms with low attention but high new P&S. These examples all relate to firms in non-carbon-intensive sectors e.g. telecommunications (Alcatel), technology (Applied Materials, HP), financial (Aviva, KBC, Swiss Re, UBS) and retail (Marks and Spencer).

In summary, the link between attention and new P&S is not significant in 2003. Attention to the risks and opportunities of climate change by itself does not lead to new P&S development. The relationship becomes significant in 2006 and 2009, at a time when new P&S development is higher across the board. In 2009 in the high attention group, for instance, firms are mostly in the development or maturity stages

of new P&S. It seems that there is a two-way relationship between attention and new P&S development, where actions related to new P&S actually reinforces attention which then may lead to more innovation. The instances of a disconnect between attention and new P&S are limited and only apply to non-carbon-intensive firms. On the whole, firms across sectors seem to be careful about publically presenting themselves in a way that connects to their substantive actions. This leads to the first proposition:

Proposition 1: Attention to the threats and opportunities of environmental issues is associated with new P&S, particularly in development and maturity stages.

Experience with new P&S (substantive action) reinforces attention (symbolic action) which leads to more innovation.

Interpretation

Table 5 summarises the cluster analysis results based on interpretation in 2003, 2006 and 2009. In 2003, 2 main clusters emerge: Threat and Opportunity. The biggest grouping (Opportunity, n=53) has a more positive than negative interpretation of the risks and opportunities associated with climate change. The smaller group (Threat, n=25), however, has more negative than positive interpretations as well as higher new P&S scores. There are significant differences between the groups based only on improved P&S (Kruskal-Wallis test: $p=0.01$) but not based on new P&S.

In 2006, there are three main clusters: Balance, Opportunity and High Opportunity. The Balance cluster has the highest new P&S score and the High Opportunity (the group with the highest positive interpretation) has the lowest new P&S score. The differences between clusters based on new P&S are, however, not significant. Finally, in 2009, there are three main clusters: Opportunity – low attention, Opportunity – medium attention, and Opportunity – high attention.

Table 5: K-means clustering for all firms 2003 to 2009 - interpretation

2003	Threat <i>n=25</i>	Opportunity <i>n=53</i>		<i>Mean</i> <i>n=78</i>
Improved P&S	0.12	0.92		0.67
New P&S	0.96	0.64		0.74
Attention	151.92	186.51		175.42
Positive	2.87	4.36		3.88
Negative	4.10	1.29		2.19
Balance	-1.22	3.07		1.70
Tentative	3.42	1.24		1.94
Certainty	0.67	0.71		0.70
Log (CO2)	13.16	15.01		14.42
2006	Balance <i>n=19</i>	Opportunity <i>n=55</i>	High opportunity <i>n=7</i>	<i>Mean</i> <i>n=81</i>
Improved P&S	2.16	2.40	2.86	2.38
New P&S	2.00	1.84	1.71	1.86
Attention	247.84	413.27	181.14	354.41
Positive	3.41	4.10	8.79	4.35
Negative	3.21	0.97	0.83	1.48
Balance	0.20	3.13	7.96	2.86
Tentative	2.82	0.87	0.73	1.32
Certainty	0.46	0.73	0.37	0.64
Log (CO2)	13.33	15.15	14.77	14.69
2009	Opportunity – low attention <i>n=35</i>	Opportunity – medium attention <i>n=25</i>	Opportunity – high attention <i>n=25</i>	<i>Mean</i> <i>n=85</i>
Improved P&S	1.74	2.52	3.68	2.54
New P&S	1.43	2.64	3.64	2.44
Attention	517.89	904.32	1568.96	940.68
Positive	4.42	3.80	3.83	4.06
Negative	2.02	1.50	1.73	1.78
Balance	2.39	2.30	2.10	2.28
Tentative	2.28	1.90	1.55	1.96
Certainty	0.50	0.61	0.70	0.59
Log (CO2)	13.14	17.24	13.87	14.56

The clusters are more similar in terms of positive and negative interpretations than in previous years and there is a greater focus on opportunities across all clusters. The

differences between the clusters are mainly based on attention and P&S scores. There are significant differences between the clusters (Kruskal-Wallis test: $p=0.0001$) for new P&S. Once again, the cluster with the highest attention score has the highest new P&S, whereas the cluster with the lowest attention score has the lowest new P&S.

