HELSINKI UNIVERSITY OF TECHNOLOGY
Department of Industrial Engineering and Management
Laboratory of Development and Management in Industry

Eeva Maria Lappalainen

RISK MANAGEMENT STRATEGIES AND PRACTISES IN RESPONSE TO THE EUROPEAN UNION EMISSIONS TRADING SCHEME

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology.

Espoo, 9 August 2006

Supervisor: Professor Tuula Pohjola
Instructor: Timo Linnainmaa, M.Sc. (Technology)

ABSTRACT

Author: Eeva Maria Lappalainen		
Subject of the thesis: Risk Management Strategies and Practises in Response to the European Union Emissions Trading Scheme		
Number of pages: 91 + 18	**Date:** 08/09/2006	**Library location:** TU
Professorship: Environmental and Quality Management		**Code of professorship:** TU-117
Supervisor: Professor Tuula Pohjola		
Instructor: Timo Linnainmaa, M.Sc. (Technology)		

Human-induced climate change and its impacts are considered to be one of the most threatening phenomena to environmental, social, and economic wellbeing on Earth. These threats are currently well recognised and several international climate change mitigation efforts have taken place. Among these efforts is the Kyoto Protocol – a treaty that introduced legally-binding emission targets to major industrialised countries. To comply with its target, the European Union (EU) established an Emissions Trading Scheme (EU ETS) obliging some 11,500 emitting installations in the EU area to cover their yearly carbon dioxide emissions with tradable allowances (EU Allowances, EUAs).

This thesis provides an in-depth understanding of companies' strategies and practises when managing the risks introduced by the EU ETS. First, an exhaustive insight into climate change regulatory framework, risks and risk management techniques, and market organisation was detailed in the literature review part of the thesis. The current risk management strategies and practises were then mapped through a web-based survey sent to 192 companies in the EU area. Data from the 47 approved responses were analysed with small-scale content analysis (qualitative data) and by forming shares and distributions of the quantitative data.

The thesis results revealed a great degree of variety in the EU ETS risk management strategies and practises that companies were using. Generally, nearly all companies considered managing risks related to the EU ETS to be important; three quarters of the respondent companies had established an own EU ETS risk management strategy and one tenth used their general risk management strategy. The selected strategies usually contained the persons responsible for EU ETS affairs, and the nature of trading. The level of EU ETS risk management activities, though, differed between companies. Half of the companies supported their risk management by using portfolio analysis, or by constructing price or market models. Additionally, the use of financial instruments was generally more extensive in bigger companies. The risk management practises related to the EU ETS concentrated mainly on minimizing the impact that the EU ETS has on companies, and on following a few of the basic compliance strategies – EUA trading, internal abatement, and investments in emission reduction projects or carbon funds – available.

Keywords: Risk management, risk, EU ETS, climate change regulatory framework	**Publishing language:** English

TIIVISTELMÄ

Tekijä: Eeva Maria Lappalainen		
Työn nimi: Riskienhallintastrategiat ja -menetelmät liittyen Euroopan Unionin päästökauppaan		
Sivumäärä: 91 + 18	**Päiväys:** 9.8.2006	**Työn sijainti:** TU
Professuuri: Ympäristö- ja laatujohtaminen		**Koodi:** TU-117
Työn valvoja: ma. Professori Tuula Pohjola		
Työn ohjaaja: Diplomi-insinööri Timo Linnainmaa		

Tänä päivänä ehkä merkittävimmät uhat maapallon ja sen asukkaiden hyvinvoinnille liittyvät ilmastonmuutokseen ja sen vaikutuksiin. Ilmastonmuutoksen torjuntaan onkin kiinnitetty jo pitkään huomiota, ja sen edistämiseksi on solmittu useita kansainvälisiä, päästöjen vähentämiseen tähtääviä sopimuksia. Sopimuksista keskeisin, Kioton Pöytäkirja, asetti merkittävimmille teollisuusmaille sitovat päästöjen vähennystavoitteet. Oman Kioton tavoitteensa noudattamiseksi Euroopan Unioni (EU) päätti aloittaa päästökaupan vuoden 2005 alussa. EU:n Päästökauppa velvoittaa noin 11 500 EU:n alueella toimivaa teollisuuslaitosta kattamaan vuosittaiset hiilidioksidipäästönsä vapaasti kaupattavilla päästöoikeuksilla (EU Allowance, EUA).

Tämän diplomityön tavoitteena oli tuottaa tietoa yritysten riskienhallintastrategioista ja niihin liittyvistä menetelmistä EU:n päästökaupassa. Työn aluksi esiteltiin kirjallisuuskatsauksessa ilmastonmuutoksen hallintaan liittyvä lainsäädännöllinen viitekehys, päästökauppaan liittyvät riskit ja riskienhallintamenetelmät sekä nykyiset päästökauppamarkkinoiden käytännöt. Työn empiirinen aineisto kerättiin kyselytutkimuksella, jossa sähköinen kyselylomake lähetettiin 192 yritykselle EU:n alueella. Saadut 47 vastausta analysoitiin pienimuotoisella sisällönanalyysillä (kvalitatiivinen) sekä muodostamalla osuuksia ja jaotteluja kvantitatiivisesta datasta.

Diplomityön tuloksena havaittiin selvää hajontaa yritysten päästökaupan riskienhallinnan strategioissa ja menetelmissä. Yleisesti ottaen lähes kaikki yritykset pitivät päästökauppaan liittyvää riskienhallintaa tärkeänä. Kolmella neljäsosalla yrityksistä oli käytössä oma riskienhallintastrategia päästökaupan kohdalla ja yksi kymmenesosa käytti yrityksen yleistä riskienhallintastrategiaa. Yritysten valitsemat strategiat sisälsivät tavallisesti ainakin maininnat vastuullisista henkilöistä sekä kaupankäynnin luonteesta. Riskienhallinnan menetelmät puolestaan erosivat yritysten välillä. Esimerkiksi vain puolet yrityksistä käytti portfolioita riskienhallinnassaan tai muodosti malleja markkinoista ja hinnoista. Lisäksi riskienhallintaan liittyvien johdannaisten käyttö oli yleisempää suuremmissa yrityksissä. Yritysten EU:n päästökauppaan liittyvä riskienhallinta keskittyi pääasiassa päästökaupan aiheuttamien vaikutusten minimoimiseen sekä muutamien perusstrategioiden – kaupankäynti päästöoikeuksilla, sisäiset päästöjen vähennystoimenpiteet sekä sijoitukset päästövähenemäprojekteihin tai hiilirahastoihin – noudattamiseen.

Avainsanat: Riskienhallinta, riski, Euroopan Unionin päästökauppa, ilmastonmuutoksen hallinnan lainsäädännöllinen viitekehys	**Julkaisukieli:** Englanti

FOREWORD

During the past few years I have become more and more interested in sustainability issues and their value within companies and organisations. Therefore, I was delighted to have the chance to write my Master's thesis on a topic combining sustainability with company strategies. Having now finalised my thesis, I am glad of the chance to pursue further research in the same topic. Many thanks must go to those people who made my thesis possible and supported me throughout the writing process.

First of all, I would like to thank my instructor, Mr. Timo Linnainmaa, for giving me the opportunity to work in such an exciting area. Additionally, I would like to thank Professor Tuula Pohjola for her continuous support and feedback when supervising my thesis. I would also like to thank all of the members of the Market Analysis and Risk Management of EU Emissions Trading (MARMET) project group for giving me invaluable feedback and advice for my thesis.

Special thanks should also be dedicated to the members of the Environmental and Quality Management Unit at the Helsinki University of Technology for creating a fun and supportive environment in which to work. I would especially like to thank Anna for all of her ideas and advice regarding this thesis.

I would also like to thank my boyfriend and part-time proofreader, Tom, for his patience and advice when I was writing the thesis. All of my friends and family also deserve many thanks for making me remember the importance of having fun and relaxing.

Espoo, August 2006

Eeva Lappalainen

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

The Earth absorbs energy through radiation from the Sun. This energy is further redistributed by the atmospheric and oceanic circulations, and eventually radiated back to space. (IPCC, 2001a) A key element of this process is the Earth's atmosphere. Radiation from the Sun passes through easily, but the atmosphere stops thermal radiation reflected from the Earth's surface, thus warming the Earth. (UNFCCC, 2006a) This process, the greenhouse effect, is a necessity for life on planet Earth: it is estimated to raise the average temperature by 30 ºC (IPPC, 2001a).

