TU Danni

H05569

Majeure Finance

Do the stock markets price climate change risks?

End-of-study Research Paper

Tutor: HYAFIL Antoine

Abstract

Climate change is (or potentially is) an important risk facing the companies. It's of interest to find if the stock market integrates this risk category into its price fluctuations. This paper takes the European equity market as the research target and looked into some carbon-intensive sectors' (electricity, oil & gas, construction, aviation, and automobile) climate risk exposure and their share performance and found some price fluctuations that might imply a correlation between the two elements. A further company-specific regression test shows that there might be a positive correlation between company's carbon management performance (quantified by CDLI scores) and its share performance; the significance of this correlation varies among sectors.

Due to the limited availability of data, this analysis's results should be treated with prudence. This study can be enforced by a more complete multi-factor regression integrating as exclusively as possible the factors affecting the share prices, with climate change risk factor quantified and evolving with the time.

Keywords: climate change, risk exposure, carbon management, correlation analysis.

Acknowledgement

I'd like to warmly thank Mr. Antoine Hyafil, professor of the chair of Deloitte "Finance & Energy" of HEC Paris, for his kind tutorship for my research project and all the help he provided for the completion of this research paper.

I'd also like to thank all the professors of the majeure finance who greatly contributed to my academic interest and progress during my studies at HEC Paris, without whom this research paper would not have been realized.

Introduction

Climate change has been an issue since around twenty years; the recent climate events have been marked by such phenomena as the rise of average temperature in many regions, rise of sea level, melt of ice sheet in polar area and many big glaciers and the change (or potential change) of winder pattern, water availability, frequency of extreme weather events. People are paying more and more attention along with more widespread international cooperation to fight against the climate change.

Enterprises, with their economic and social positions in our society, are in the center of the discussion and are exposed to climate risks and opportunities directly or indirectly. These risks, in form of direct damage, business environment change, regulation or reputation issues, are important issues for companies. The nature of risks varies much from one sector to another, while the risk exposure depends also on companies' carbon management strategy and practice.

Climate change is important for companies. The objective of this paper is to find if the stock market integrates this risk category into its price fluctuations. The body of this report includes the following four parts:

What is climate change and what measures are people taking to tackle it.

What are the direct and indirect risks facing companies.

A correlation analysis at sectoral level (some carbon-intensive sectors) for climate risk exposure and their share performance.

A company-specific regression test of the correlation between company's carbon management performance and its share performance.

Content

Part I - What is climate change

What is climate change

The Earth's climate is affected by several factors, among which solar radiation, land cover, and the amount of greenhouse gases (GHGs) in the atmosphere. GHGs are important as they affect the amount of solar energy that is trapped on Earth and that is reflected back to the space. Typical greenhouse gases include for instance carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Climate change, as defined by the Intergovernmental Panel on Climate Change (IPCC)[1], refers to "observational record that occurs because of internal changes within the climate system or in the interaction between its components, or because of changes in the external forcing either for natural reasons or because of human activities"[2]. Observational record refers to a state that can be identified (by statistical methods for instance) and that persists for an extended period (decades or longer).

The consensus today is that the climate is currently changing. Global warming seems a widely recognized fact[3], although there's still uncertainty in related conclusions. According to the Fourth Assessment report (AR4) of the IPCC released in 2007, we observed such phenomena as "eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850)…Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm/yr and since 1993 at 3.1 [2.4 to 3.8] mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and the polar ice sheets." [4]

Other facts include the shrinkage of arctic sea ice sheet, regional changes such as droughts, frequency of hot waves, wind patterns, etc. Although not sure if all these facts (or part of them) are due to pure periodical variations or a long-term confirmed tendency, AR4 of IPCC called the climate change "unequivocal".

The cause of climate change is mainly due to the concentration of GHGs in the atmosphere (an

[1] A scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP). Its mission is mainly providing an objective information source (of scientific, technical and socio-economic nature) on climate change issues for the stakeholders. IPCC is politically neutral.

[2] IPCC glossary, ptf, http://www.ipcc.ch/glossary/index.html

[3] With uncertainty; still a controversial issue.

[4] AR4, IPCC, *Climate Change 2007*

increase of 70% between 1970 and 2004 (80% increase for CO_2).[5] Reasons can be the more concentrated GHGs emissions and the change of land use (less and less forests, etc.) The causes of this change can be natural reasons or human activities and it's usually difficult to distinguish among the reasons. Still, the current consensus thinks it's very likely linked to human activities. Since industrial revolution, human have been releasing and therefore causing accumulation of more and more GHGs in the atmosphere by population increase, living standards improvement, economic development, etc. We've been developing agriculture, burning fossil fuels, and changing the land use, etc.

Continuing concentration of GHGs will push up further the temperature and cause many other climate issues. The IPCC Special Report on Emissions Scenarios (SRES, 2000) projects an increase of global GHG emissions by 25 to 90% (CO2-eq) between 2000 and 2030. "For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emissions scenarios." [6] Projections with longer horizons are more sensitive to different projection models and assumptions of scenarios.

Climate change has impacts on many different things: Rising sea level might force many people near the coast to immigrate; the properties at their original home place will no longer exist. Changing temperature and water availability (of which the impact magnitude depends on regions, latitudes, extent of warming, etc.) can affect negatively the food production. The limitation posed by lack of water has many other negative consequences. More-likely-to-be-frequent storms, hurricanes and floods can generate physical damages.

[5] AR4, IPCC, *Climate Change 2007*
[6] AR4, IPCC, *Climate Change 2007*

Response to climate change

As climate change is becoming hotter as a topic, people are paying more attention and providing various solutions to the risks we're facing. The ways to respond to this challenge include adaptation and, more essentially, mitigation.

Humans, just as other creatures on Earth, have much experience of adapting to challenges posed by the environment. We build pipes to bring water to dry area. We build dam and water reservoir to face water seasonality. We invent lightning-rods to protect building from lightning damages. The possibility and our capability of adaptation have been and will continue to be enlarged by the economic development along with technology improvement. However, passive adaptation will always leave us very much vulnerable, while posing costs and not solving many social, political and cultural problems. Conflicts among people can be produced along with related environmental issues. Furthermore, the continuation of climate change should increase the magnitude of its impacts with the time, so adaptation alone can not cope with this challenge and is not a sustainable choice. We should surely adapt to the changing situation as a basic response to mitigate negative impacts, but a more essential and sustainable solution should be to mitigate the GHGs emissions in order to slow down and finally control the climate change pace, and even reverse some negative impacts.

As it's essentially a global issue, governments' and international organizations' united behavior is important to make a change.

In order to provide essential information (scientific, technical or socio-economic) about the situation, causes and consequences of climate change to policy makers and many other parties so that the potential adaptation and mitigation measures could be realized, the IPCC was established in 1988 by the WMO and UNEP. As an intergovernmental body, the IPCC is above-all a scientific organization whose work is policy-related but policy-neutral at the same time. In 1990 IPCC published the first Assessment Report of which the findings were important to promote a wide international cooperation and united action on the climate change.

Then the year 1992 saw the appearance of the United Nations Framework Convention on Climate Change (UNFCCC). Governments of 192 countries ratified for a cooperation to tackle the climate change by gathering and sharing information on emissions, policies and best practices, launching

national strategies including provisions of financial and technological support for developing countries, and cooperating on preparing for adaptation to climate change impacts.[7]

In 1995, under the framework of the UNFCCC, whose commitments were considered not adequate, developed countries committed to taking action to reduce their emissions to the 1990 level by 2000. This Berlin Mandate marked an important advancement and permitted the establishment of further agreements for years beyond 2000.

Later in 1997 the famous international agreement Kyoto Protocol was adopted under UNFCCC. 37 industrialized countries and the European Community set their targets of reduction of GHGs emissions, for the time period of 2008-2012. This was a real corner stone as it committed the countries to take real actions, whereas the former events signified mere intentions to do so. Reduction targets were setted, under the form of emission allocations, which took into account the bigger responsibility of developed nations for today's climate change during their longer-time industrial activities and large contributions to past GHGs emissions. This treaty also marked the creation of the emission trading, by which "unused" quota from one party can be sold to another that needs to emit more than his allocated units.

Kyoto Protocol also allowed a party committed to reduce emissions to implement emission-reduction project in developing countries, a behavior resulting in certified emission reduction (CER) credits. This Clean Development Mechanism (DCM) encouraged sustainable development and provided some flexibility to committed countries. Similarly, Joint Implementation allowed a committed country to implement a reduction project in another committed country to earn emission reduction units (ERUs).

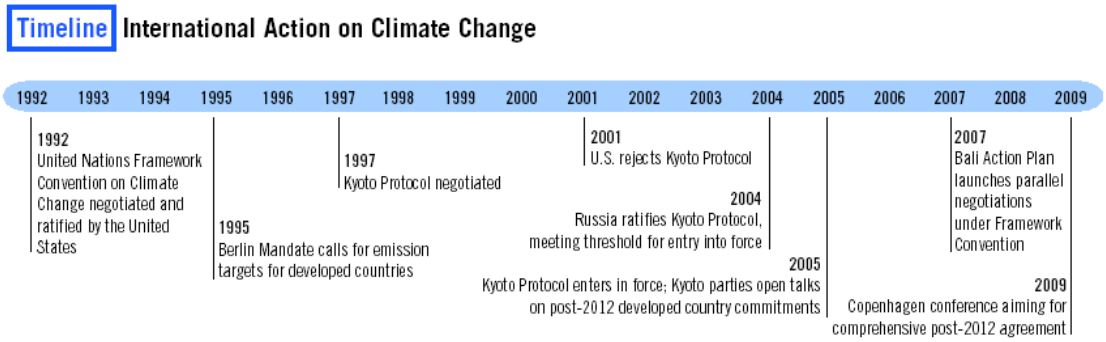
The European Community, playing a leading role in the fight against climate change, had its European Commission launched the European Climate Change Programme (ECCP) in 2000, of which the goal was the implementation of Kyoto Protocol: European Community as a whole committed to reduce the emission of 8% of their 1990 level. With the contribution of ECCP, The Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 established a scheme for greenhouse gas emission allowance trading within the Community (EU Emission Trading System, ETS), the largest ETS in the world. This is one of the best examples of

[7] UNFCCC website: http://unfccc.int/essential_background/convention/items/2627.php

climate policies. In 2005, to continue the battle against climate change, European Commission launched the second ECCP (ECCP II), of which the working groups indicate its working focus: ECCP I review, EU ETS review, aviation, CO_2 and cars, carbon capture and storage (CCS), and adaptation[8].