The cluster analysis suggests that firms become more similar over time in their interpretation of the threats and opportunities associated with climate change, with a greater focus on opportunities by 2009. Among the non-carbon-intensive sectors in the sample, there is more variation in interpretations. This is most likely due to firms in these sectors developing an awareness later than firms in carbon-intensive sectors (such as energy companies and utilities) of the importance of climate change to their business. Firms that found themselves in the Threat cluster in 2003 also mostly belonged to non-carbon-intensive sectors. Over time, however, their interpretations became more opportunity-focused. I explore this change from threat to opportunity interpretation for two sectors, financial and telecommunications, to shed light on the mechanisms that connect threat interpretations to new P&S development.

Financial sector

In 2003, few of the financial sector firms in the sample had started developing any new P&S in response to climate change. By 2009, however, there is considerable activity in new P&S development. There are four main categories of new P&S: carbon markets, investor P&S, retail P&S and adaptation. The most rapid increase is in the carbon markets category. This is closely linked to the development of the EU Emissions Trading Scheme (EU ETS) which commenced its first phase of operation in 2005^{vii}. At the beginning, the focus of most firms was on carbon trading but by 2009 there is entry into hedging and forecasting services for clients, as well as services for investors in developing country carbon reduction projects. The adaptation

category is the least developed area of new P&S development. Few companies even mention adaptation specifically in their P&S portfolios. By 2009, however, several firms acknowledge the importance of being involved in adaptation discussions, even though the role for financial services in this area remains unclear.

In 2003, the firms in the financial sector with mature new P&S portfolios have more threat-based than opportunity-based interpretations of climate change (RBC, UBS, Axa and ANZ). Their interpretations remain more focused on threats than opportunities in 2005 except in the case of ANZ, whereas the tendency among other firms in the financial sector is to become more opportunity-focused. Many of those that lag behind in terms of new P&S development also have a more threat-based than opportunity-based interpretation. However, they initially have a different focus particularly in terms of the types of threats identified.

Table 6 summarises the main categories of threats discussed firstly by firms with little or no new P&S in 2003 and then by firms in the development or mature stages of new P&S development.

Table 6: Summary of threat identification by firms in negative cluster 2003

Stage of new P&S development in 2003	2003	2005	2008
<i>Little or no new P&S (scores of 0/1)</i> AIB AIG Allstate Barclays Credit Suisse HSBC KBC Santander	- General risks to society - No significant direct impacts in the short to medium term, only long-term - Focus on internal operations	- Indirect effects through clients - Environmental risk assessment processes (Banco Santander, Credit Suisse);	- Reputation - Physical risks both direct and through business activities
<i>Development/ Mature P&S (scores of 2 to 5)</i> ANZ Aviva Axa RBC UBS	- Interdependence with other sectors - Physical risks and new role for financial service providers - Reputation	- Environmental risk assessment processes - Direct and indirect impacts - Focus on learning and interaction with stakeholders	

Those with low new P&S development in 2003 tend to focus mainly on the general risks to society of climate change in 2003. There is also a restriction of focus on threats that might cause a direct and immediate impact on the firm. For instance, AIB in 2003 explains that the “timescale over which climate change will cause significant changes is longer than our normal business planning horizon”. Barclays and Credit Suisse also discuss possible future threats but conclude that there are no areas for immediate concern. There is only one example in 2003 of a firm that directly questions whether climate change impacts are in fact likely to materialise. AIG in 2003 discusses the potential for risks but adds that this is dependent on whether “it (climate change) indeed does have a causal effect in increasing extreme weather patterns such as floods and hurricanes. However, that relationship is not yet conclusively proven”.