Carbon dioxide (CO_2) from burning of coal, natural gas, and oil together with increased methane and nitrous oxide from farming have supplemented the natural levels of these gases in the atmosphere. (UNFCCC, 2006a) During the last century, the concentration of atmospheric greenhouse gases and aerosols has increased substantially, altering the sensitive radiation balance of the atmosphere. This has lead to an enhanced greenhouse effect – temperatures on Earth have risen and affected the climate. (IPCC, 2001a) Climate change and its impacts are considered to be some of the most threatening phenomena to environmental, social, and economic wellbeing on Earth. There is already evidence that for instance the frequency of floods and droughts in some areas has increased, and, thus, affected the social and economic systems of these areas. (IPCC, 2001b)

The threats posed by the climate change are currently well recognised and several international efforts have been taken to mitigate the change and its impacts. The main motivator has been the United Nations and its global climate change treaty, the United Nations Framework Convention on Climate Change (UNFCCC). The Convention, approved in 1992, initiated the efforts to reduce climate change, as well as to adapt to whatever increases in temperature that may follow. The Convention was further strengthened when the Kyoto Protocol was agreed in 1997. The Protocol introduces "individual, legally-binding targets to limit or reduce" the greenhouse gas emissions of major industrial countries. According to the Protocol, the European Union (EU) is obliged to reduce its greenhouse gas emissions by 8 % from the 1990 levels. (UNFCCC, 2006a) To comply with these emission reduction targets, the EU

established an emissions trading programme to reduce the emissions in its area in a cost-effective and economic way. The programme, the European Union Emissions Trading Scheme (EU ETS), started in January 2005, and has since obliged some 11,500 industrial installations in the EU area to cover their yearly CO_2 emissions with tradable allowances (European Union Allowances, EUAs). (EU, 2006)

The advent of the EU ETS has introduced several new challenges that companies need to face. Companies are required to set up monitoring systems and control practises, to develop a view on future market trends, and even to incorporate costs of emissions and tradable allowances into their accounting and risk management practises. Additionally, the fluctuating prices of the allowances create short-term market risk, and therefore influence investment decisions. Uncertainties related to long-term climate policy, on the other hand, enhance the business risks that companies face. To control all this, companies need to develop a strategy to cover and manage all aspects of emissions trading and its risks. (Kaminski, 2004)

At the moment, knowledge of the risk management strategies and practises at companies' disposal when managing the risks that the EU ETS pose is relatively scarce. This thesis aims to map the state of risk management for EU ETS within companies complying with the EU ETS, as well as finding the differences between traditional risk management and the EU ETS risk management. This thesis is conducted as a part of a bigger research project, Market Analysis and Risk Management of EU Emissions Trading, which concentrates on both modelling the prices of the new financial instruments that the EU ETS has created, and on constructing a risk management model for companies under the EU ETS.[1]

1.2 PROBLEM FORMULATION

The purpose of this thesis is to increase the understanding of companies' risk management strategies and practises for EU ETS. The main research problem addressed by this thesis is thus formulated as: What are the different risk management strategies and practises companies are using for the EU ETS?

[1] More information can be found at: http://www.mm.helsinki.fi/mmtal/ye/pomar/marmet.html

The main research problem is approached through the following sub-problems:

- Do companies have risk management strategies for EU ETS?
- How do companies assess and manage the risks EU ETS is posing?
- Do risk management strategies and practises for the EU ETS differ from the traditional risk management strategies and practises that companies are using?

1.3 Objectives of the Thesis

The main objective of this thesis is to give a comprehensive insight into the risk management related to the EU ETS and the climate change regulatory framework. Therefore, this thesis will:

- Give a detailed overview of the regulatory framework of controlling global climate change and its mitigation efforts,
- Give an extensive introduction to the different risk management strategies and practises available for companies' disposal,
- Outline the market organisation, trading practises, and the new financial assets introduced by the EU ETS, as well as
- Highlight and evaluate the most used EU ETS risk management strategies and practises.

1.4 Scope of the Thesis

The scope of this thesis is limited within the companies operating under the EU ETS framework. Thus, the companies that will be researched have some part of their operations regulated by the EU ETS. No other limitations are set to ensure the diversity of the data set and data analysis.

1.5 Definitions and Abbreviations

This thesis employs several important terms and definitions. These are presented in the following chapters in alphabetical order. Abbreviations of the commonly used terms are presented in *Appendix 1 Abbreviations*.

Climate change. This thesis follows the definition of climate change of the UN (1992) and defines it as "a change of climate which is attributed directly or indirectly to human activity". Due to climate change, the composition of the Earth's atmosphere is permanently altered.

Emissions. In this thesis, emissions are defined as "the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time" (UN, 1998). Thus, emissions only include those of greenhouse gases, and exclude e.g. waste and solid emissions.

Risk. Risk as a concept generally comprises of the potential negative impact on an asset of value that may arise from some present or future event. Risk is a function of the probability of an event taking place and the impact that the event would have. This thesis follows this concept and defines risk as "the exposure to a proposition of which one is uncertain". (Holton, 2004)

Risk Management. In this thesis, the concept of risk management is limited to cover only the premises of corporate risk management. Risk management therefore entails the measuring, assessing, and managing of risks related to corporate activities with the primary goal of eliminating the probability of costly outcomes; particularly those that could cause financial distress or make the company unable to carry out its strategies (Stulz, 1996). Managing risks enables the companies to preserve or create value by selecting optimal management strategies, methods, and instruments (Wang, 2001).

Risk Management Strategy. The definition of a risk management strategy in this thesis includes all of the basic strategic decisions, which every risk manager addresses. These decisions include, for instance, the degree of risk assumed, the use of centralized and decentralized risk management programs, as well as decisions about risk management practises. (Schmit & Roth, 1990)

Risk Management Practise. In this thesis, a risk management practise is defined as containing all of the measures and procedures taken to manage risks related to the EU ETS.

1.6 RESEARCH METHODOLOGY

This thesis employs both explorative and descriptive research approaches. An explorative approach is used during the literature review of theories related to both emissions trading and risk management. The aim of this explorative research is to gather qualitative data in order to better understand the topic under study. The rest of the thesis employs descriptive research approach. The objective of this descriptive part is to give an accurate image of the researched phenomenon by gathering reliable and accurate data. (Järvenpää & Kosonen, 2000; Kyrö, 2004)

The research methods used in this thesis, literature review and survey questionnaire, are qualitative. Additionally, a small-scale bibliometric review is conducted to support the information retrieval of the literature review. Quantitative methods, including distributions and shares, are used in the data analysis.

The research methods together with the underlying research methodology are explained in detail in *Chapter 2 Research Methodology and Methods*.

1.7 STRUCTURE OF THE THESIS REPORT

This thesis report is divided into five sections. In the introductory section the background of the thesis is presented together with the research gap and research interests. Further, the objectives of the thesis are introduced, and the research problems are formulated. The second section lists the research methods used in this thesis in detail, as well as introduces the data collection and analysis processes. Section three, which follows, contains the literature review introducing the underlying theory of the climate change regulatory framework and outlining the theory of risk management. The survey results are set out in section four together with research findings and discussion. Section five concludes this thesis report.

2 RESEARCH METHODOLOGY AND METHODS

2.1 RESEARCH METHODOLOGY

The research methodology of this thesis follows both explorative and descriptive research approaches. The purpose of explorative research is to gather data (mainly qualitative data) in order to increase the depth of understanding of the topic that is being researched. Explorative research is often used prior to conducting more in-depth and exhaustive quantitative research. (Järvenpää & Kosonen, 2000; Kyrö, 2004) In this thesis, the explorative research approach is the underlying methodology when reviewing the theories related to the climate change regulatory framework and companies' risk management strategies and practises. The explorative research approach was selected as it was felt to support the information gathering objectives of this thesis – mapping the possible risk management strategies and practises – and to help when conducting the empirical part of this thesis.

The empirical part of this thesis employs a descriptive research approach. Descriptive research aims to give an accurate image of the phenomenon that is being studied. The research methods related to this approach strive to gather as reliable and accurate data as possible to support the depiction of the studied item. Descriptive studies are usually set in a certain, limited time frame; cross studies depicting the situation at one point in time are common. (Järvenpää & Kosonen, 2000; Kyrö, 2004) The descriptive research approach was believed to offer several benefits for the construction and conduct of the empirical research part of this thesis. The approach was seen very useful, as the topic of the thesis is somewhat novel and prior similar research is lacking.

2.2 DATA COLLECTION

2.2.1 SECONDARY DATA SOURCES

The secondary data sources of this thesis consist mainly of the literary sources gathered for the literature review. These data sources were collected largely from the journal and article databases in the disposal of Helsinki University of Technology. Suitable data sources were first searched with keywords such as "risk management", and "emissions trading" through the search functions offered by these databases. The search results were then evaluated and the final literary data sources selected. In

addition, a small-scale bibliometric review (please see *Chapter 2.2.3 Bibliometric Review*) was conducted when selecting the articles and sources of theories related to risk management. This improved and validated the data selection process within the risk management discipline; an initial examination of the general risk management topic revealed over 4,000 relevant articles. The bibliometric review was limited to the theories of risk management, as the literary sources related to climate change regulatory framework were more straightforward and easy to obtain.