With the Kyoto Protocol commitments to expire in 2012, the world is looking to the 2009 Copenhagen United Nations Climate Change Conference for further agreement for actions beyond 2012. This conference is likely to yield important further agreements and united actions.

Till today, the most important events related to the awareness and the fight against climate change are summarized in the following graph:



(Source: The brief of the "Climate Change 101: Understanding and Responding to Global Climate Change[9]")

[8] European Commission website. http://ec.europa.eu/environment/climat/eccpii.htm
[9] A report of the PEW Centre on global climate change, January 2009. pp 3 (brief)

Part II - Climate change risks/costs for companies

Everybody is surely responsible for our environment and our planet. All parties and individuals are subject to the consequences of climate change, generate impacts on the climate change, and should make the efforts for a better environment.

At a more practical point of view, and based on our current social and economic structure, enterprises are one of the most important and influencing actors by whom the impacts of climate change pass to individuals while the essential efforts to fight against climate change are executed. It therefore makes sense to examine the climate change impacts on various companies and their realized or potential efforts to mitigate climate change risks / consequences.

Categories of risks/costs

Enterprises are directly subject to climate change risks/costs. According to the Germanwatch discussion paper of March 2004[10], we can generally divide the potential costs into two categories: direct and indirect costs.

Direct costs include:

- **Physical impacts/loss**, including damages caused by negative climatic events such as heat periods, flooding, water shortage, etc.
- **Interruption of production**
- **Changes in market demand and supply** (including supply costs such as raw material price, natural resource price, etc.)

Indirect costs include:

- GHGs **emission regulation** (EU ETS is a good example for Europe; similar regulation can materialized in other countries/regions in the future)
- Impact on company **reputation** of its climate change risk related behavior
- Risk of **litigation**

Furthermore, **technology risk** is also an indirect threat. The uncertainty comes along with the technology development and its associated costs. Climate change risks stimulate investments in low-carbon or zero-carbon technologies and might yield achievements to take clean processes to commercially economic level and make it a threat to conventional industry. The development of green energy (wind, solar, bio-diesel, etc) can for example be a threat to conventional energy. Research on carbon capture and storage (CCS) is getting attention and funds, potential storage sites location can affect the economic value of existing infrastructure. Most of these technology improvements might be far from realization but they are indeed a risk.

Uncertainties related to technology availability and regulations are very high today. The price of the carbon is also very unstable (for example in the EU ETS the carbon price raged from 2 to 31 euros/tonne during 2006). These aspects, with their uncertainty and potentially very large economic impacts, make companies' climate-change strategic planning very difficult. Fixing a strategy (long-term, as it's called a strategy) itself becomes a "**climate-change strategy risk**" for

[10] Germanwatch Discussion Paper on Climate Change Risks and Company ratings, March 2004, pp 1-2

a company.

Potential significant changes of the business of a company can pose challenges to **human resource management**. New technology needs training, for instance. Recruitment and retention, career development, working environment can all be touched.

Even more categories of risks can be identified as we go further into details.

Some further illustrations and evidence of indirect risks

A good illustration of the reputation risk can be found in some non-governmental pressure coming from NGOs focusing on corporate behavior for climate change issues.

The Carbon Disclosure Project (CDP) is an important and influencing one. Established in 2000, CDP is a non-for-profit organization that holds the largest database of corporate climate change information in the world[11]. CDP provides climate change information on corporations to investors, corporations, governments and other stakeholders in order to promote attention and action to fight against climate change. CDP makes annual requests of information related to climate change to more than 3700 corporation in the world and collects valuable information that serves as an analysis basis. The information can be used to measure the footprints of emissions and encourage enterprises to reduce emissions. The use of CDP's results can direct investments and other economic or non-economic behavior which can influence the performance of enterprises that answer to the survey.

Similarly, the Global Greenhouse Gas Register of World Economic Forum (2005) promotes voluntary disclosure of GHG emissions; Equator Principles, developed by several private banks based on the environmental standards of World Bank and IFC, commit adopting organizations to provide financing only to projects meeting the environmental and social benchmarks of the Principles. UN Environment Program (UNEP) Finance Initiative.

All these efforts about carbon disclosure and measurement of related risks show the increasing importance of climate change risks for companies, investors, and other stakeholders.

Disclosure is not at all the end of the story. Regulations for companies' carbon behavior are even more inevitable, and the further development of regulation measures is always on the way.

For now, other than the cap-and-trade system as mentioned above, there also exist sectoral agreements that commit adopting parties to common progresses or objectives in order to reduce emissions of a certain sector. This mechanism is often more "flexible" and easier to negotiate with potential participants. The form of these agreements can be for example target energy efficiency/intensity, use of certain technology, etc. In the European Union, carbon efficiency standards have been proposed to car manufacturers. According to the International Energy Agency

[11] CDP website. www.cdproject.net

(IEA) analysis, the sectors potentially most suitable for sectoral agreements (due to a better uniformity of product/process) are aviation, aluminum, motor vehicles, steel and cement[12].

The objective of this report is to check if the stock market prices the climate change risks that companies are exposed to. While it's more or less easier for direct costs, the quantification of indirect costs is more complicated. It depends on the degree of materialization of these risks, and the management of these risks inside enterprises, etc.

[12] World Energy Outlook 2008 (WEO2008), International Energy Agency (IEA), 2008. pp 430

Part III - Sectors' exposure

Enterprises' GHGs emissions come from various sources/sectors. Different companies doing different businesses with various production processes (tangible or intangible) certainly have different magnitudes of direct emissions. Their use of electricity, an important category of GHGs emissions, also depends much on their business models. So as their use of third-party services that induces other emissions. Based on these differences, among others, companies are often subject to different degrees of regulation, mitigation risks and reputation concern.

The pressure for a good carbon management is of different intensity too, no matter for the sake of lowering direct costs, mitigating physical and financial consequences, complying with regulatory directions, improving the financial performance of the company, or establishing a better reputation and a better realizing the social responsibility of the enterprise.

In short, these differences described above disturb much the direct comparisons of companies' risks, opportunities and related efforts and performances. A method that mitigates a bit this problem is to divide companies according to their sectors and then perform analyses at sectoral level. Companies in the same sector usually have similar activities and therefore similar emission types and possibly comparable levels.

Furthermore, if we examine companies' business in the same market (the European market is studied in this paper), they become even more comparable. The regulation level is similar (or even the same), with the mitigation risk more comparable (under the same or similar-development-stage juristic systems). The reputation problem is similar too, as clients, investors, and many other stakeholders are within the same geographic area and/or economic society. Also, the technology availability is more comparable within the same market (than for instance the technology availability facing a company in a region of incomparable degree of economic development).

Before going further to individual companies' level, it worth looking at different sectors first and trying to have a picture of their climate related mechanisms, including emission levels, reduction pressure, sources of risks, level of regulation, etc. Also, examining sector's share performance compared with the market (using sectoral indexes' performance minus market index' performance) can possibly give some insights about these specific sectors' risk exposure and stock price sensitivity to the climate change issue.

Choice of sectors

The 2008 CDP disclosed emissions breakdown by sectors is as following:

*(Source: CDP 2008 Global 500 report*13*)*

(Scope 1 and 2 include direct emissions and energy consumption)

According to the CDP 2008 report, "The total emissions of the Utilities (1,164 million metric tons CO^2-e[14]) and Oil & Gas companies (762 million metric tons CO^2-e) that responded to CDP6 exceeded those of respondents from all other industries put together.[15]"

And according to the World Energy Outlook 2008 of IEA, in 2005 the energy-related emission accounted for 61% of all GHGs. The CO_2 from land use change accounts for the largest share of non-energy related emissions (15% of GHGs). Other important non-energy emission leading

[13] Carbon Disclosure Project 2008 Global 500 report, pp 35
[14] CO^2-equivalents
[15] Carbon Disclosure Project report 2008, Global 500, pp 35

sources are cement production and natural gas flaring (4% of GHGs). In the reference scenario conceived, a future (projections till 2030) based on established trends and policies, without new initiatives by governments on energy security or climate change, the power-generation and transport sectors contribute over 70% of the projected increase of the world energy-related CO_2 emission to 2030[16].

Another fact of the energy sector is, the energy-related emission level is kind of "locked-in", due to the long life of the energy infrastructure (especially that for power generation). The infrastructure that has already been built or is now under construction is going to last for a long time, in the absence of large-scale costly early retirement (which is no so likely). The current infrastructure and its emission level can therefore not be changed dramatically before long. This fact was taken into account and influenced much the projections of emissions in both 550 and 450 policy scenarios[17] conceived by the IEA. Energy-related emissions are and are likely to continue to be the most important parts of all emissions.

With its high share in GHGs emissions as shown above, the energy sector will surely be in the heart of target for emission control/reduction. This fact increases the risk facing the energy sector and makes it an important research target for this paper.

More in detail than "energy sector" as a whole, the electricity and oil & gas sectors will be checked separately.

Construction is another important carbon-intensive sector with high emission level. And as mentioned above, sectors such as aviation and motor vehicles are also carbon-intensive industries that are potentially suitable for sectoral agreements. They are all likely to be important targets of emission reduction efforts.