By contrast, those with more mature P&S development in 2003 focus on how the threats for the financial sector are intrinsically linked to threats to other sectors. The focus is not just on the direct impacts for the firm, but also on the threats that operate through carbon-intensive clients. The physical and reputational risks of climate change for firms with mature new P&S in 2003 are also prominent. For instance, in 2003 RBC has a detailed discussion of the negative effects on markets the bank finances, as well as the implications for the insurance business from changes in weather patterns:

“Risks include adverse effects on market sectors we finance, including natural resource based industries and tourism. We may also be affected by the altered risk profiles of our clients and by government policy on mitigation and adaptation to climate change. We also see potential risks in the property casualty insurance sector and in reinsurance. RBC Insurance, a member of RBC that offers property and casualty insurance products could be among those insurers

affected by increased property damage claims resulting from an increase in adverse weather events”. (RBC, 2003)

By 2005, firms that had initially low levels of new P&S development have started to identify the importance of the indirect effects of climate change through their clients. The issues of reputation and physical risks, however, only start to become prominent in 2008. There are several examples in 2008 of firms referring to natural disasters. For example, Allstate refers to “recent hurricane seasons...in the Gulf Coast and Florida”. KBC describes the potential for short-term impacts in the non-life insurance business with specific reference to January 2007, when “insurance claims resulting from winter storm Kyrill weighed somewhat on our 1Q 2007 financial results”.

Firms with both early and later new P&S development have identified environmental risk assessment processes as a mechanism to improve the firm’s ability to respond to potential threats. In many firms, this involves developing new environmental risk management processes. In Credit Suisse, for instance, a “dedicated internal unit evaluates the potential threats from large-scale loss events” and in Banco Santander, mechanisms in the general risk assessment processes are adapted in order to incorporate climate change considerations. The firms with more mature early new P&S development discuss more detailed and formalised processes of incorporating climate change risks into existing processes. For example, ANZ formally recognises the direct and indirect impacts of climate change in its environmental charter. This has led to specific measures such as “factoring carbon intensity into borrower assessments”. UBS has also established “environmental risk management policies and processes” in each business group. These firms also have a focus on learning and interaction with stakeholders, with for example the founding of specific research

functions for socially responsible investment in UBS, as well as investment in internal understanding of environmental risks in ANZ, UBS and Aviva.

In comparison to these firms that have a more threat-based interpretation of climate change in 2003, the firms from the financial sector that are grouped in the positive cluster miss out on identifying certain new areas for development. This appears to be precisely because they are not engaged in a more thorough exploration of both the threats and opportunities of climate change for the firm. Nomura and RBS are both in the positive cluster in 2003 and are both slower than firms in the negative cluster to develop new P&S. By 2009, however, RBS had managed to catch up. In 2008, RBS recognises the importance of indirect effects through customers and sectors, risks related to reputation, the role of stakeholders, and has also set about acquiring new capabilities for emissions trading through the acquisition of ABN AMRO. Nomura on the other hand continues to have a positive focus in 2005 and 2008, as well as a general focus on “some possibilities of impact”.

Telecommunications

In the telecommunications sector, there was little in the way of new P&S development before 2009. In 2006, a small number of firms had started to acknowledge that communication technologies could be “adapted and specialized in new ways to minimize climate change” (Ericsson, 2006). It is not until 2009, however, that there are specific examples of new products and services being mentioned, either at research and development stages or as being introduced to the market. There are two main categories of products and services developed in response to climate change in 2009: dematerialisation and substitution; and environmental services. There is also a more general trend among several firms in adopting product

life-cycle approaches and applying sustainability criteria to new product and service offerings.

The cluster results place Alcatel-Lucent and Telstra in the negative cluster in 2003. Both of these firms stand out by 2009 as having the most mature new P&S compared to all other telecommunications firms in the sample. As in the case of the financial sector, both firms also differ in the types of threats identified in 2003 compared to other telecommunications firms. Alcatel and Telstra in 2003 and 2005 have a strong focus on the weather-related risks of climate change to their infrastructure. This focus on infrastructure involves long-term planning and a long-term focus on the changes associated with environmental issues like climate change. Other firms focus mainly on the rising costs of energy use in operations and on the more general risks of climate change for society. This focus on operational energy use in particular is short-term. KPN goes so far as to say that “as a telecoms company, we’re not part of a polluting industry” and that the existing product and service portfolio already “makes travelling less necessary”.