In addition to traditional literary sources, some Internet sources were used when reviewing the literature. Websites and documents published in the Internet were reviewed especially when looking for information about the regulatory frameworks related to climate change and the EU ETS. Internet sources were used, when they were felt to be sufficiently reliable, as they are often the best and most contemporary sources of official information about climate change and its regulatory framework.

The selected data sources cover theories of the climate change mitigation and its regulatory framework, as well as of the risk management discipline. Sources emphasize the new challenges that the EU ETS has introduces, and the risk management strategies and practises needed to hedge the impacts caused by these new challenges. The majority of these selected secondary data sources are presented and reviewed in *Chapter 3 Literature Review*. Some of the Internet sources, mainly information obtained from the official websites of the EU and the EU Member States, are also used in the primary data collection phase (please see *Chapter 2.2.2 Primary Data Sources*).

Additional secondary data was gathered through participation in three seminar days, two workshops, and one conference which all had emission trading related topics. Participation in these events provided in-depth background information on emissions trading in general and on the EU ETS. These events helped the author to familiarise herself with the thesis topic, and assisted in the formulation of the research problems and objectives. Further secondary data was also collected through conversations with the research colleagues of the author and EU ETS specialists. These conversations mainly supported the formulation and design of the survey questionnaire; useful advice and feedback to the questionnaire and its usability was received.

2.2.2 PRIMARY DATA SOURCES

The primary data for this thesis was collected through a web-based survey conducted between March and June 2006. The survey was sent to 192 companies in the EU area. 54 responses were obtained of which 7 responses were partial, and were thus deleted before the data analysis. The overall response rate of the survey was 28.1 %, dropping to 25 % after partial responses were excluded.

2.2.2.1 SAMPLE SELECTION

All the companies to which the survey was sent were within the scope of this thesis, in that they had obligations under the EU ETS. To ensure this, the companies were drawn from the individual NAPs of the 25 EU Member States. The allocation plans were first downloaded from the official EU ETS website of the EU, and completed, when needed, from the official websites of the Member States themselves. All the allocation plans were obtained in December 2005.[2]

After the NAPs were obtained, the companies were first rated and selected according to their industry and the size of their installations. After this, these initially selected companies were contacted in order to get the accurate contact details of a person responsible for EU ETS affairs. A maximum of 70 companies per one EU Member State were selected for this initial contact phase; in most cases only 5-20 companies were contacted from one Member State. As the majority of the installations under the EU ETS are engaged in energy activities, the majority of these initially selected companies were energy producers.

The contact details of the person responsible for EU ETS and its risk management were obtained through several ways: using the lists of participants in seminars and conferences related to EU ETS and energy risk management, contacting the company in question via e-mail enquiry or phone call, as well as gathering referrals from EU ETS specialists and research colleagues of the author. Due to the often-incomplete information about the installations and operators that was available, a majority of the companies were first approached via e-mail or through the contact forms on the

[2] In December 2005, the EC had approved NAPs of all the EU Member States at least conditionally.

website of the companies. Altogether 386 enquiries were sent, from which 107 responses were obtained. A further 27 pieces of contact information were later obtained through phone conversations. The rest of the contact details (71 pieces) were obtained from the lists of participants and referrals. After the initial company selection, the emphasis on energy companies was diluted in order to ensure the diversity of responses and risk management needs. Additionally, companies from all the EU Member States and of all sizes were selected. The company selection was finalised after majority of the contact details had been gathered; then companies that were seen to be interesting and important data sources were contacted via phone.

In total 205 pieces of contact information were obtained during the contact phase. Of these, contact details 13 were excluded due to a change of employee or changes related to the companies' holdings. Approximately one fourth of the selected companies with proven contact details were Finnish. This was intended to enable comparison between Finland and the rest of the EU Member States, and thus, to improve the detection of differences between the two. Additionally, as the research was conducted in Finland, it was easier to contact Finnish companies.

The selected companies according to the EU Member States are presented in *Table 1* together with the shares of energy companies among the selected companies.[3]

Table 1 Selected Companies According to EU Member States

Member State	Selected Companies	Energy Companies		Member State	Selected Companies	Energy Companies	
Austria	11	5	45%	Latvia	4	2	50%
Belgium	5	1	20%	Lithuania	3	3	100%
Czech Republic	5	3	60%	Luxembourg	1	0	0%
Cyprus	2	1	50%	Malta	1	1	100%
Denmark	11	3	27%	Netherlands	3	3	100%
Estonia	2	1	50%	Poland	4	2	50%
Finland	56	32	57%	Portugal	4	1	25%
France	10	4	40%	Slovak Republic	3	1	33%
Germany	11	5	45%	Slovenia	3	1	33%
Greece	4	2	50%	Spain	6	3	50%
Hungary	4	2	50%	Sweden	12	8	67%
Ireland	6	3	50%	UK	15	9	60%
Italy	6	2	33%				
Total	**192**	**98**	**51%**				

[3] The division according to the EU Member States is done based on the individual NAPs. Companies that were mentioned in multiple NAPs were marked under their assumed domicile. Also, the shares of energy companies include only those companies that have energy production as their main industry.

2.2.2.2 SURVEY QUESTIONNAIRE

The survey questionnaire used in this thesis was built to reflect the main points and implications derived during the literature review. Additionally, an interview questionnaire on the EU ETS and its risk management used by three research colleagues of the author was studied and benchmarked. Web-based survey software, SurveyMonkey[4], was used, when designing and sending the survey questionnaire. The software was used, as it provided advanced design features for surveys, and enabled the construction of databases and e-mailing lists. The survey software also allowed direct collection of the survey responses in spreadsheet form.

The questions of the survey questionnaire concentrate on the main themes listed in the problem formulation of this thesis – risk management strategies and practises that companies are using, as well as their assessment of the risks and uncertainties related to EU ETS. Additionally, a series of background questions were included to enable categorisation of the data during the analysis phase. The questionnaire is divided into six different categories around these main themes. These categories are: background information, EU ETS operations, risk management strategies, risk management practises, the role of carbon funds and CDM/JI projects, and uncertainties related to EU ETS. The survey questions aim to indicate the level of EU ETS activities and risk management practises within the companies. Included questions were either open-ended, aiming to provide qualitative data, or required a choice of given options. Some questions with multiple selection options were also included. The final survey questionnaire is presented in *Appendix 2 Survey Questionnaire*, and the reasoning behind the selected themes and questions in *Appendix 3 Survey Themes*.

Before sending the final survey questionnaire, it was first tested by the research colleagues of the author, and then sent to four company representatives for final testing. The questionnaire was then modified according to the feedback obtained, mainly by decreasing the amount of qualitative, open-ended questions, as well as improving the general clarity and usability of the questionnaire. The survey questionnaire was sent as a link via e-mail to the contact persons in the database.

[4] http://www.surveymonkey.com

2.2.3 BIBLIOMETRIC REVIEW

2.2.3.1 BIBLIOMETRIC RESEARCH METHODOLOGY

A major part of a review article is supported by citations, and the bibliography pointing to cited publications is central to the validity of any research paper (Weinstock, 1971; in Smith, 1981).[5] Through their bibliographies, scholarly journals and articles provide a significant information source regarding the structure and changes of a scientific literature; the aim of bibliometrics is to examine these changes and map the structures of scientific disciplines (Ramos-Rodríguez & Ruíz-Navarro, 2004; McCain, 1988). Bibliometrics, therefore, involves counting citations to other publications in a body of literature whilst using these counts to develop statistical distributions and clusters (Culnan, 1987). The bibliometric approach relies on the belief that journal publishing represents the core of scientific communication. Additionally, it is assumed that a certain positive correlation between the number of citations and the quality of work exists. (Osareh, 1996)

Bibliometric studies utilize the linkages between documents, created through citations and references, to investigate networks of subject similarity. Generally two measures – bibliographic coupling and co-citation – have been used to examine these networks. Bibliographic coupling focuses on the linkages between source documents according to the number of shared references. Two documents are bibliographically coupled if they share one or more references. (Small, 1973) The strength of bibliographic coupling depends on the amount of references the two papers have in common (Osareh, 1996). Co-citation measures, on the other hand, focus on the frequency with which two items of earlier literature are cited together by later literature. Articles that are cited together are usually topically related; they either belong to the same topic area or areas that are closely connected. (Gmür, 2003; Schildt & Sillanpää, 2004)

In a typical bibliometric analysis, the relationships between cited references are evaluated based on the co-occurrence of references within articles; the co-citation

[5] Citation is generally defined as the "action of citing or quoting any words or written passage", as references, on the other hand, indicate the directions to a book, passage, etc., where certain information may be found. (Oxford English Dictionary, 2006)

counts (Schildt & Sillanpää, 2004). One of the main methods of analysis in bibliometrics is citation analysis, the examination of references and citations within scientific papers. Citation analysis methods apply various techniques, such as citation counting, bibliographic coupling, and co-citation analysis to study the structure of scientific disciplines. (Osareh, 1996) Methods of bibliometric analysis also include co-citation analysis; the measuring of the number of documents that have cited any given pair of documents. This co-occurrence of citations is interpreted as a measure of content similarity. (Ramos-Rodríguez & Ruíz-Navarro, 2004)

2.2.3.2 DATA COLLECTION AND DATA ANALYSIS

The data for the bibliometric review was retrieved from the ISI Web of Science citation databases using the search functions available.[6] The initial search for articles with the keyword "risk" provided a data set of over 100,000 items. Therefore, a subsequent search with the words "risk management" was conducted. Of the resulting data set of 4,841 articles, all articles with nine or less citations were deleted. Additionally, book reviews and editorial pieces were excluded from the data set. The remaining data set of 425 articles was then further decreased to 129 articles by deleting articles from disciplines outside the scope of the thesis. These disciplines included medicine, healthcare, geosciences, food sciences, chemistry, and forestry.