It is therefore reasonable to pay special attention to the following sectors, oil & gas, power-generation, construction and transport, as examples of carbon-intensive industries that are and will possibly continue (at a more aggressive basis than other sectors) to be the most responsible industries for the GHGs emissions. These sectors are highly exposed to both direct and indirect risks of climate change. Their stock prices might engage and reflect more climate change risks than other sectors less sensitive to climate change.

[16] World Energy Outlook 2008 (WEO2008), International Energy Agency (IEA), 2008. pp 381-399.
[17] World Energy Outlook 2008 (WEO2008), International Energy Agency (IEA), 2008

This part of the paper is going to examine these five typical carbon-intensive sectors: **electricity, oil & gas production, automobiles, aviation and cement/construction** for their climate change risks and stock performance, trying to figure out if there is a relationship between the risk and stock returns (returns of indexes of different sectors and their performance compared to the market).

Other important carbon-intensive sectors include chemicals, pharmaceuticals, raw materials, mining, paper, packaging, etc. The study of this paper can be extended to these industries to integrate more data and establish a better position to conclude.

Choice of market

As for the choice of markets, **European market** data are studied here.

Europe has a leading role in the fight against climate change since the beginning of the awareness of this global issue. The European community as a whole committed to important emission reduction targets in the Kyoto Protocol. Systems such as the EU ETS provide a relatively high materialization level of climate change regulation risk. The environmental standards for many industries such as car manufacturing are relatively high. The efforts and policy directional force for cleaner technology is also greater; for instance the governmental efforts to promote green energy, including generous subsidies, etc.

European companies, facing therefore more regulation and pressure, are likely to be more aware of the issue, while the European stock market might also be a bit more aware of the related risks and reflect them in the market fluctuations. These aspects support the choice of the European market for the studies of this paper. Data availability is another good reason.

In order to reflect the above-mentioned sectors' stock performance, the following indexes are used. The largest market-cap companies (in the component list of these indexes) for which CDLI scores[18] are available are objectives of the next part of this paper (further studies inside each sector to see if climate change leaders' stocks are performing better than their competitors lagging behind concerning climate change issues).

Dow Jones STOXX® Blue-chip index for Europe:

- **European market**: Dow Jones STOXX 50®

Dow Jones STOXX® 600 Europe Supersector indexes:

- **Oil & Gas**: DJ STOXX 600 Oil & Gas
- **Construction**: DJ STOXX 600 Construction & Materials
- **Automobile**: DJ STOXX 600 Automobiles & Parts

Dow Jones STOXX® TMI Europe Sector index:

- **Electricity**: DJ STOXX TMI Electricity

Dow Jones STOXX® TMI Europe Subsector index:

- **Aviation**: Dow Jones STOXX® TMI Airlines

[18] A rating that reflects companies' carbon disclosure achievements and efforts. See next part of the paper.

Key issues for these five carbon-intensive sectors

Electricity

Direct risks to the electricity sector include potential physical damages, production interruptions and supply-demand changes.

Some natural disasters such as storms and flooding are surely physical risks for electricity facilities and infrastructure. More frequent hurricanes, lightning and storm weather can be an increasing threat to the electricity transmission system. The snow/ice load and wind (whose pattern might be changed by the global warming) also affect the electricity grid and might cause interruptions or destroy in unfavorable occasions.

Water resource (rivers for instance) is key for hydro electricity generation. Water shortage can cause production interruption. While global warming can cause water shortage itself, the shortage can be worsened by directing water resource for other key activities during droughts (direct water use of households for example).

The work of wind turbines depends on the wind patterns. For example they can only work and generate electricity when the wind speed is inside a certain interval. Change of wind patterns, if negative, can therefore reduce the efficiency of wind turbines and cause production interruption or even physical damages.

Thermal electricity generation, such as coal/gas/ nuclear-based generation, often includes a cooling process using water. Given a higher temperature of the water source (e.g. rivers and lakes) due to global warming, this cooling system might become less efficient. More frequent droughts and heat waves in summer months will naturally decrease water availability (due to evaporation, etc.) and are therefore potentially downside factors for production. Meanwhile, with higher temperatures in hot seasons, the demand of electricity for cooling of houses and building might increase. This strengthened pressure can cause trouble to electricity generators. It can also push up the price of the electricity to extreme levels.

Adaptation can provide short- and mid-term solutions for some of these risks: load management should play a role for instance. Pricing strategy can serve to control / manipulate (to a certain degree) customer behavior and ease the demand pressure, while production planning can make better use of scarce resources and relieve a bit the production shortage. However adaptation

measures are surely not sustainable solutions, and they can't solve all problems. For instance social conflicts can result from intensified resource scarcity (e.g. water) or pricing strategy (e.g. price increase). These direct risks are obvious for electricity companies.

Indirect risks facing the power industry include regulation, technology risk, reputation risk and litigation risk.

Regulation can take many forms. It can be a "cap and trade" system or just a limitation of water use while the temperature reaches a certain point. Energy generation companies are certainly exposed to these regulation risks. Litigations might arise along with them. Technology risk can come from the development of carbon-free electricity to the conventional electricity. Reputation risk is also high as the power industry is in the heart of the discussion concerning climate change; attention means indeed risk. Lagging behind competitors on this aspect might generate negative impacts such as decrease from clients' demand and investors' funds.

And like other industries, electricity companies bear strategic risks, human resource risks, etc.

In the CDP Global 500 2008 report, Electricity sector (included in the utility sector in CDP's analyses) is the true leader in the carbon-intensive sectors concerning the carbon disclosure practice[19]. Intuitively, this fact might be a result of the high regulation and reputation pressure that this sector faces, as well as the high direct risks as mentioned above.

Oil & Gas Production

The situation of the oil & gas production sector is quite similar to that of the power industry.

Events such as flooding, hurricanes and strong wind can cause physical damages to energy infrastructure such as the oil production platforms (on- or off-shore), refinery stations, transmission facilities, terminals, etc. Water shortage or other issues might cause production interruption. The demand of oil & gas is positively related to the demand of electricity.

Regulation can be posed on, and oil & gas is not paid less attention than the power generation. Technology risk always exists as we try to find clean energy to substitute conventional energy; this motivation and effort is being reinforced by the threat of global warming.

One finding clearly distinguishes the oil & gas industry from power industry however: while both

[19] Carbon Disclosure Project report 2008, Global 500, pp 33

sectors have large emissions and bear great regulatory risk and attention, power industry topped the CDLI scoring list (which is an evaluation of the carbon disclosure effort, see next session for details of CDLI scores) among carbon-intensive sectors and the oil & gas companies are not scoring that well[20].

This lack of correlation between emission level and carbon disclosure might imply that larger risks don't necessarily generate larger motivation for better management; however this lack of correlation might also be due to the fact that CDP data don't cover all companies (61% of all carbon-intensive companies in Global500 companies).

Construction

Construction/building products companies' production includes chemical process and/or fuel/energy use that release GHGs, so as their transportation/logistics systems, similar to many other industries.

Along with physical damage threats (floods, hurricanes, etc.) to production sites such as factories and facilities and potential production interruption, direct risks also include, more importantly, potentially much higher energy costs for production. These costs constitute a big part of their production costs and are therefore important risks.

More difficult natural environment might also require more resistant building products to withstand harder conditions. Maintenance standards might also be higher. These can be a challenge for construction products producers. This aspect involves large technology risk: risky R&D activities are required, while successful new products might rule the old products out of the market.

Regulation risks are important too. This industry is already been looked very closely. Construction companies' replies to the 2008 CDP questionnaires show that they consider the risk of regulation the biggest risk facing this sector, concerning cap and trade, energy efficiency standards or fuel/energy prices, etc.

Different regulation levels and practices in different regions have economic impacts on companies and might generate re-localization of production sites. This kind of movements could be big

[20] Carbon Disclosure Project report 2008, Global 500, pp 33

business strategic decisions with heavy consequences if failed; at the same time potential new adaptations of GHGs emission regulation at the destination country / region are risks for the re-localization projects.

Construction companies are doing well on their carbon disclosure practice. They are the second-ranked sector in the CDP Global500 2008 report. Along with the electricity sector, construction might imply a positive correlation between emission level and carbon disclosure performance.

Aviation

Aircrafts release much CO_2 and also other GHGs in the atmosphere each year. Aircrafts vapor can lead to formation of clouds with greenhouse effect.

With the fast development of air transportation, while the EU's total greenhouse gas emissions fell by 3 % from 1990 to 2002, emissions from international aviation increased by almost 70 %[21].

Climate change will have direct physical consequences on aviation. Transport is a sensitive industry to weather events, especially the air transport: more frequent extreme weather events are bad news for airlines companies and the downside impacts are very large. Energy prices are likely to go up and push up the direct costs of air transport. Indirect risks as regulation and reputation are also important issues. Aviation companies can for instance face heavier taxes of which the objective is to reduce emissions, and be required to enter the cap and trade system.

However from the time when people began to talk about climate change till now, little impact has been observed yet, neither physical impacts nor new regulations. But this situation can't last and is likely to change quickly. A Directive to include aviation into the EU Emissions Trading Scheme (ETS) was published in the Official Journal on 13 January 2009[22].

Aviation companies are currently doing poorly managing these risks and disclosing their situation. In the CDP 2008 global500 report, transport & logistics is the poorest-performing sector among carbon-intensive industries based on CDLI scores (non-carbon-intensive sectors have different scoring criteria and are not directly comparable). The verification and reporting of emissions data are less organized than the average of carbon-intensive sectors.