By 2008, Alcatel’s and Telstra’s focus has shifted towards opportunities. In the case of Alcatel, the identification of physical risks from climate change feeds into its identification of opportunities from the physical implications of climate change. For example, the discussion in 2008 includes new products and services such as early warning systems to deal with weather changes, as well as smarter power grids. Telstra also discusses the importance of telecoms in minimising the physical impacts of climate change, as well as improving monitoring and reduction of impacts through smart metering. All of the other telecommunications firms in the sample also have a more opportunity-focused interpretation in 2008, however many of these firms have a focus on operational opportunities to improving energy efficiency or a focus on

increasing the demand for existing telecom services rather than venturing into new markets.

In summary, firms that were able to identify the threats associated with climate change in more detail early on, were in a better position to identify opportunities for new P&S before others. In both the financial and telecoms sectors, the types of threats identified by those with more mature P&S early on were long-term (physical risks), focused on reputation and recognised the importance of thinking about environmental impacts beyond the boundaries of the firm (interconnected, not only internal operations). These priorities in the case of the financial sector, for example, facilitated a greater focus on learning and interaction with stakeholders. In this case, an early focus on threats later led to an open and flexible approach to new P&S development. This leads to the second proposition:

Proposition 2: Early interpretation of environmental issues that is more threat than opportunity-based provides firms with a long-term, reputation-oriented and interconnected approach. This approach facilitates the early development and introduction of new P&S.

Over time, the interpretation of firms, even those with initially threat-based approaches, became more positive. As new P&S development matures, the experience of P&S development processes appears to influence the interpretation of environmental issues such as climate change. For instance, the initial identification of threats to physical infrastructure by telecoms firms later led to the identification of opportunities to respond to these threats in other sectors through new P&S innovation. This in turn influences the interpretation of climate change, not just within the firm but also within the sector and potentially other sectors. This leads to the final proposition:

Proposition 3: As new P&S development matures, the interpretation of environmental issues becomes more opportunity-focused.

Discussion

In this section, I discuss the main implications of the results from the cluster analysis and illustrative case studies before describing the limitations of the study and the possibilities for extension.

Attention, interpretation and new P&S

Attention to the risks and opportunities of climate change is positively associated with high levels of new P&S by 2009. High levels of attention do not appear to lead to early new P&S development, however. In 2003, there is no link between the level of attention and the extent of new P&S developed by firms. By 2009, on the other hand, there are clear divisions between clusters of firms based on attention and new P&S scores. Firms with the highest attention have the highest levels of new P&S, and those with the lowest attention have the lowest levels of new P&S. This is most likely due to the fact that new P&S development in response to environmental issues actually reinforces the attention that managers give to these same issues over time.

If we consider new P&S as a substantive action and attention as a symbolic action, this gives us some insights into the interaction between the two. In the previous literature, substantive action and symbolic action are often represented as a dichotomy. For instance, if firms choose to act in a substantive way by investing in measures that improve the environmental impact of products or processes, they are likely to see positive returns (Walker and Wan 2012; Russo and Fouts 1997). If, on the other hand, firms choose to act in symbolic ways that aim to demonstrate their commitment but don't involve any tangible investments in reducing environmental

impacts (e.g. participation in voluntary environmental schemes, reporting of green activities), they may suffer from a loss of legitimacy among stakeholders (Walker and Wan 2012). The first proposition in fact suggests that there is little disconnect between symbolic and substantive actions, most likely due to the potential for legitimacy loss. Instead, substantive and symbolic actions appear to reinforce each other, as long as substantive action comes first.