The data analysis of the bibliometric review was conducted in two stages. First, the bibliographic linkages between the articles in the initial data set were examined, after which a co-citation analysis was conducted. Both bibliographic coupling and co-citation analysis were used in order to improve the identification of the clusters. Additionally, linkages between the articles were examined through the analysis of citations between the data set articles.

The obtained 129 articles were downloaded into an MS Excel spreadsheet, after which the articles referring to same source articles were manually combined, and the amount of joint source articles was summed. The bibliographic linkages between the data set articles were then assessed through the amount of similarity in the

[6] The databases that were used are: Science Citation Index Expanded (SCI), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI) (www.isiknowledge.com).

bibliographies: articles having more than three common source articles were examined. Lastly, the bibliographic couples and the linkages between the data set articles were analysed by displaying them graphically. For this, software for social network analysis was utilized – Ucinet 6 for Windows, by Borgatti et al. (2002).

After the bibliographic couples were established, the co-citations between the articles were analysed. First, the documents citing selected data set articles were retrieved from the ISI Web of Science citation databases, and downloaded into MS Excel spreadsheets. After this, the citing documents were sorted and combined based on the co-occurrence of data set articles in the bibliographies of the documents. The cited documents were obtained for data set articles having more than 15 citations. The limit to the number of citations was increased from the initial ten citations in order to improve data management and to enable more accurate analysis. The co-citation analysis was further pursued by clustering the co-occurring data set articles based on the number and strength of the linkages between them. Lastly, these clusters were evaluated according to the key words and abstracts of the articles within the clusters.

The general linkages between the articles in the initial data set were also examined through an analysis of the references to the data set articles from the articles themselves. The references were first identified and then summed. Articles having the most citations to the articles in the data set were analysed by displaying the linkages graphically with the Ucinet 6 software for Windows (Borgatti et al., 2002).

2.2.3.3 RESULTS

The references obtained from the bibliographies of the 129 data set articles totalled 3,681 source articles. Of these sources, 366 articles were referred to by at least two articles in the data set, and 118 at least by three articles. These bibliographic linkages between data set articles are highlighted in *Figure 36* and *Figure 37* in *Appendix 4 Bibliometric Review* – the figures present the clusters that are formed when the minimum number of references to source articles was three and four. Through the bibliographic coupling analysis, two rather distinctive clusters were identified. The One is formed around the articles by Fischhoff, Slovic, and Paté-Cornell (cluster 1), and the other is mainly represented by articles of DeMarzo & Duffie, Géczy et al., Froot et al., and Tufano (cluster 2). The clusters are somewhat distant: in the analysis

of four or more references to source articles, the clusters are even separate. A third cluster (cluster 3) can be outlined around the articles of Jarrow et al., Diebold et al., and Christoffersen, though the cluster has tight linkages with cluster 1.

The analysis of the linkages between the 129 data set articles and their references to other articles in the data set provided little additional information compared to the bibliographic coupling analysis. Only four articles within the data set had been cited four or more times by the other data set articles. Additionally, many of the cited articles had linkages to only one article in the data set, thus creating paired nodes that were not linked to any bigger clusters. The linkages between the articles in the data set revealed similar clusters as in bibliographic coupling analysis: a cluster containing articles by Froot et al., DeMarzo & Duffie, Géczy et al., and Tufano (cluster 2 in bibliographic coupling), as well as a cluster concentrating on the articles by Diebold, Andersen et al., and Christoffersen (cluster 3 in bibliographic coupling). However, a clear cluster formed around the articles of Fischhoff, Slovic, and Paté-Cornell (cluster 1) in the bibliographic coupling analysis was missing. These linkages are shown in detail in *Figure 38* in *Appendix 4 Bibliometric Review*.

Co-citation analysis was conducted by using those articles in the initial data set which had more than 15 citations. This resulted in a new data set of 74 articles. The articles citing the data set articles were first obtained, resulting in 2,574 articles, and then combined according to co-citations to the data set articles. This resulted in a set of 904 articles having two or more references to the articles in the data set. 236 of these articles contained three or more references and 219 articles had at least four references to the data set articles. When the articles with four or more co-citations with the data set articles were combined, a set of 49 co-cited articles was obtained. When examining these 49 articles, three clear clusters were identified. To a large extent, these clusters follow the clusters already identified in the bibliographic coupling analysis; therefore the clusters are named accordingly. The most referred articles in these clusters are presented in *Table 9* in *Appendix 4 Bibliometric Review*.

As already indicated by the amount of co-occurrence of the articles, the characteristics of the articles within each cluster were very similar. The first cluster, cluster 1, is characterized by softer issues of risk management, such as risk

perception, trust, and communicating the risks to stakeholders. The articles concentrate on the discrepancies between communicating a risk and how the risk is perceived. The second cluster (cluster 2), on the other hand, concentrated mainly on assessing and hedging financial risks. The articles also assess the benefits and possible disadvantages that stem from risk management. The third cluster (cluster 3) emphasized the financial side of risk management through forecasting and evaluation, covering some hedging and measuring issues. *Table 10* in *Appendix 4 Bibliometric Review* summarises the main characteristics of the identified clusters.

2.2.3.4 CONCLUSIONS

The bibliometric review of the contemporary corporate risk management that was conducted identified three distinctive clusters within the selected data set. These clusters included two clusters concentrating on the financial side of the corporate risk management discipline: hedging and forecasting. The third cluster, on the other hand, concentrated on risk perception and communication. The clusters with themes related to financial risk management were somewhat interrelated, while the cluster emphasizing risk perception remained quite isolated.

As the objective of the bibliometric review was to map the structure and clusters of corporate risk management, the topic area of the cluster 1, risk perception and communication, is somewhat different from the definition of corporate risk management. Additionally, the topics in cluster 3, forecasting and evaluation, were felt to be outside of the scope of this thesis. Thus, the articles that were reviewed as the source data in this thesis were mainly from cluster 2, concentrating on hedging and financial risk management. The articles selected through the bibliometric review are presented in *Table 11* in *Appendix 4 Bibliometric Review*.

2.2.4 CHALLENGES RELATED TO DATA COLLECTION

The challenges in the data collection phase concentrated on the collection of primary, empirical data, especially on the selection of the companies to send the survey to. Though the NAPs of the 25 EU Member States were obtained relatively easily, the individual installations and operators listed in the plans were harder to find, and furthermore, to contact. In many cases the NAPs that were used were formulated in the official language of the Member State, as the English translation was not found.

This, together with the scarcity of information about the installations and operators when searched in the Internet, hindered the selection of companies as survey respondents. Additionally, the conducted phone calls were often partial due to difficulties in communication.

Some additional challenges in the collection of the primary data were caused by the insufficient answers and incomplete information provided by some of the respondents. These deficiencies in the data set were felt to be minor, and were resolved through deleting the incomplete answers from the final data set.

2.2.5 Reliability and Validity of Data Collection

The reliability of the secondary data used in this thesis is believed to be good. A majority of the literary sources were obtained from well-regarded, reliable sources, such as academic and industry journals. Additionally, the used Internet sources are considered reliable, as only the websites of official sources (the EU, the UN, and governments of the EU Member States), and key industry players and organisations (Point Carbon, IETA) were referred. The seminars, workshops, and conferences that were attended by the author were also of good quality; many contained speeches by prominent EU ETS experts and specialists.

The primary, empirical data of this thesis is also believed to be reliable. The survey questionnaires were sent to company representatives that are specialists on the risk management strategies and practises of their own companies. Therefore, the reliability of the survey responses is not challenged. Additionally, as the respondents were informed about the anonymity of the survey results, the responses are further believed to be unbiased and reliable.

The content validity of the survey questionnaire is assumed to be good, thus the questionnaire is believed to represent well the risk management strategies and practises related to the EU ETS (Järvenpää & Kosonen, 2000). This assumption is made, as the survey questionnaire was carefully formulated from the current theories of risk management and climate change regulatory framework. Additionally, further confirmation of the content validity was obtained when the survey was tested among research colleagues of the author and company representatives.