[21] European Commission website: http://ec.europa.eu/environment/climat/aviation_en.htm
[22] European Commission website: http://ec.europa.eu/environment/climat/aviation_en.htm

This poor performance might be explained by the much lighter regulation compared to the three carbon-intensive industries mentioned above. It therefore supports a positive relationship between regulation and disclosure and not necessarily between emission level and disclosure.

Automobile

A motor vehicle's production process is marked by CO_2 emissions at almost every stage: raw materials extraction, components production and fuel production. When the vehicle goes into everyday use it's indeed worse: it releases CO_2 everywhere it goes at all times when it moves around. The emissions from automobile use are a very well-known source of GHGs.

While direct costs such as physical damage are present as for other industries, automobile manufacturers' products demand is heavily affected by the regulation A clear risk is the regulation on the fuel efficiency standards posed on their products, environmental taxes on the products, etc. The problem related to company reputation is important too, as the products' carbon intensity is increasingly related to the car maker's business image when people are getting more and more aware of the climate change issues.

One feature for automobile industry is that there're very obvious geographical differences concerning market demand. In Europe and Japan, along with high fuel prices and smaller roads customers show strong preference for smaller and more fuel-economic cars, while in the US larger vehicles constitute more important share of sales. The differences among products concerning size, weights, etc make the emission levels very different. Automobile companies' sales are also marked with geographical differences. In general, companies like GM and Ford are mainly selling in the US, while PSA and Renault are more focused on the European market. Their production mix shows these differences and their emission intensity is also in line with these differences (PSA and Renault generally have low sales and profit carbon intensity compared to Ford and GM). This paper focuses on European companies and the largest share of their sales is in Europe. This fact increases the comparability among these companies, as they face similar regulation and have similar clients and investors.

The results in the CDP Global500 2008 report included automobile sector in the manufacture

sector, in which it was the best-performing sector concerning carbon disclosure[23]. The average of manufacture sector is about the average of carbon-intensive sectors.

[23] Carbon Disclosure Project report 2008, Global 500, pp 55

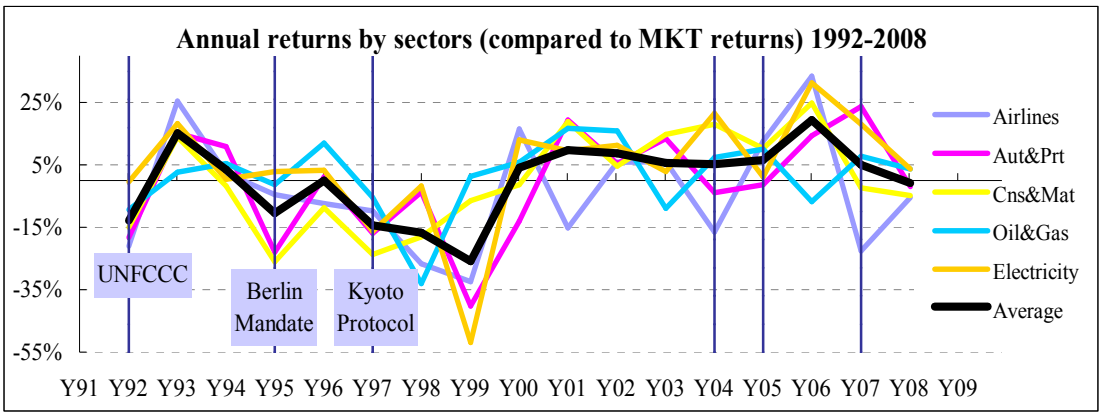
Stock returns & climate change risk exposure analysis

The stock prices from year 1992 and 2008 are used. The year 1992 corresponded to the year of the naissance of UNFCCC that marked the important rise of global concern for the climate change.

For each index the annual returns (with year-end and dividend & split adjusted prices) are calculated and compared with the market returns of the same period. The differences are used as each sector's performances (see appendix I for data of each sector's returns compared to the market). The "average" corresponds to the average return of the five sectors (compared to the market).

Five-sector average performance vs. climate change events

The results are presented in the following chart:



The Black line in the chart shows the average performance of the five sectors. Some facts can be identified concerning this average performance.

We can note that the years 1992, 1995, 1997-1999 are marked with **negative value**, meaning that during these years the average return of the five sectors are less than that of the whole market.

As mentioned in the first part of the paper, by looking at the history of people's work on climate change issues, we can see that the year 1992 was the year when the UNFCCC was established, the year 1995 was the year of Berlin Mandate and the year 1997 saw the negotiation and acceptance by many important countries of the Kyoto Protocol.

These events marked big advancements of the fight against climate change, signifying the dragging of more attention to GHGs emissions control/reduction, and regulation for companies, potentially higher price for carbon, etc.

When these issues came up they appeared as constraints and possible downside pressure for

financial performance of companies. The share price **change** of these carbon-intensive companies, on average, was indeed **negative** at these moments, as the black line went down (for 1995 and 1997). This coincided with the climate change events.

A certain amount of time after the arrival of a negative sign for a company (such as an climate change advancement here) to the market and triggers a drop of return, the profitability (as meant by the share price) should go up again as the company adjusts and responds to the new challenge. Additional profitability is required by investors to compensate this newly-arrived additional risk so that they don't choose to put their capital to somewhere else. The pace of this rebound might be a sign of the graveness of the shock; by this standard we see that the acceptance of Kyoto Protocol had a larger and more resistant influence on the stock performance than the first two events: after the pull-down of the event happened in 1997, the average of the five sectors' indexes didn't go back to the market level until the year 2000 (this five-sector average was at about the same level of the market in the year1996). In comparison, this average return went up in one year after the occurrences of the first two events (UNFCCC and Berlin Mandate).

After the year 2000, the following climate change events were relatively important:

In 2001 the US rejected Kyoto Protocol. In 2004 Russia accepted Kyoto Protocol. In 2005 Kyoto Protocol commitments entered into force. In 2007 Bali Action Plan launched further negotiations.

And in December 2009, the up-coming Copenhagen conference is likely to mark another corner stone for climate negotiations and agreements; "climate-change people" are looking forward to this conference to bring out large breakthrough for international cooperation on this important issue.

The average performance of the five sectors' shares was however relatively calm for these events. The average return stayed a bit above the average market return (with a small rise in 2006 and a downturn in 2007; still a better return than the market in 2007).

The US rejection in 2001 was an opposite shock compared to the acceptance of the Kyoto Protocol; it might have generated some doubts on the continuity and the force of the united fight against climate change. In this year these carbon-intensive companies' shares did go up a bit. But compared to precedent events it didn't show much change this time. This calmness might be explained by the fact that these indexes represent the European region which already committed to

the Kyoto Protocol; these companies were already deemed to the regulation of this protocol. Also, even at a global level, this set-back was likely to have been considered as a short-term event, and the climate change issue would continue to receive attention while future actions were still expected. Concerning the long-term future of the policies and economic features of the fight against climate change, the market might have not seen any changes and therefore didn't react.

The line was flat for 2004; the return in 2004 was almost at the same level as in 2003. And when the Kyoto protocol entered into force in 2005, the line was also flat. These facts corresponded to the rule that the stock market acts on an anticipation basis: the market reacts to the arrival of a new piece of information and integrates this information thereafter except for an arrival of opposite information. The market learnt about the realization of Kyoto Protocol when it was negotiated and when the commitments of European countries were made (in 1997) and expected these commitments to be fulfilled. The beginning of real fulfillment wouldn't affect the price anymore as it was already integrated (however a non-fulfillment which is unexpected should trigger another price change). The flat return in 2004 could be explained by that people had expected Russia to accept Kyoto Protocol before this actually happened (it was the opposite case in 2001 for the US and triggered a change of price, as described).

The 2007 marked however a drop of performance compared to the market. The Bali Action Plan brought new information: Future negotiations were planned and other climate-change agreements were expected to be signed. Risks for carbon-intensive companies pressed on.

Although we observe the above-mentioned coincidences which **may imply** an influence of climate change issues on these five carbon-intensive sectors' companies' share prices (the appearance of climate change risks has a negative impact on the stock prices of carbon-intensive companies), we should be **prudent** to arrive on such a conclusion. The movements of share prices can also be due to other events who worked in the same direction.

A more complete and strict analysis can be performed by regressing the share returns on the quantified risk exposure of each sector (for instance regressing annual returns on annually quantified risk exposure).

The quantification of the risk exposure of a sector to the climate change risk is complicated. It

should be related to (and maybe not be limited to) emission levels, emission intensity, emission reduction feasibility and costs, level of regulation, level of management of climate change risks by the sector, etc. A system to synthesize these aspects, allocate reasonable weight to each factor, and quantify each factor is needed to produce a quantified risk exposure. Plus this risk exposure should be dynamic as companies evolve.

By checking the correlation between the share price and the risk exposure variable, and after testing the statistical significance of the correlation, we will be in a better position to conclude on this correlation.

An even better solution should be a multi-factor regression taking into account of other factors affecting the share prices. This can rule out (as much as possible, depending on the completeness of the multi factors) the opposite effects of different factors on the share price, and make each factor's influencing mechanism clearer.

Remarks on each sector

Assuming that the fluctuations of the average performance of the five sectors' shares compared to the market did result, at least partially (we should still be prudent at this stage), from the influence of climate change issues, we can go further for some other analyses and expect more insights that may be of some value.

Taking the average of the five sectors' share performance as a factor indicating the climate change events influence, we step even further and tolerate another bias: the evolution of the average performance (compared to the market) of the five sectors is considered the climate change risk influence itself.

If we allow this bias, by examining the correlations of each sector's performance to the average to the five sectors (as shown in the following table), we can infer the different degrees of sensibility of these sectors to climate change influence. The point to notice is that, this average is dependent on each of the five sectors' performance in our calculation. The regression of each sector's stock return on that of the five-sector average therefore amplifies the correlation coefficients and the r^2 (square of Pearson product-moment correlation coefficient) value. This mechanism is similar to that of a regression of an individual stock return on market return (as this individual stock is

included in the market), during which we however consider the two elements independent. The problem here is related to the fact that we have too few sectors and too little data so this average is too sensible to each sector's data. A better analysis is therefore an analysis with more data of more sectors so as to reduce this sensitivity.