In 2003, firms in sectors that were non-carbon-intensive tended to be in the early stages of responding. These firms are less heavily regulated and were initially under less pressure from the public to respond to climate change because their operations are not as highly polluting as firms in carbon-intensive sectors. Nevertheless, over the period 2003 to 2009 pressure increased for all firms to develop responses to climate change. The cluster analysis results show that at the beginning of the period, interpretations can be classified into threat-based and opportunity-based. The firms in the threat-based cluster were generally non-carbon-intensive firms. Over the course of the period, interpretations became more similar in terms of the balance between threats and opportunities. By 2009, interpretations were more opportunity-focused across all clusters.

The changes in two non-carbon-intensive sectors, financial sector and telecommunications, illustrate how threat and opportunity interpretation play different roles at different times in the new P&S development process. Illustrations from these sectors firstly elaborate on the mechanisms that connect threat interpretations to new P&S development. In particular, the early and detailed interpretation of environmental issues as more of a threat than an opportunity allowed firms to identify the long-term, interconnected nature of the problems associated with climate change. The initial focus on threats developed a basis for responding to opportunities that emphasised

learning, interaction with stakeholders and reputational impacts. The second proposition suggests that these features of an initially threat-based interpretation allow for the early development and introduction of new P&S. Other firms that initially had a more opportunity-based approach were able to gradually develop mechanisms that allowed for the development of new P&S, although at a slower pace and to a lesser extent.

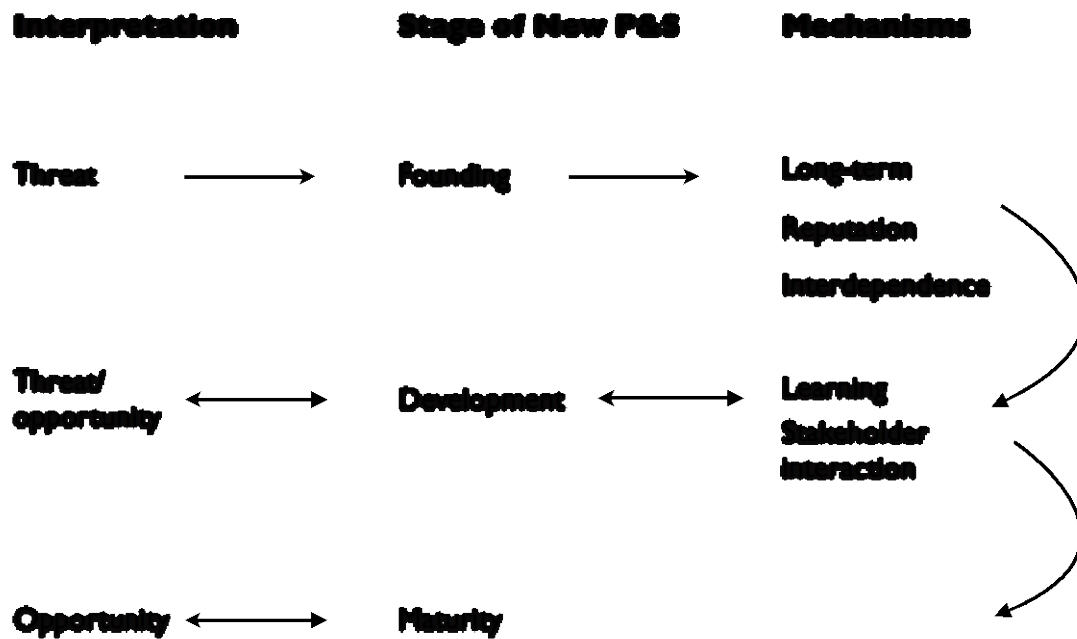
The effects of the interpretation of climate change are not static. The results from the analysis of firms in non-carbon-intensive sectors suggest that, over time, an increasing focus on opportunities and more balanced interpretations become important. This suggests that as learning improves, the importance of a more balanced understanding of threats and opportunities for innovation in new products and services grows. The initial impetus to innovate at a time when learning is in its early stages, is associated with attention to threats more than opportunities. However, as understanding of the issue develops across firms, a more balanced perspective is associated with greater product and service innovation.