2.3 METHODS OF DATA ANALYSIS

2.3.1 BACKGROUND ON DATA ANALYSIS

The methods of data analysis used in this thesis were mainly quantitative. Some qualitative analysis was conducted to complement the data analysis. The methods of data analysis are explained in detail in *Chapters 2.3.2 Quantitative Analysis* and *2.3.3 Qualitative Analysis*. The nature of the data analysis was inductive, as more general themes were derived from individual cases (Kyrö, 2004).

The data analysis was conducted with the help of MS Excel spreadsheets to which the responses were downloaded directly from the survey software used. In order to find potential patterns and differences between the risk management strategies and practises of different companies, the research data was first analysed as a whole and then according to certain variables. The results of these secondary analyses were then compared with the results of the whole data set. The variables used in the secondary data analysis were: domicile, EU ETS sector, company size (sales), use portfolio analysis and/or construct price models, and invested in CDM/JI projects and/or carbon funds. The analysis, according to the different variables, was conducted by analysing and comparing different sub-categories as they emerged. The sub-categories within each variable are presented briefly in the beginning of the corresponding section in *Chapter 4 Results.*

2.3.2 QUANTITATIVE ANALYSIS

The quantitative analysis conducted in this thesis concentrated mainly on deriving percentages and shares for the categories detailed in the questions of the survey questionnaire. In order to draw these shares, the individual answers were first converted into numerical form, after which the answers in the different categories were summed with the help of the built-in functions of the MS Excel spreadsheet software used. The shares of the categories were then presented as percentages of the total amount of valid answers or as the sums of answers in that particular class. The presentation format depended on the question that was being analysed: questions that contained the possibility to select multiple options were presented with sums, as the questions having only a single option with percentages. Questions containing the option for multiple selections were also analysed according to the amount of options

selected. Hence, the selections of a single respondent were summed and categorised under certain groups. The shares of these additional categories were mainly presented as percentages of the total amount of valid answers.

The basic quantitative analysis was initially intended to be complemented by brief statistical analysis of the correlations and determinants of different variables, such as the correlation between the domicile and the use of portfolio analysis. This statistical analysis was not conducted as the amount of respondents remained relatively low and therefore large enough classes were not able to be compiled.

2.3.3 Qualitative Analysis

The qualitative data analysis in this thesis was conducted as small-scale content analysis. The data was analysed step by step, and the data material was devised into content analytical units. Firstly, the data was collected and organised into MS Excel spreadsheets. After this, the qualitative data was coded and categorised through the use of a category development procedure. Lastly, the data and codes were compared and analysed. Of the 17 open-ended questions that were included in the survey, 11 questions were analysed with the content analysis approach. The questions that were not analysed referred to specific items (names of external parties and carbon funds) or general comments. These questions were omitted as they were felt to need no further analysis. *Table 12* in *Appendix 5 Content Analysis – Questions* presents the analysed questions.

Categorisation and grouping, as conducted in the quantitative analysis, were not used when analysing the data with qualitative methods. A majority of the open-ended questions were answered by less than half of the respondents, thus rendering the sample too small for proper categorisation.

2.3.4 Challenges Related to Data Analysis

The challenges related to data analysis appeared mainly when conducting the qualitative analysis; in addition to the seven respondents that stopped answering the questionnaire after the first section, a majority of the respondents skipped the questions designed to provide qualitative data. This naturally affected the qualitative data analysis and the presentation of its results.

Some questions providing quantitative data were also skipped by the respondents. This was not, though, as common as with the questions designed for qualitative data gathering. The slight discrepancies related to these missing answers were considered during the data analysis. The calculations of the percentages and shares were done with the whole amount of respondents as the divisor, even though the missing answers were not included in any of the analysed classes.

The reliability of the data analysis is therefore considered to be satisfactory; the selected methods for data analysis, content analysis and the calculations of percentages and sums, are well known with proven and relatively simple processes. Errors during the data analysis are thought to be minor or even nonexistent. Neither the combination of qualitative methods, nor the primary quantitative methods of analysis were considered to have had an effect on the reliability of the data analysis. The combination was selected as it was felt to improve the understanding of the research results and their reliability.

3 LITERATURE REVIEW

The literature review of this thesis will begin with an introduction to the current climate change regulatory framework. Firstly, the premises of climate change are presented, after which the mitigation measures and agreements are outlined. This part of the literature review will give an understanding of the regulatory settings and uncertainties that companies must contend with.

After the regulatory settings of climate change mitigation are presented, the literature review part of this thesis considers the theoretical works related to risk management. Different sources of risks related to EU ETS are examined in detail, after which the rationale and motivation behind companies' risk management efforts are presented. Risk management in practise is also reviewed, with sections covering the most commonly used methods and frameworks. This part of the literature review will improve the understanding of companies' risks related to climate change mitigation and emissions trading, as well as of the risk management models and frameworks at companies' disposal.

The last part of the literature review concentrates on emissions trading in practise. Possible compliance strategies are introduced, together with the market organisation around the EU ETS. Additionally, the premises of carbon funds, funds that invest in emission reduction projects, are presented in detail. Information about the procedures related to emissions trading will help to understand the diversity and extent of instruments and market intermediaries around EUA trading.

The structure of the literature review and its main topics are shown in detail in *Figure 1*. The figure will be completed with short summaries of the reviewed topics as the literature review progresses. Additionally, the main implications deriving from the different sections of the literature review will be added to the figure in the end of each section.

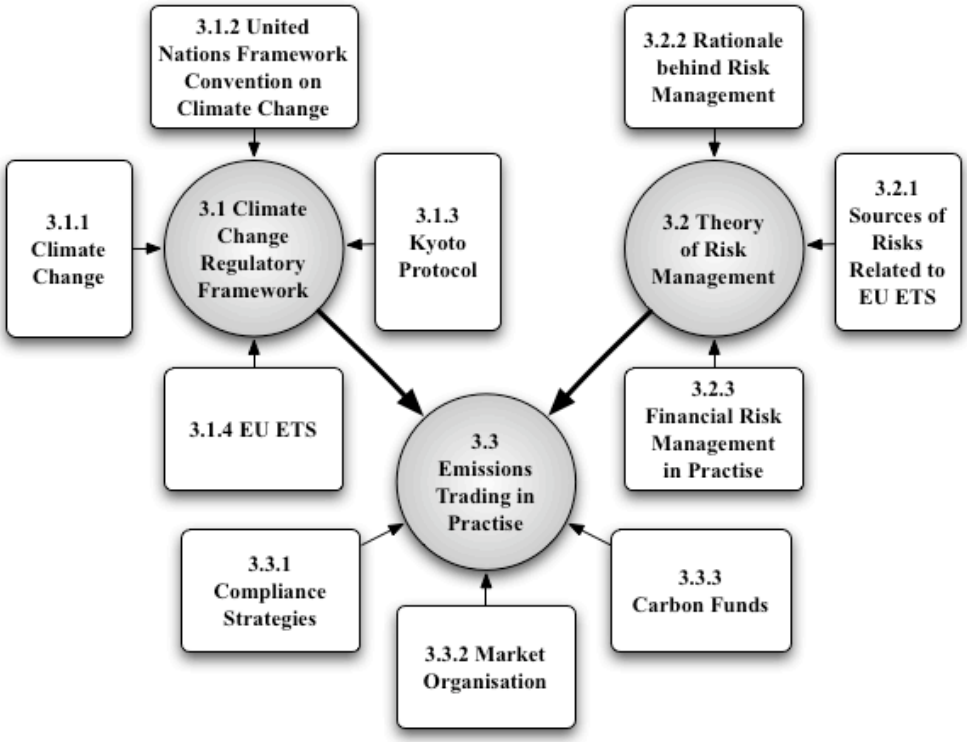

Figure 1 Structure and Main Topics of the Literature Review

3.1 CLIMATE CHANGE REGULATORY FRAMEWORK

3.1.1 CLIMATE CHANGE

Life on Earth is made possible by energy radiated from the Sun. Fast-moving visible sunlight reaches the Earth's surface and, when reflected back, changes to become a calmer and slower type of energy – infrared radiation. (UNFCCC, 2006a) This slower radiation warms the Earth, when being redistributed by the atmospheric and oceanic circulations. Eventually the energy is radiated back to space; its escape is slowed down by a group of atmospheric gases, the greenhouse gases, including water vapour, CO_2, ozone, and methane. (UNFCCC, 2006a; IPCC, 2001a) The greenhouse effect process is estimated to raise the Earth's average temperature by circa 30 ºC thereby making the planet habitable (IPCC, 2001a).