Although facing this limitation, the regression still allows us to compare each sector's relationship with the average:

	Electricity	**Oil&Gas**	**Cns&Mat**	**Airlines**	**Aut&Prt**
Correlation coefficient	0.83	**0.46**	0.81	0.75	0.82
r2	0.70	**0.21**	0.65	0.56	0.67

Correlation coefficients are positive (the statistical significance is not clear yet as the r^2 is amplified due to the reason mention-above). It means there does exist a uniform trend for these five sectors (if correlations are justified as statistically significant).

It worth mentioning that while the other four sectors are having correlation coefficients of equal to or larger than 0.75 to the five-sector average performance (compared to the market), the sector Oil & Gas has a correlation coefficient of only 0.46. And looking at the r^2, we observe that the Oil & Gas sector has a much lower r^2 than the other four. It means the **Oil & gas share returns evolution is less similar to the other four sectors, and the other four sectors are much more positively correlated to each other**.

By taking out Oil & Gas out of the average and checking the correlation between oil & gas and the average of the other four (and therefore eliminating the problem of self-dependence as described above), we can get a closer view of this detection. The correlation of each sector's return with the average of the four sectors (electricity, construction, airlines and automobile) is as following (the other four sectors still have the self-dependent amplification problem):

	Electricity	**Oil&Gas**	**Cns&Mat**	**Airlines**	**Aut&Prt**
Correlation coefficient	0.86	**0.29**	0.79	0.77	0.84
r2	0.75	**0.08**	0.63	0.59	0.70

The correlation coefficient of Oil & Gas to the average of the other four is only 0.29. And doing a regression of oil & gas return on the average of the other four gives an r^2 of only 0.08 (only 8% of the share performance of oil & gas can be explained by the co-movement of the other four sectors). This link is not really statistically significant.

It's not the case for the other four sectors if we do the same process. For example a regression of electricity sector's performance on the average of the construction, airlines and automobile sectors gives an r^2 of 0.54, and the correlation coefficient is 0.73.

This statistical insignificance is important, because if we assume that the other 4 sectors' co-movement captures all climate change influence (although a questionable hypothesis again), we will imply from the insignificance that the oil & gas sector's performance that we see here is NOT correlated to the climate change events, based on the data used in this paper. **A more reasonable implication is that there are some other events that direct the oil & gas shares prices in the opposite direction of that decided by the climate change risks. And these opposite-direction events are not so important for the other four sectors.**

Another finding is that, by comparing the two tables listed above, we can see that ruling the oil & gas out of the calculation improves the calculated correlation coefficient for other sectors (a consequence of the self-dependence problem), except for that of the construction.

Based on the above-proposed implication concerning the oil & gas, it's possible that the construction sector is more influenced (than the other three) by one or more factors (different from climate change) that also influence much the oil & gas.

This finding on the construction sector reveals another limitation of the method, due to the one-factor linear regression: the influences of other factors are not captured, and the calculated coefficient for this "one-factor" is likely to be polluted by one or more other factors.

A more reliable analysis will be a multi-factor regression that identifies as many relevant factors as possible and minimize the ignorance of the "offset" effects of different factors' influence.

However the difficulty for such a multi-factor regression model is the quantification of the climate change risk exposure factor, as explained in the five-sector average analysis. Furthermore, the completeness of the model concerning other possible factors is also a major difficulty. The level of the precision of regression results will be limited, as here, if the multi factors taken into account are not complete to a certain level.

Part IV - Company specific studies

The objective of this part of the paper is to find if there's a positive correlation between a company's carbon management performance and the company's share performance.

Within the same sector and the same market, we consider that the climate change risks facing the companies are at about the same level. What needs to be done is to look at these companies' share performance and check if climate-change-management leaders are doing better than their competitors who are less good at managing carbon related issues.

In order to have a view on the correlation of carbon management and the share performance, it is necessary to quantify the carbon management performance and the share returns. The methodology is to regress the share returns on the carbon management performance and see if there's a statistically significant positive correlation between the two. The regression is performed for each sector.

The share returns are calculated the same way as in the upper part of sectoral analyses. The carbon management performance is however more complicated. We need to look here into some available ratings on the carbon management issues of companies and examine to which degree these ratings can represent the carbon management performance of each company. Data availability for companies is also an issue.

After deciding which rating to use, the regression is performed and the results are analyzed.

Carbon management ratings

CDLI scores

CDLI represents Carbon Disclosure Leadership Index. It's been established by the Carbon Disclosure Project (CDP), along with CDLI scores of individual companies.

The methodology[24] as in the 2008 global500 report includes four sections to evaluate the carbon disclosure and management performance of companies:

- Risks and opportunities

This section values management's awareness and understanding of different kinds of risks and opportunities related to climate change. Scores are given based on how much attention is paid, how specific and deep the understanding is, and whether there're strategies/plans related to the stated awareness to make things happen.

- GHGs emissions accounting

This section examines how direct emissions and electricity-consumption-related emissions are calculated and reported, to which degree management can detail the scope 3 emissions (due to the use of outside services), concerning sources and quantity, and how reliable these accounting processes are (if there's verification or audit process for the information). This part also checks the company's participation (or not) to the EU ETS, and the affect of this participation on the company's economic situation. More detailed answers along with strategies and plans usually show better awareness and governance from the management of climate change risks.

- Performance

This section checks the quality of companies' carbon reduction plans (including targets, periods, projected actions, financial affects, etc.), emission intensity (for instance such ratios as emission/EBITDA) and its management, and projections of future emissions.

- Governance

This section focuses on how climate change related issues are managed inside a company. Issues concerned are the mechanisms of responsibility attribution, performance assessment, etc. This part also checks companies' communication policies; whether and to which degree climate change issues are published, through which channels, and whom the information reaches.

[24] Carbon Disclosure Project report 2008, Global 500, appendix 2, pp 122-126

For carbon-intensive companies the weights for 4 parts are approximately 3:5:5:2, and for non-carbon-intensive companies the weights are approximately 4:4:2:1. Exact weights also take into account the participation to EU ETS. Details are available in the CDP 2008 reports.

Points to be noted concerning this scoring system:

The absolute levels of actual emission levels, emission intensity, reduction achievements and plans are NOT included.

The data, analyses and scores are based on companies' own answers to the CDP questionnaires. The information used here can not be exclusive and is not able to cover other disclosure sources such as companies' own annual reports, environment/social responsibility communications, and presentations/meetings with their different stakeholders.

Incompleteness of data is always a problem for all rating efforts. The Carbon Disclosure Project already provides one of the richest databases for climate change related researches, and it is considered one of the most important information sources for information on enterprises' carbon-related activities.

Emission levels, intensity and reduction plans are surely important to evaluate a company's carbon management performance. If two companies in the same sector having approximately the same emission amounts and intensity present two quantitatively comparable reduction reports and plans, we're likely to favor the one with larger reduction achievement and ambitions.

But today's situation still has a way to go before reaching such a clear and straightforward point.

For most companies, the key points for us to get an idea about their climate change risk behavior still focus on how exclusive and reliable the declared emission amounts are, whether or not a company is participating in a cap and trade system (which only exists in very limited geographies), whether a company plan its emissions and how feasible the planning is, etc. These variables as evaluation tools vary a lot from one company to another, even for those companies on the climate change battle's front line, Europe. These essential aspects provide valuable insights concerning companies' awareness, attitude and so-far achievements.

In short, with several constraints and "shortfalls" of CDLI scores as a complete and effective

evaluation metric for companies' carbon management, the scores do provide much useful information and some insights to get an idea about how climate change is managed in different companies and identify climate leaders in their sectors.

The CDLI scores will serve as indicators of companies' carbon management behavior for studies of this paper, to be compared to companies' stock performances. The objective is to see if there's a correlation between the two factors, whether climate leaders in a sector has their stocks performing better than their lagging-behind competitors.

Climate Change Governance Checklist (CCGC) scores

This CCGC scores system comes from a report (2006) of Ceres[25]: Corporate Governance and Climate Change: Make the Connection[26]. Ceres is an American national network of investors, environmental organizations and other public interest groups. The mission of Ceres is to work together to address sustainability challenges such as climate change issues[27].

This report evaluated 100 companies in 10 carbon intensive industries in America, including four of the five industries that this paper focuses on: Electric power, oil & gas, automobiles, and air transport (except for cement/construction). The criteria are how companies address climate change risk through board oversight, management execution, public disclosure, emissions accounting and strategic planning[28].

Different from the CDLI scores which are based on company replies representing their strategies and practices on a global level, this report mainly examined companies having operations in America, including only 24 non-US companies. And this examination is limited to these companies' behavior inside America. Among the standards of CCGC, the emissions accounting (which is attributed 24% weight in the evaluation) should be largely affected by the accounting standards in the US and the its comparability with accounting practice in other parts of the world (and therefore at a global level) should be somehow limited. This is one reason that CCGC scores are not so appropriate to evaluate European companies' carbon management performance which will be related to these companies stock performance in the European market.

[25] Website: www.ceres.org
[26] Corporate Governance and Climate Change: Make the Connection. March 2006.
[27] www.ceres.org
[28] Executive summary, Corporate Governance and Climate Change: Make the Connection. March 2006. pp 1.

Some other issues are posed at sectoral level. For example, due to the characteristic of the power generation industry, the players in the European market (the focus of this paper) are generally different from those in the US market. This "US" score is therefore not so suitable for European power companies.

Although given these limits, it still worth comparing the CDLI and CCGC scores of the same companies to check how coherent or how different the scores are.