This resonates with developments in the recent dynamic capabilities literature that suggest that it is the ability of senior managers to balance efficiency and flexibility that ultimately leads to superior performance (Eisenhardt et al. 2010). In terms of interpreting environmental events then, managers need to be able to balance both threat and opportunity interpretations. In the context of climate change, where there is considerable uncertainty about the consequences for business and for society, and where new information emerges on a frequent basis, this kind of balancing act is crucial. In fact, the recent literature suggests that the ability of senior managers to evaluate events as both positive and negative leads to more innovative responses (Plambeck and Weber 2009). The simultaneous application of both threat and

opportunity frames is therefore important in responding to change in the external environment (Gilbert 2006). My results confirm this but also suggest that ambivalent interpretations, or the interpretation of a challenge as both threat and opportunity, are more important as learning about the challenge across firms advances. Initially, threat-based interpretation can support the development of mechanisms that allow for opportunities to be explored and exploited at a later stage. Furthermore, the third proposition suggests that as new P&S improve, this process of development contributes to a more opportunity-focused interpretation of environmental issues.

Figure 5 illustrates how threat and opportunity interpretation are associated with founding development and maturity stages of capability development for new P&S. Initially, a threat-based interpretation through identifying the long-term, interdependent nature of climate change and the potentially negative implications for reputation, encourages more effective development of new P&S. As new P&S develop, the experience encourages a more balanced and opportunity-based interpretation of climate change.

Figure 5: Opportunity and threat interpretation as new P&S develop



Limitations

There are several limitations in the current analysis. Firstly, I use CDP data to measure product and service changes as well as the interpretation of climate change. The fact that I use different years of data for P&S compared to interpretation variables in the later years of analysis reduces the potential for common method bias. In the future, however, crosschecking this data with other sources of information on new P&S and interpretation by senior managers may improve the robustness of the results. Secondly, the coding of the qualitative data was carried out by only one coder to date. A second coder will be engaged to ensure that the coding framework allows for inter-coder reliability.

Thirdly, the period after 2009 is not yet included in the analysis. There is a possibility to extend the analysis to include data on 2011 interpretation of threats and opportunities of climate change by firms and 2012 discussion of products and services. This would allow me to examine the effects of senior management interpretation after 2009, when external pressures on business to respond to climate change were reduced in the aftermath of the financial crisis and the Copenhagen climate change summit. I would expect that the effects of interpretation are likely to depend on the overall extent of stakeholder pressures. For example, when there is strong regulatory and consumer pressure, interpretation as more of a threat than an opportunity may be necessary for firms to innovate. On the contrary, when the environment is characterised by less pressure, interpretation as an opportunity may be more important. Including post-2009 data would allow me to strengthen this aspect of the analysis. Finally, the empirical results draw more insights for firms that are under less direct stakeholder pressure to respond to climate change. This is a strength in that these firms have been less often considered in the empirical literature (Starik and Marcus 2000; Furrer et al. 2012; Okereke et al. 2012). But in future work, it would be helpful to compare those under more and less pressure to respond to stakeholders, in terms of the role of managerial interpretation. At present, the ability to generalise from the analysis of two non-carbon-intensive sectors to other firms and sectors is difficult.

Conclusion

In this paper, I explore how senior management attention to and interpretation of the threats and opportunities of climate change affect environmental innovation outcomes. In summary, I make two main theoretical contributions.