Human activities, mainly the burning of coal, natural gas, and oil, as well as the release of methane and nitrous oxide from farming, substantially increase the amount of greenhouse gases in the atmosphere. A greater amount of these gases prevent more of the Sun's radiation from being reflected back into space, leading to artificially high temperature levels on Earth, and to alterations in the climate. (UNFCCC, 2006a) Ever stronger evidence exists that most of the warming observed

over the last 50 years is attributable to human activities (IPCC, 2001a). For instance, it has been estimated that increased amounts of CO_2 emissions are responsible for over 60 % of the enhanced greenhouse effect (UNFCCC, 2006a).

Changes in global temperatures are clear: during the last century the average global temperature rose by 0.6 ºC, and climate change models estimate a rise of 1.4-5.8 ºC by the year 2100. Even small changes in temperatures can lead to greater changes in climate – in cloud cover, precipitation, wind patters, and the duration of seasons. (UNFCCC, 2006a) Additionally, potential changes in the frequency, intensity, and persistence of climate extremes are one of the key impacts of climate change. There is already clear evidence that the frequency of floods and droughts in some areas has increased, affecting the social, economic and ecological systems of these areas. (IPCC, 2001b) In addition to weather extremes, a number of unique ecological systems are recognised as being especially vulnerable to climate change. These systems, such as coral reefs, mangroves, and tropical forests, are gradually vanishing in many of their natural regions. (UNFCCC, 2006a) Furthermore, rising global temperatures have decreased the extent of snow and ice cover on Earth, as well as increasing the average sea level and ocean heat content (IPCC, 2001a).

Changes in global climate have many severe consequences: millions of people depend on static weather patterns, such as monsoons and precipitation. Changing climate will be difficult and disruptive to the lifestyles and economic livelihood of these people. Rising sea levels threaten the heavily populated coastlines of such countries as Bangladesh and the Netherlands, fouls much needed freshwater supplies of millions of people, and spurs mass migrations. Additionally, drops in agricultural yields in some regions together with drying of continental interiors, such as the Great Plains of the US, can cause severe disruptions in land use and food supply. The spread of diseases such as malaria and cholera may also expand. (UNFCCC, 2006a)

Even though the relative impact of climatic and socioeconomic factors related to climate change are difficult to quantify, climate change and its impacts are generally considered to be some of the most threatening phenomena to environmental and economic wellbeing on Earth (IPCC, 2001b; UNFCCC, 2006a). Resolving the climate change problem is complicated, requires the involvement of the entire world,

and is connected with serious and difficult issues such as poverty, economic development, population growth, and disease (UNFCCC, 2006a). Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has reviewed scientific research on climate change, as well as presented summaries and advice about climate problems and policies at the disposal of governments (IPCC, 2006). Additionally, most of the world's countries have joined the international treaty, the United Nations Framework Convention on Climate Change (UNFCCC) to consider means to mitigate and adapt to climate change (UNFCCC, 2006a).

The main points related to climate change are presented in *Figure 2*.

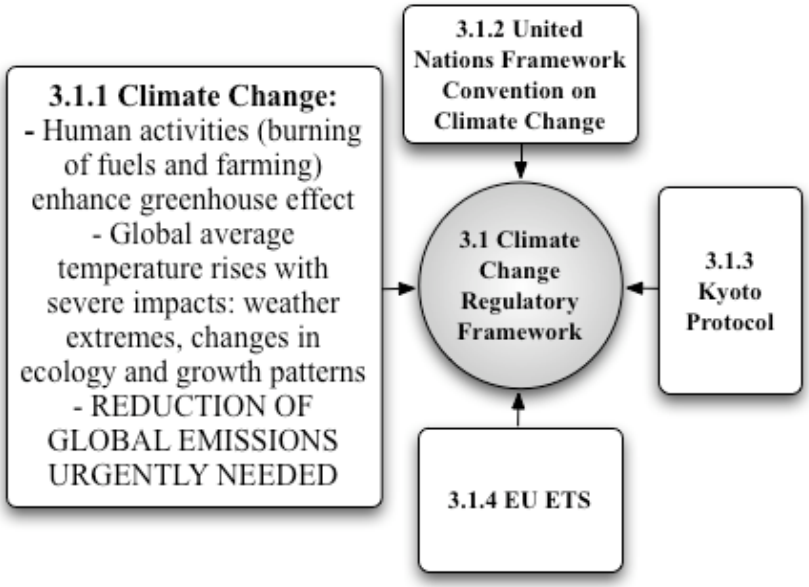

Figure 2 Climate Change

3.1.2 UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Concern about climate change increased substantially in the 1980s, when environmental issues gained growing popularity among the public. Later in the decade, the IPCC started its work to assess the scientific basis of climate change and advise governments on climate policies. The first real effort in climate change mitigation work was the global climate change treaty, the United Nations Framework Convention on Climate Change (UNFCCC), introduced in Rio de Janeiro, in Brazil in 1992. The Convention initiated efforts to reduce climate change, as well as to adapt to whatever increases in temperature may follow. The treaty entered into force in March 1994, and it enjoys near universal membership, with 188 countries and the European Union having ratified it. (UNFCCC, 2003; UNFCCC, 2006a)

The premise of the Convention is the recognition of the reality of climate change, as well as the influence that human activities have and continue to have upon it (UN, 1992). The treaty sets an overall framework for intergovernmental efforts to tackle the challenges caused by changing climate. The Parties to the Convention, i.e. the countries having ratified the treaty, should both take precautionary measures to prevent or minimize causes of climate change, and to implement policies and measures to protect the climate against human-induced change. The Parties are also committed to gather and share information on their emissions, to promote sustainable technologies, and to support cooperative actions. (UN, 1992; UNFCCC, 2006a)

The Parties to the Convention are divided into three groups with varying commitments. Annex I group contains the industrialised countries that were OECD members in 1992, together with countries with economies in transition (EIT), including the Russian Federation and the Baltic States. Annex II countries encompass the Annex I countries of which the EIT countries are excluded, and the non-Annex I group of countries contains the remaining countries, majority of them still developing countries. All Parties to the Convention are subject to general commitments to respond to climate change; the Annex I countries are additionally required to implement policies and measures "with the aim of reducing their greenhouse gas emissions to 1990 levels by the year 2000". (UNFCCC, 2003)

The decision-making body of the Convention is its Conference of the Parties (COP), an association of all the countries that are Parties to the Convention. The main responsibility of the COP is to ensure that international efforts to address climate change continue to proceed. At its annual meeting, the COP reviews the implementation of the Convention, examines the commitments of the Parties, and adopts decisions to further develop the Convention's rules. A key task for the COP is to also review the national communications and emission inventories submitted by Parties. Additionally, negotiations over substantive new commitments take place during the COP meetings. (UNFCCC, 2003; UNFCCC, 2006a)

Until today, eleven COP meetings have been held. The latest meeting, COP 11, was held in Montreal from late November to early December in 2005. During the meeting, a path to future international action on climate change was outlined: a

dialogue on approaches for long-term global cooperative action to address climate change was launched, together with a process for establishing future commitments under the Kyoto Protocol beyond 2012. (UNFCCC, 2006b) The meeting was also the first meeting of the COP/MOP, Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol, a decision-making body of the Kyoto Protocol. The Protocol was adopted in COP 3 in Kyoto, Japan in 1997 and commits industrialised countries to legally binding emissions reduction targets. (UNFCCC, 2006a)

A short summary of the UNFCCC and its content is outlined in *Figure 3*.

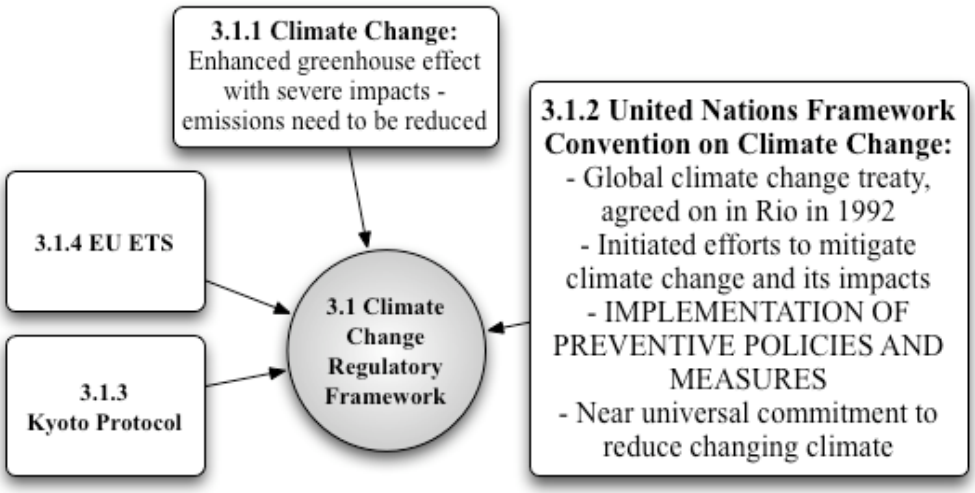

Figure 3 United Nations Framework Conventions on Climate Change

3.1.3 THE KYOTO PROTOCOL

The UNFCCC treaty was further strengthened in the COP 3 in Kyoto, Japan in 1997 when the Kyoto Protocol was adopted. The Protocol commits the Annex I Parties to the Convention to set "individual, legally-binding targets to limit or reduce their greenhouse gas emissions". (UNFCCC, 2006a) In order to enter into force, the Protocol required the ratification of 55 Parties to the Convention, including enough Parties from Annex I countries to encompass 55 % of the group's CO_2 emissions in 1990 (UNFCCC, 2003). The Protocol entered into force on 16 February 2005, after the Russian Federation ratified it in late 2004. Today, 163 countries have ratified the Protocol, of which the EEC and 35 other countries are required to reduce their greenhouse gas emissions below the levels specified for each of them in the Protocol. The individual reduction targets for these countries, mainly Annex I Parties, are listed in the Annex B of the Kyoto Protocol. (UNFCCC, 2006a) These individual reduction commitments are presented in *Table 2*.