For the air transport CDLI scores are not available, and for the power industry the companies in Europe and America are generally different. The results of the two scoring systems for these two industries are therefore unavailable.

In oil & gas and automobiles industries, six companies of global scale and presence that are studied in this report are listed below, with their 2006 CDLI and CCGC scores:

	2006	
	CDLI	CCGC
BP	95	90
ROYAL DUTCH SHELL	85	79
TOTAL	85	62
BMW	85	35
DAIMLER	75	43
VOLKSWAGEN	70	37

With these quite limited data, if we calculate the correlation coefficient of CDLI and CCGC respectively for the two industries, the oil & gas gives 0.798 whereas automobile gives -0.419 (negatively related at a quite notable level). This might imply two things:

First, CDLI and CCGC scores' evaluations are not so comparable due to their different research objectives. The two scores of the same company reflect different aspects of their carbon management behavior (or, with relatively limited overlaps).

Second, if we suppose that CDLI and CCGC scores do reflect companies' carbon management performance (even though they have some different standards) and should give similar results (positively related with statistical significance), then the two coefficients from the above-mentioned data possibly mean that big oil majors can be roughly compared under the assumption that their carbon management strategy is executed in all their locations with similar importance and results in similar performance, but this assumption doesn't work for car makers.

This finding is coherent with the fact stated in the sectoral analyses in the upper part of the paper: Car makers' business practice varies a lot from one geographical part to another because of clients'

different expectations and preferences: In Europe and Japan people prefer small and fuel-economic cars whereas in US large and heavy cars have a large share of the sales. The CO_2 emissions intensity and carbon management practice also vary from one region to another, especially when we try to compare the Europe and the US. For the companies studies here, their main business are in Europe, while the business in the US is a relatively small part. CDLI scores which evaluate at a global level should represent the main practice of these companies whereas the CCGC scores just evaluate their practice in the US, a small part of their operations, and are less representative. It's not surprising that the two scoring systems give non-coherent results.

Compared to the CDLI scores, CCGC system is less suitable to study European companies and its data are less complete for this purpose.

Carbon Beta™ analytics platform

The carbon beta analytics platform quantifies the carbon risk exposure at company-specific level, covering more than 2000 companies in the world. The evaluation takes into account the emission level, compliance costs (with respect to regulation regimes), and carbon management performance.

While CDLI scores focus on carbon disclosure efforts, the carbon beta platform integrates more dimensions into the evaluation and is more complete to evaluate the carbon risk and management of a company.

This is an evaluation system developed by the Innovest Strategic Value Advisors[29] (now a part of the Riskmetrics Group[30]). The mission of the company is to identify non-traditional resource of risk and return for investors to form up portfolios that out-perform the market. Among the risks and solutions provided by Riskmetrics Group is the sustainability advisory, in which the climate risk management is integrated. These analytics and information are the products and services provided to clients such as institutional investors, governments, universities, research centers, etc and are therefore private.

The most recent results were published by Innovest in March 2009 with the title Carbon Beta and

[29] http://innovestgroup.com/
[30] http://www.riskmetrics.com/

Equity Performance: Understanding Climate Risks & Opportunities[31] (similar researches were also published earlier). According to the carbon beta ratings, climate risk leaders and laggards companies have been identified and their share returns have been compared.

Unable to perform an analysis with the Carbon Beta ratings and stock returns in the studies here, it's still possible to compare the main findings here with those of the Carbon Beta Analytics Platform (see next session correlation analysis).

[31] A documentation of a seminar presentation is available on the company website: www.riskmetrics.com

Correlation Analysis

Companies are analyzed based on their CDLI scores of the period 2006-2008 and their share performance (dividend and split adjusted returns[32]) over the same period.

The carbon disclosure index existed since the year 2004, but for 2004-2005 there were no scores but only the "inclusion" or not of a company in the list of carbon disclosure leaders. These two years' data were not sufficient to perform the following analysis.

For each sector, the correlation coefficient between the stock returns (dividend and split adjusted) and the CDLI scores of this sector's 3-5 companies (listed below) is calculated. A linear regression of stock returns on CDLI score is then performed so as to decide the statistical significance of this detected correlation (by looking at the r^2 of regression results, given by Excel).

The following companies are included in the analysis. They are relatively-large-market-cap companies in the component lists of sector indexes used in the upper part of this paper.

The number of companies studied for each sector ranges from 3 to 5. This number is quite limited, because the companies that are both listed in the components lists of the indexes (as used as sectors' performance indicators in the European market in the upper section of the paper) and in the CDLI scores lists of the reports of CDP for consecutive 3 years (2006-2008) are themselves very limited. Here in this section of the paper the studies are limited to the European market to be consistent with the part of sector exposure studies and to make potential information linkage between the two parts possible so as to provide more insights. More companies should be available if we include the North-American market in the studies for example.

[32] Source: Yahoo! Finance. http://finance.yahoo.com/

Sector	Sector index	Companies
Oil & Gas	DJ STOXX 600 Oil & Gas	BP ROYAL DUTCH SHELL B TOTAL ENI BG GRP
Electricity	DJ STOXX TMI Electricity	ENEL IBERDROLA SCOTTISH & SOUTHERN ENERGY
Constructions	DJ STOXX 600 Construction & Materials	CRH LAFARGE VINCI SAINT GOBAIN HOLCIM
Automobile	DJ STOXX 600 Automobiles & Parts	BMW DAIMLER RENAULT VOLKSWAGEN

Note: The CDLI scores for airlines companies (Air France-KLM, Lufthansa, British Airways and Ryanair, etc) are not available in the CDP reports. So this sector is not included in this section's analysis.

The CDP reports in which CDLI scores are collected are published annually (in September of each year).

The analysis is therefore performed on two horizons:

- Annual

Annual returns of stocks and corresponding annual CDLI scores are used.

As CDLI scores are published in September, stock prices at the beginning of October are used as annual prices to calculate returns.

- Monthly

Monthly returns of stocks are used.

To make CDLI scores at the same horizon, the annual scores are "smoothed" by dividing the annual change by 12 and adding 1/12 of the change to each month's score till it reaches the annual score published in September (which equals the October CDLI score of the report year).

This monthly method integrates more data to calculate the correlation coefficient between stock returns and CDLI scores by taking into account monthly returns. However smoothing the annual

CDLI scores to monthly level is likely to have introduced much noise to the information basis and have therefore lowered the reliability of the results. Whether the exactitude of the correlation is improved compared to the annual method is uncertain. The improvement by more information can be partially or totally offset by the noise-picking smoothing method.

Annual analysis results

- ***Main results***

The correlations between stock returns and CDLI scores calculated for each sector are listed below (see appendix II for complete list of annual returns and CDLI scores for all companies):

Sector	Correlation Coefficient	r2
O&G	0.271	0.073
Electricity	0.601	0.361
Construction	0.356	0.126
Automobile*	0.820	0.673

**: The results here for the automobile industry have excluded the company Volkswagen in the calculation, as the share prices of Volkswagen have been far from normal with returns of about 150% for 2007 and 2008 due to reasons such as acquisition rumors, etc. Excluding Volkswagen gives the results above, while including this company makes the correlation coefficient equal to only* 0.194 *and a corresponding* r^2 *equal to* 0.038.

Positive and statistically significant correlation coefficients should show that better carbon management has positive impacts on companies' share prices and that the stock market appreciates and rewards to a certain degree (depending on sectors and other factors) the good practice to take action to face the climate change risks. This depends on sectors.

Different levels of correlation (shown by the different sectors) mean that the stock market sensitivity to carbon management varies from one sector to another. See the following part "sector-specific insights".

We should recall here that the data with which this analysis is done are very limited (only 3 years CDLI scores and only 3-5 companies for each sector). And the fact that the results are very sensible to the inclusion or exclusion of Volkswagen in the calculation for the automobile industry shows actually this very limitation of the analysis.

A better and more reliably analysis can be performed if we have companies' carbon management

ratings over a longer period (not just 3 years as CDLI scores here). Also, CDLI scores focus on carbon disclosure efforts and achievements, a more complete rating taking into account more factors (such as emission level, intensity, reduction plans, etc., as mentioned above) will be more persuading and improve the quality of the analysis.

The monthly analysis, trying to tackle this problem, is performed after this annual one, but it has another limitation (see the part of monthly results).

- ***Sector-specific insights***

The value of r^2 of in the results means that the correlation is relatively significant for electricity and automobile, insignificant for oil & gas, and not clear for construction (depending on the confidence level required to accept the r^2 of 0.17 as significant).

In the sector exposure analysis, the Oil & Gas industry shows little correlation between stock returns and climate change events, here the Oil & Gas industry also shows little correlation between stock returns and carbon management performance (statistically insignificant with r^2 equals 0.073).

While the other sectors' stock performance is more or less sensitive to carbon management practice, we can possibly understand why oil & gas companies are performing more poorly than the construction and electricity companies concerning carbon disclosure and management (as shown by the CDLI scores): they are not pushed so much toward a better carbon management because their share price simply doesn't take this aspect into account.

For construction, similar to the sector exposure analysis, this sector shows less correlation than the electricity and automobile sectors, indicating that carbon management performance influences the stock performance of construction companies than that of electricity or automobile companies. Only about 12.6% of stock performance of construction companies can be explained by their carbon management performance (compared to 36% and 67% for electricity and automobile industry, respectively).

While showing very similar results in the analysis of industry exposure to climate change events, electricity companies' shares show, surprisingly, much less sensitivity to carbon management performance than those of automobile companies. This is surprising because according to the CDP findings, the electricity (included in the utility sector) is doing better than the automobile

(included in the transport sector) concerning carbon disclosure efforts and related management. This can be seen by checking the average CDLI scores of the companies included in this analysis (77 for electricity and 74.3 for automobile excluding Volkswagen, a relatively small difference though).