Firstly, I identify additional mechanisms than presented in the previous literature that can enable threats to lead to positive innovation outcomes. I find that an early focus on threats is associated with longer-term assessments, the recognition of interdependence and a focus on reputation. In the empirical analysis, I focus on firms with initially low stakeholder pressure to respond to environmental issues such as climate change. This allows me to look at early stages of innovation development, and changes in a period where focus on business responses to climate change were increasing. Secondly, I add a temporal dimension to the relationship between managerial interpretation and innovation. The results show that the relationship between interpretation and innovation is not static. The recent literature has focused on the importance of balancing interpretations for strategic outcomes. My results suggest, however, that different interpretations may have more impact on innovation outcomes at different stages of development. Specifically, threat-based interpretations may be more important in the early phases, whereas opportunity-based interpretations become more important when innovation development is entering into development and maturity stages. The results also suggest that the relationship between interpretation and innovation is not unidirectional. Instead, the initial development of new P&S feeds back into interpretations and contributes to the evolution of more balanced and opportunity-focused interpretations over time.

For policymakers, this underlines the importance of improving incentives for businesses to adopt long-term and collaborative approaches. Early engagement with these dimensions, which are particularly relevant to long-term and global challenges such as climate change but also potentially to other social and environmental issues, provides a foundation for substantive action and innovation. In terms of framing environmental challenges, policymakers may also learn from the fact that a focus on

only the positive may hinder levels of commitment that are both high enough and early enough to lead to innovative responses. For managers, the results highlight how managerial interpretation can provide firms with flexibility in responding to changes in the external environment. This dynamic managerial capability is likely to differentiate the ability of some firms to develop sustainable competitive advantage compared to others. At the same time, the importance of interpretation highlights the responsibility that senior managers have to develop flexible and balanced interpretations of environmental issues such as climate change. These interpretations can influence how and when new products and services are introduced, and ultimately the extent of innovation in response to climate change as well as other environmental and social challenges.

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Appendix

Table 7: Improved P&S capabilities

Description	Stage of development	Sample quotes
General discussion of potential for existing products and services to be more climate friendly but without specific examples	Identification	“Financing for clients on infrastructure adaptation projects, clean energy projects, and energy efficiency upgrades”. (Citigroup, 2003)
Specific examples of existing products or services where improvements are under development	R&D	“Developing screening tools for climate change risk in credit risk assessment”. (CIBC, 2006)
Above plus external partnership	R&D with partnership	“AIG sponsored, along with Lloyd's, a project to assess how to incorporate climate change risk into CAT models. We held two workshops... with climate change scientists, CAT modelers, and companies in the insurance industry.” (AIG, 2009)
Specific examples of existing products or services that have been enhanced to be more climate friendly	Action	“E-statement program to reduce paper consumption by an estimated 40 tonnes annually” (RBC, 2006)
Above plus external partnership	Action with partnership	“In response to customer concerns about the environment, and to promote environmental best practice in the home, HSBC Malta has taken the initiative to offer discounts on energy efficiency products for the home to all new home loan customers. New customers receive discount coupons that can be redeemed against purchase of eco-friendly products from four participating companies” (HSBC, 2006)

Notes

ⁱ In International Paper's 2003 response to the CDP, the company describes itself as "part of the solution".

ⁱⁱ These quotes are from each firm's response to the CDP annual survey in 2003.

ⁱⁱⁱ For example, ExxonMobil chief executive Rex Tillerson publicly declared in 2012 that "we have spent our entire existence adapting. We'll adapt. It's an engineering problem and there will be an engineering solution", in a speech at the Council on Foreign Relations quoted in The Guardian (2012). "Climate change fears overblown, says Exxonmobil boss". 28 June: <http://www.theguardian.com/environment/2012/jun/28/exxonmobil-climate-change-rex-tillerson>

^{iv} CDP, "Catalyzing business and government action", Accessed November 23, 2012, <https://www.cdproject.net/en-US/Pages/About-Us.aspx>

^v Table 7 in the appendix provides an overview of examples for the different stages of capability development for improved P&S, using examples from the financial sector.

^{vi} Each of the variables in the analysis was standardised to unit variance before clustering. The result in the tables in this section refer to the variables in their original scales.

^{vii} The EU Emissions Trading Scheme (EU ETS) was the first large-scale mandatory market for carbon dioxide (CO₂) emissions. The first phase of the EU ETS commenced in 2005 and since then approximately half of the CO₂ emissions that originate from the EU have had a market price (Ellerman and Buchner 2007).