Table 2 Reduction Commitments of Annex I Parties (UN, 1998)[7]

Party	Reduction Commitment *	Party	Reduction Commitment *
Australia	108%	Liechtenstein	92%
Austria	92%	Lithuania **	92%
Belgium	92%	Luxembourg	92%
Bulgaria **	92%	Monaco	92%
Canada	94%	Netherlands	92%
Croatia **	95%	New Zealand	100%
Czech Republic **	92%	Norway	101%
Denmark	92%	Poland **	94%
Estonia **	92%	Portugal	92%
European Community	92%	Romania **	92%
Finland	92%	Russian Federation **	100%
France	92%	Slovakia **	92%
Germany	92%	Slovenia **	92%
Greece	92%	Spain	92%
Hungary **	94%	Sweden	92%
Iceland	110%	Switzerland	92%
Ireland	92%	Ukraine **	100%
Italy	92%	UK	92%
Japan	94%	USA	93%
Latvia **	92%		

* Quantified emission limitation or reduction commitment (percentage of base year/period)
** Countries that are undergoing the process of transition to a market economy (economies in transition, EIT)

The individual emissions reduction commitments amount to an aggregate reduction target of 5.2 % from 1990 levels during the first commitment period from 2008 to 2012. Of the Annex I Parties, the 15 Member States of the European Community agreed to redistribute their overall reduction target, 8 %, among themselves in a proportional way. (UNFCCC, 2003) The emissions reduction targets of the Kyoto Protocol cover emissions of the six main greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The base year or period to which to compare the reduction commitments is generally emissions in the year 1990. For HFCs, PFCs and SF_6 an optional year of 1995 can be used, and for some new EU Member States the base year differs from the years 1990 and 1995. (UNFCCC, 2006a)

The guidelines of the Kyoto Protocol were further complemented in the sixth COP in Marrakech, Morocco in 2001. Then, the Parties formally adopted a rulebook, the Marrakech Accords, to set the framework for the Protocol's implementation. In

[7] Of the Annex I Parties to the Convention, Belarus and Turkey are not included in the Kyoto Protocol's Annex B, as the countries were not Parties to the Convention when the Protocol was adopted (UNFCCC, 2006a). For simplicity, though, the countries having reduction commitments under the Protocol are referred as the "Annex I Party" later in this thesis report.

addition, the Protocol will be reviewed yearly at the second session of the COP, at the Meeting of the Parties to the Protocol (COP/MOP). The first COP/MOP was organised together with the COP 11 in Montreal in late 2005. (UNFCCC, 2006a)

To achieve the Kyoto Protocol's targets, Annex I Parties are required to implement climate change policies and measures that have a mitigating effect on climate change. Suggested measures to achieve the desired effects include enhancing energy efficiency, favouring sustainable agriculture, promoting renewable energy sources, reducing emissions from transportation, and removing subsidies and other market distortions. (UNFCCC, 2003) Parties may also offset some of their emissions by increasing the amount of greenhouse gases removed from the atmosphere by so-called carbon sinks in the land use, land-use change and the forestry (LULUCF) sector. Eligible actions include reforestation and deforestation, as well as forest and cropland management. Greenhouse gases removed through these activities generate credits which are known as Removal Units (RMUs). (UNFCCC, 2006a)

In addition to domestic measures and sinks, the Protocol introduces three innovative, flexible mechanisms that aim to increase opportunities to reduce emissions or increase greenhouse gas removals in a more cost-effective way (UNFCCC, 2006a). These mechanisms are presented in the following chapters.

3.1.3.1 JOINT IMPLEMENTATION

Under Joint Implementation (JI), an Annex I Party may implement a project that reduces emissions or increases removals by sinks in the territory of another Annex I Party. The accrued reductions in emissions are credited as Emission Reduction Units (ERUs) and counted against the Party's own target. (UNFCCC, 2006a) To avoid double counting, a corresponding subtraction is made from the host Party's assigned amount (UNFCCC, 2003). In practise, a majority of the JI projects take place in the EIT countries of the Annex I Parties, as these countries possess great potential for low cost emission reductions. (UNFCCC, 2006a)

Two possible procedures for carrying out a JI project exist. The first procedure, often called "track one", is applied if the host Party meets all eligibility requirements related to JI projects. In this situation, the host Party may issue ERUs itself and

further transfer them to the investing Party. The second procedure, "track two" may be applied if the host Party does not meet all the eligibility requirements. In these cases, the generated ERUs need to be verified by the Supervisory Committee. The JI Supervisory Committee was set up by the COP/MOP 1 in Montreal in 2005 and started its operations in 2006. (UNFCCC, 2003)

3.1.3.2 CLEAN DEVELOPMENT MECHANISM

The second flexible mechanism introduced by the Kyoto Protocol is the Clean Development Mechanism (CDM). Under the CDM, Annex I Parties can implement projects that reduce emissions in non-Annex I Parties. The resulting reduction credits, Certified Emission Reductions (CERs), are at the investing Party's disposal to use against its own reduction targets. One of the objectives of the CDM is also to help the non-Annex I Parties to achieve sustainable development. (UNFCCC, 2006a) The CDM is especially expected to generate investments in developing countries, and to enhance the transfer of sustainable technologies (UNFCCC, 2003).

The rulebook of CDM projects was set out in the Marrakech Accords. The projects focus on emission reduction, though the rules for including afforestation and reforestation activities are being developed. These rules will include a limit on the extent to which the Annex I Parties may use the credits accrued from such sink activities. (UNFCCC, 2003; UNFCCC, 2006a) The CDM Executive Board guides and oversees the practical arrangements of the CDM projects. The Board also issues the CERs for the individual projects. The CDM Executive Board was elected at the COP 7 in Marrakech in 2001. (UNFCCC, 2003)

3.1.3.3 INTERNATIONAL EMISSIONS TRADING

The third flexible mechanism of the Kyoto Protocol is the International Emissions Trading (IET). The IET enables the Annex I Parties to acquire Assigned Amount Units (AAUs) from other Annex I Parties. Parties can therefore pursue lower cost reduction units from those Parties that are able to more easily and cheaply reduce their emissions. In addition to AAUs, Parties may also trade ERUs from JI projects, CERs from CDM projects, or even RMUs from sink activities to comply with their commitments. (UNFCCC, 2003)

In order to answer concerns that some Parties could "oversell" their AAUs and then be unable to meet their own targets, the Protocol rulebook requires each Annex I Party to hold a minimum level of credits at all times in a commitment period reserve that cannot be traded. Only ERUs verified by the JI Supervisory Committee can be freely transferred regardless of the level of the commitment period reserve. (UNFCCC, 2003; UNFCCC, 2006a)

A short summary of the Kyoto Protocol and its content is presented in *Figure 4*.

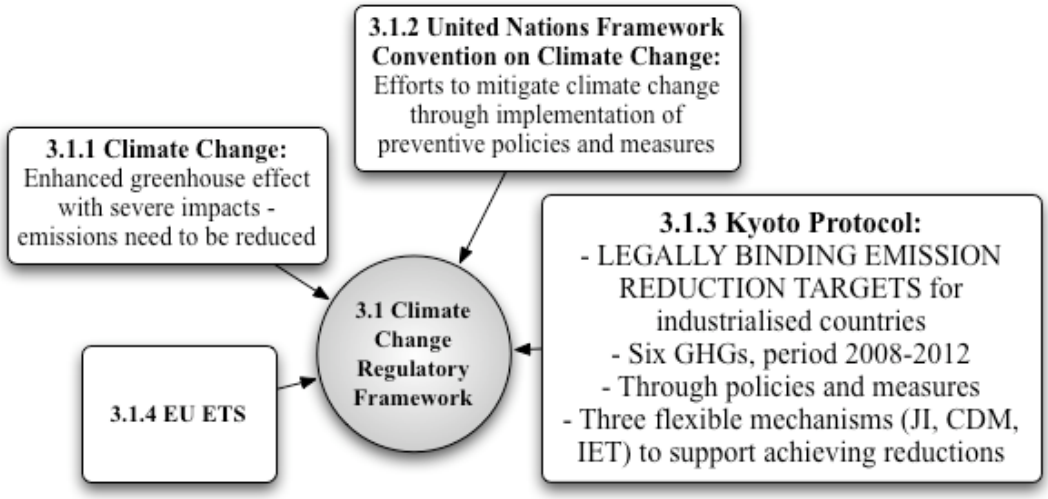

Figure 4 Kyoto Protocol

3.1.4 EUROPEAN UNION EMISSIONS TRADING SCHEME

The EU has long been committed to global efforts to reduce the greenhouse gas emissions from human activities. In 2000, the European Commission (EC) established an initiative – the European Climate Change Programme – to help identify the most environmentally effective and cost-effective policies and measures to cut greenhouse gas emissions at European level. The key goal of the initiative is to ensure that the EU meets its target for reducing emissions defined under the Kyoto Protocol. (EC, 2005; EC, 2006) The initiative relies on stakeholder co-operation to in the preparatory work for common policies and measures (COM, 2000).