These insights are based on the results of the calculation based on the limited data, so we should also be prudent for any conclusion.

Monthly analysis results

The correlations between stock returns and CDLI scores calculated for each sector, based on monthly data, are listed below:

Sector	Correlation Coefficient	r2
O&G	0.033	0.001
Electricity	0.107	0.007
Construction	0.133	0.018
Automobile	0.328	0.108

The correlation coefficients calculated are still positive but the value of r^2 shows that these coefficients are insignificant.

This is likely to be because of the smoothing process of the CDLI scores that picked up much noise into the information and make the monthly CDLI scores having less sense than those annual scores.

A parallel calculation is performed to examine this problem: a regression of monthly share returns on companies' financial leverage[33] has been performed for the Construction and Oil & Gas sector. To be comparable, the annual average (year-end) leverage data were used and a similar "smoothing" process was involved to generate monthly data.

This regression on financial leverage gives for Construction an r^2 of 0.014 (a bit smaller but comparable with the 0.018 for CDLI scores). And the correlation coefficient between stock return and financial leverage is 0.12 (vs. 0.13 for CDLI scores). For Oil & Gas it gives an r^2 of 0.0017 (vs. 0.0011 for CDLI scores) and a correlation coefficient of -0.042 (vs. 0.033 for CDLI scores).

This calculation concludes that the financial leverage is also a factor that has no significant positive correlation with stock monthly return, with comparable level of r^2 (with CDLI scores

[33] Total debt / Common equity. Data source: Thomson One Database.

regression). Furthermore, the signs of the calculated correlation coefficients of stock return and leverage inside construction and oil & gas companies were different (positive for construction and negative for oil & gas). It seems inconsistent with many empirical studies.

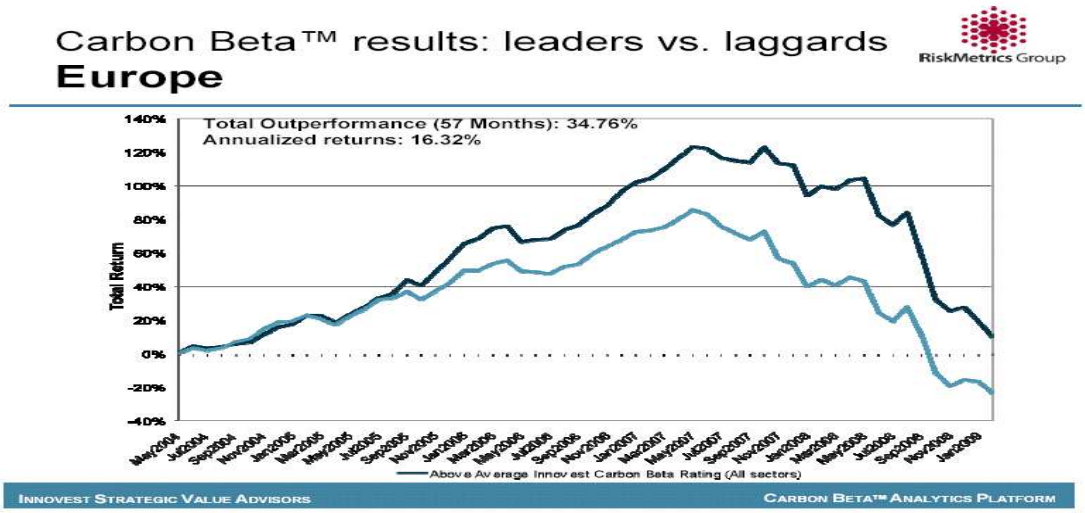
A possibly explanation is that the "smoothing" process hurts much the exactitude of data and makes the regression unreliable.

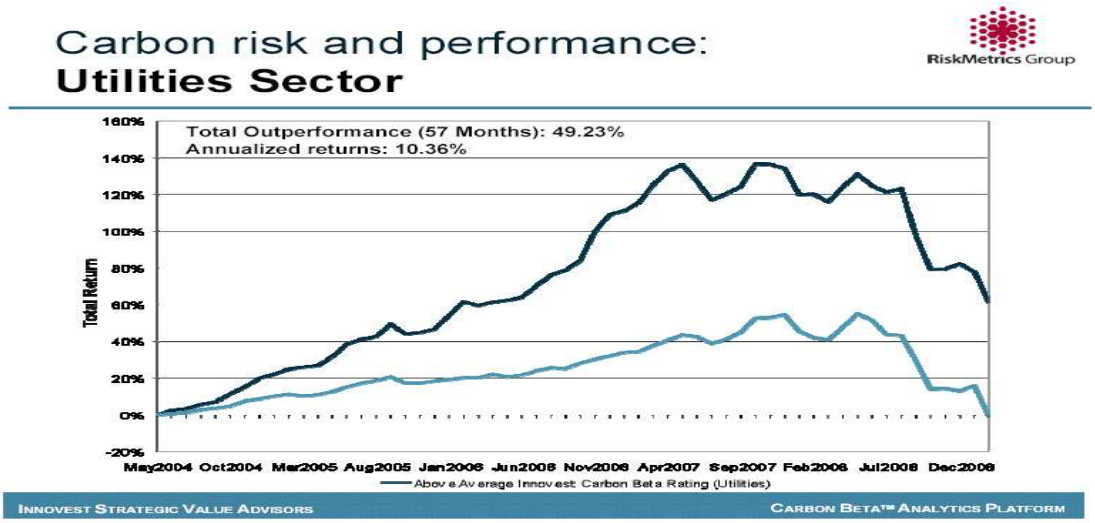
Because of this problem it's difficult to conclude basing on the monthly data analysis.

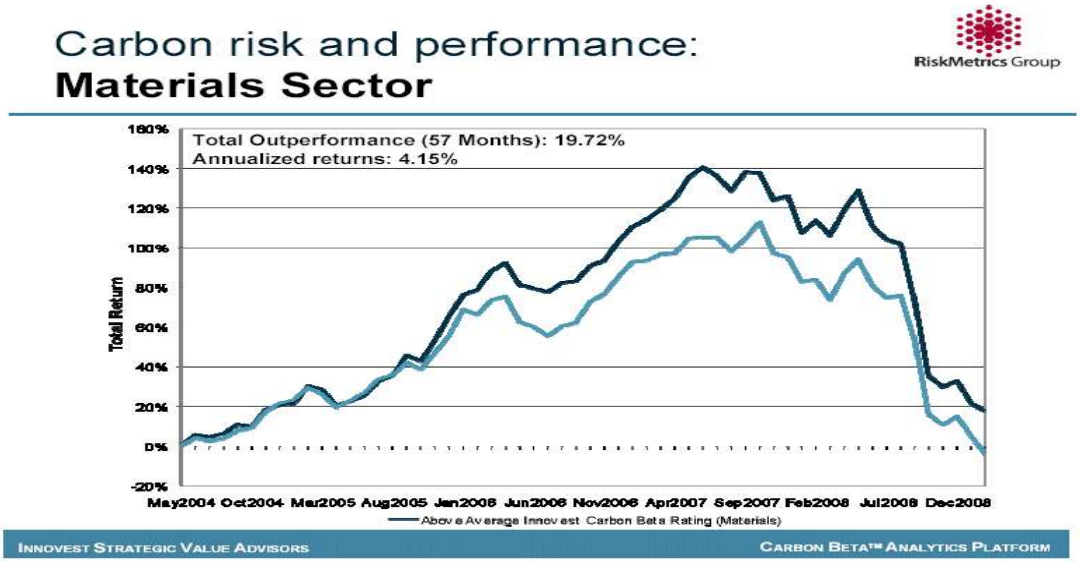
Coherence with the Carbon Beta™ analytics platform results

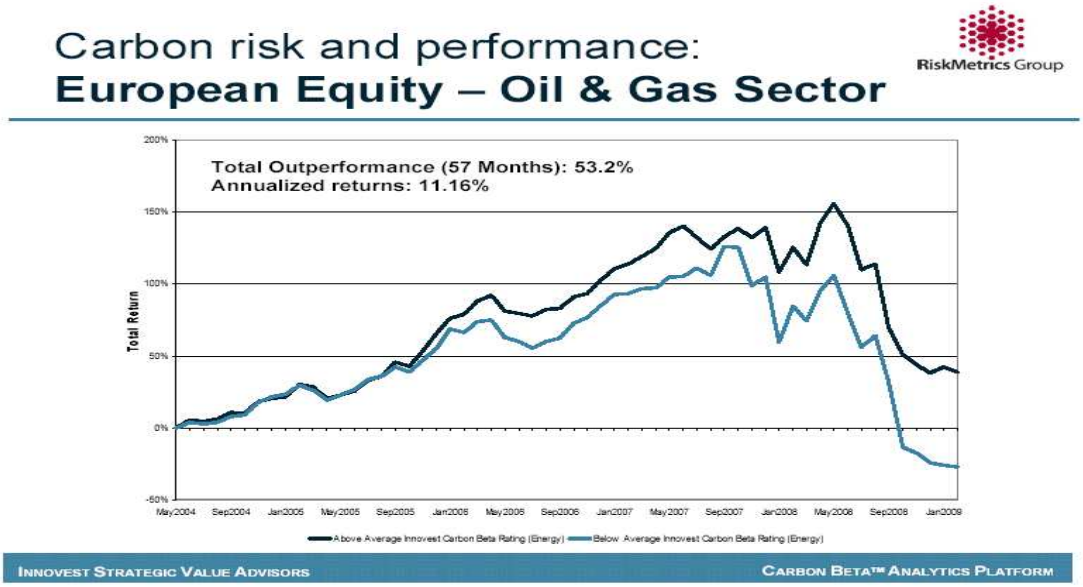
While the exact data about carbon beta ratings are not available for this paper, some main conclusions relating the carbon beta ratings to the share returns of companies are.

In the 2009 March communications of Innovest, some major conclusions concerning share performance of climate risk leaders and laggards (at both global and sectoral level) are:









(Source: Carbon Beta and Equity Performance: Understanding Climate Risks & Opportunities[34]*)*

These results show that climate risk leaders' shares are providing more returns than laggards, for companies in Europe as a whole. This situation is more evident for the utilities sector (in which the Electricity is included) and less evident (but still quite significant) in the materials sector (in which construction is included) and oil & gas sector.

Note also that for utilities and materials the results are at a global level, and for oil & gas it's for European equities.

While "utilities" is larger than electricity and "materials" larger than construction, the results

[34] Seminar presentation of Innovest, March 2009. pp 25-29. Available on the company website: www.riskmetrics.com

shown here are coherent with the findings in this paper: Climate risk leaders have their shares performing better than laggards; the difference is larger for the electricity sector than that of construction.

Innovest's results also show that the European equities in the oil & gas sector are also seeing the climate risk leaders doing better than laggards. In this paper this relationship seems positive but not statistically significant. This fact might be due to data insufficiency.

In all, the results are generally coherent with different levels of significance.

Conclusion

The sectors exposure analysis shows that the climate change issues seem to have negative impacts on carbon-intensive sectors share prices (represented by the electricity, oil & gas, construction, aviation and automobile sectors). However the movements of share prices can also be due to other events who worked in the same direction. A more detailed multi-factor regression model can distinguish influence from different factors and could possibly provide further conclusions.

Oil & Gas sector's stock performance has little correlation with the other four sectors (electricity, construction, aviation, and automobile) while the other four are positively related. Among the four closely-related sectors, Construction is the one that has a closest correlation with Oil & Gas. A possible explanation is that some factors other than climate change have more impact on Oil & Gas (also a bit on Construction) and less on the other three. Again, a multi-factor regression model can help distinguish this or these factors and provide a better picture.

A company-specific regression of stock performance on company' CDLI scores shows different levels of correlation (with different levels of statistical significance) between the two elements for different sectors. The positive relationship is detected for automobile and electricity sectors and not for the oil & gas. The level of statistical significance of the correlation for construction industry is between the two, depending on the confidence level required. However due to the limitation of the availability of data (few companies over a short period of time have been studied), the results might not be reliable enough, and should be improved with an analysis with more data if available. Furthermore, the CDLI scores as a measure of the carbon management performance of companies have some shortcomings. Using a rating that better quantify the carbon management practice can further improve the analyses.

The company-specific findings are in general coherent with the analytics (March 2009) provided by the Innovest Strategic Value Advisors.

Appendix

Appendix I

European market and five carbon-intensive sectors' annual stock returns (dividend and split adjusted) compared to the market[35]:

	Electricity	Oil&Gas	Cns&Mat	Airlines	Aut&Prt	Average
Dec-92	-0.4%	-9.3%	-14.9%	-21.0%	-18.2%	-12.8%
Dec-93	18.2%	2.7%	14.0%	25.5%	15.3%	15.1%
Dec-94	0.4%	5.5%	-1.7%	2.5%	10.8%	3.5%
Dec-95	2.9%	-1.4%	-26.1%	-4.6%	-22.9%	-10.4%
Dec-96	3.3%	11.9%	-8.7%	-7.5%	1.1%	0.0%
Dec-97	-16.2%	-5.5%	-23.6%	-9.7%	-17.1%	-14.4%
Dec-98	-1.8%	-33.1%	-18.0%	-26.8%	-3.8%	-16.7%
Dec-99	-51.9%	1.3%	-6.4%	-32.5%	-40.2%	-25.9%
Dec-00	13.0%	5.8%	-1.3%	16.6%	-13.1%	4.2%
Dec-01	9.5%	16.6%	18.9%	-15.1%	19.3%	9.8%
Dec-02	11.3%	15.9%	4.5%	6.0%	5.4%	8.6%
Dec-03	2.9%	-8.9%	14.8%	6.2%	13.5%	5.7%
Dec-04	21.5%	7.5%	18.0%	-16.6%	-3.9%	5.3%
Dec-05	1.2%	10.1%	10.2%	12.6%	-1.3%	6.5%
Dec-06	31.3%	-6.7%	24.7%	33.4%	14.3%	19.4%
Dec-07	18.1%	7.9%	-2.4%	-22.5%	23.7%	4.9%
Dec-08	3.6%	3.8%	-4.7%	-5.5%	-2.0%	-1.0%

[35] Sector's share return minus market return.

Appendix II

Complete list of annual stock returns and annual CDLI scores of companies analyzed in the company specific analysis:

Oil & Gas

		Annual Return	CDLI
BP	2008	-18.8%	64
	2007	7.2%	90
	2006	-2.3%	95
ROYAL DUTCH SHELL B	2008	-20.8%	68
	2007	11.6%	65
	2006	1.9%	85
TOTAL	2008	-20.2%	64
	2007	8.5%	90
	2006	359.2%	85
ENI	2008	-22.0%	68
	2007	11.8%	85
	2006	8.9%	65
BG GRP	2008	2.6%	65
	2007	27.9%	70
	2006	40.2%	75

Construction

		Annual Return	CDLI
CRH	2008	-32.2%	53
	2007	-3.1%	75
	2006	34.8%	75
LAFARGE	2008	-64.8%	66
	2007	9.4%	75
	2006	58.6%	70
VINCI	2008	-49.0%	57
	2007	169.3%	65
	2006	37.9%	60
SAINT GOBAIN	2008	-59.4%	44
	2007	30.8%	50
	2006	29.6%	65
HOLCIM	2008	-48.5%	59
	2007	23.2%	70
	2006	35.7%	80

Electricity

		Annual Return	CDLI
ENEL	2008	-32.4%	58
	2007	16.8%	70
	2006	22.7%	75
IBERDROLA	2008	-47.7%	82
	2007	455.4%	100
	2006	72.0%	85
SCOTTISH & SOUTHERN ENERG'	2008	-22.0%	78
	2007	18.4%	90
	2006	34.1%	55

Automobile

		Annual Return	CDLI
BMW	2008	-56.5%	60
	2007	4.1%	70
	2006	25.9%	85
Daimler	2008	-63.6%	61
	2007	75.1%	90
	2006	6.6%	75
Renault	2008	-78.2%	73
	2007	30.4%	75
	2006	30.2%	80

References

1. "Climate change 2007: Synthesis Report", Fourth Assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), 2007.
2. "Climate change related risks and company ratings", Germanwatch discussion paper, January 2004.
3. "Climate Change 101: Understanding and Responding to Global Climate Change", the Pew Center on Global Climate Change and the Pew Center on the States.
4. "World Energy Outlook 2008", International Energy Agency (IEA), 2008.
5. "Carbon Disclosure Project 2005" (CDP3), Carbon Disclusure Project, 2005.
6. "Carbon Disclosure Project Report 2006 Global FT500" (CDP4), Carbon Disclusure Project, 2006.
7. "Carbon Disclosure Project Report 2007 Global FT500" (CDP5), Carbon Disclusure Project, 2007.
8. "Carbon Disclosure Project Report 2008 Global 500" (CDP6), Carbon Disclusure Project, 2008.
9. "Corporate governance and climate change: making the connection", summary report, Ceres, March 2006.
10. "The risk intelligent energy company – weathering the storm of climate change", *Risk Intelligence Series, issue No. 7*. Deloitte. 2007.
11. Rothstein Benno; Mimler Solveig; Müller Ulrike and Ottenschläger Lars, 2007. "Climate Sensitivity of the Energy Sector, Weather Risks and Adaptation to Climate Change", Forum DKKV/CEDIM: Disaster Reduction in Climate Change 15./16.10.2007, Karlsruhe University.
12. "Tracking Industrial Energy E.ciency and CO_2 Emissions", International Energy Agency (IEA), 2007.
13. Claudia Kruse, IIGCC (International Investors Group on Climate Change) Briefing Note "Climate Change and the Construction Sector", ISIS Asset Management, June 2004.
14. Duncan Austin and Amanda Sauer, "Car Companies and Climate Change: Measuring the Carbon Intensity of Sales and Profits",

http://earthtrends.wri.org/features/view_feature.php?theme=5&fid=53

(Adapted from the Chapter Three of Duncan Austin, Niki Rosinski, Amanda Sauer, Colin Le Duc. 2003. "Changing Drivers: The Impact of Climate Change on Competitiveness and Value Creation in the Automotive Industry". World Resources Institute and WRI and Sustainable Asset Management (SAM). October 2003.)

15. "Carbon Beta™ and Equity Performance: Understanding Climate Risks & Opportunities", seminar presentation of Innovest, March 2009. pp 25-29. Available on: www.riskmetrics.com
16. "Carbon Beta™ and Equity Performance: An Empirical Analysis – Moving from Disclosure to Performance", Innovest, October 2007. Available on: www.riskmetrics.com
17. Aaron K. CHATTERJI, David I. LEVINE and Michael W. TOFFEL, "How Well Do Social Ratings Actually Measure Corporate Social Responsibility?", Journal of Economics & Management Strategy, Volume 18, Number 1, Spring 2009, 125–169
18. Meir Statman and Denys Glushkov, 2008. "The wages of social responsibility", working paper, November 25, 2008.
19. Dan di Bartolomeo and Lloyd Kurtz, 1999. "Managing Risk Exposures of Socially Screened Portfolios", Northfield Information Services. www.northinfo.com/documents/63.pdf
20. Michael V. RUSSO and Paul A. FOUTS, "A Resource-based Perspective on Corporate Environmental Performance and Profitability", Academy of Management Jaumal, 1997, Vol. 40, No. 3, 534-559.
21. European Commission website. http://ec.europa.eu/environment/climat/home_en.html
22. The Pew Center on Global Climate Change website: www.pewclimate.org