The first ECCP programme examined an extensive range of policies and instruments with the potential to reduce emissions. The programme identified the creation of the emissions trading scheme with links to JI and CDM as a particularly cost-effective way to reduce EU-wide greenhouse gas emissions. Other identified measures include renewable energy sources and energy demand management. (EC, 2005; EC, 2006)

The second ECCP programme was launched in October 2005, and is aimed to further explore different cost-effective options to reduce greenhouse gas emissions (EC, 2006). Based on the suggestion of the ECCP I, the EU established the EU Emissions Trading Scheme (EU ETS); a scheme regulating the emissions of some 11,500 heavy emitters in the EU area from the 1 January 2005 (EU, 2006). The principles of the scheme are introduced in detail in the following chapters.

3.1.4.1 REDUCTION COMMITMENTS

During the adoption of the Kyoto Protocol in 1997, the 15 EU Member States agreed on a common reduction target of -8 % from 1990 levels during the commitment period of 2008-2012. This reduction target is further distributed among the EU15 Member States, giving them individual targets according their reduction potential and requirements. The ten new Member States that joined the EU on 1 May 2004 follow their own reduction targets determined in the Kyoto Protocol. Of the Member States, only Cyprus and Malta have no targets. All of the old and new Member States are full participants in the EU ETS. (CE, 2002; EC, 2005) The individual reduction commitments for all 25 EU Member States are listed below in *Table 3*.

Table 3 Reduction Commitments for the EU25 Member States (CE, 2002; UN, 1998)

EU15 Member State	Reduction Commitment *	New Member State	Reduction Commitment *
Belgium	92.5 %	Czech Rebuplic	92%
Denmark	79%	Cyprus	No commitment
Germany	79%	Estonia	92%
Greece	125%	Hungary	94%
Spain	115%	Latvia	92%
France	100%	Lithuania	92%
Ireland	113%	Malta	No commitment
Italy	93.5 %	Poland	94%
Luxembourg	72%	Slovak Republic	92%
Netherlands	94%	Slovenia	92%
Austria	87%		
Portugal	127%		
Finland	100%		
Sweden	104%		
United Kingdom	87.5 %		

* Quantified emission limitation or reduction commitment (percentage of base year/period)

The agreed reduction commitments vary greatly according to the 15 original EU Member States. Denmark, Germany, and Luxembourg agreed to commit to reduction targets of over 20 %; Greece, Spain, and Portugal, on the other hand, are allowed to increase their emissions from 1990 levels by more than 15 %.

3.1.4.2 EUROPEAN UNION EMISSIONS TRADING DIRECTIVE

The European Union Emissions Trading Directive was established through binding legislation proposed by the EC and approved by the EU Member States and the European Parliament. Directive 2003/87/EC was approved on 13 October 2003, thus establishing a scheme for greenhouse gas emission allowance trading within the EU area. The directive "aims to contribute to fulfilling the commitments of the European Community and its Member States more effectively […], with the least possible diminution of economic development and employment". Thus, the scheme aims for cost-effective and economically sensible reductions in greenhouse gas emissions that would benefit both the environment and the EU area. (EU, 2003)

Since the start of the EU ETS, each installation covered by it are obliged to possess an emission permit for their operations, as well as to surrender emission units, EU Allowances (EUAs) equal to the installation's CO_2 emissions after every year of operations. One EUA is equal to one tonne of CO_2 (t CO_2) and is freely traded between the installations covered by the EU ETS. (EU, 2003; EC, 2005)

While the EU ETS has the potential to involve many industrial and economical sectors, as well as all the greenhouse gases listed in the Kyoto Protocol, the scope of the scheme is limited during its initial phase. During the first trading period, 2005-2007, the EU ETS covers only the CO_2 emissions from large emitters in the power and heat generation industry, as well as in selected energy-intensive industrial sectors. A size threshold, according to the production capacity or output, determines which installations in these sectors are included in the scheme. (EU, 2003; EC, 2005) Even with the limited scope, nearly 11,500 installations in the 25 EU Member States are covered by the EU ETS, accounting for around 45 % of the total CO_2 emissions or around 30 % of the overall greenhouse gas emissions of the EU area (EC, 2005).

The different industrial sectors included in the EU ETS are presented in *Table 4* together with the size thresholds. The amount of installations and the EUAs allocated for the first-trading period are listed in detail in *Appendix 6 Installations and EUAs Allocated*.

Table 4 Activities under the EU ETS (EU, 2003)

Activities under the EU ETS
Energy activities
Combustion installations with a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations)
Mineral oil refineries
Coke ovens
Production and processing of ferrous metals
Metal ore (including sulphide ore) roasting or sintering installations
Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2.5 tonnes per hour
Mineral industry
Installations for the production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or lime rotary kilns with a production capacity exceeding 50 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day
Installations for the manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day
Installations for the manufacture of ceramic products by firidg, in particular rooting tiles, bricks, refractory bricks, tiles, storeware or porcelain, with a production capacity exceeding 75 tonnes per day, and/or with a kiln capacity exceeding 4 cubic meters and with a setting density per kiln exceeding 300 kg per cubic meter
Other activities
Industrial plants for the production of
(a) pulp from timber or other fibrous materials
(b) paper and board with a production capacity exceeding 20 tonnes per day

3.1.4.3 NATIONAL ALLOCATION PLANS

According to the EU ETS Directive, the EU Member States are required to draw up National Allocation Plans (NAPs) for the allocation of the EUAs to individual installations. These plans state the total quantity of allowances that the Member State intends to allocate for a particular trading period and how it proposes to allocate them to the installations covered by the EU ETS. For the first trading period, the three-year period from 2005 to 2007, the Member States are obliged to allocate at least 95 % of the allowances free of charge. During the following five-year period, 2008-2012, at least 90 % of the allowances need to be free of charge. (EU, 2003) Decisions over the allocations are made according to objective and transparent criteria, and the decisions are made public (EU, 2003; EC, 2005).

The EC assesses the NAPs drawn by the Member States, and has the power to require changes or even to reject a plan altogether. Once the EC has approved the NAP, the total quantity of EUAs allocated in it cannot be changed. Additionally, the

number of allowances per installation should be set permanently. (EC, 2005) All NAPs for the first trading period are at least conditionally approved, and currently the Member States are drawing up the plans for the second period (EU, 2006).

The limit or "cap" on the amount of EUAs allocated to individual installations creates scarcity required for an EUA trading market to emerge. Installations and companies are allowed to buy and sell EUAs at a price determined by supply and demand at a given time. If an installation has difficulties in remaining within its emissions limit, the installation can either reduce its emissions or purchase the required allowances from the markets, whichever is cheapest. Though only emitting plants are given EUAs, anyone else, including individuals and institutions, is free to buy and sell the allowances in the same way as companies. (EC, 2005)

3.1.4.4 COMPLIANCE, MONITORING AND REPORTING, AND REGISTRIES

After each calendar year, installations must surrender equal amount of EUAs to their verified CO_2 emissions in that year. Those installations that have extra allowances can sell them or save them for the following years[8]; those installations that have not surrendered enough allowances to cover their emissions will have to pay a dissuasive fine for each excess tonne emitted. Installations also have the possibility to borrow from their future allowances, though, only within one trading period. During the first trading period, the fine is € 40 per tonne, and from 2008 it will rise to € 100. In addition to the fine, installations also have to cover the shortfall with a subsequent amount of EUAs in the following year. (EU, 2003; EC, 2005) The compliance with the EU ETS is further assured by penalties for any infringements of the scheme rules, and by having the names of the non-complying installations published. (EC, 2005)

Each of the installations covered by the EU ETS is required to have a permit for its emissions of all six greenhouse gases listed in the Kyoto Protocol. This permit also sets out the monitoring and reporting requirements for the emissions of the installation; operator's capability to monitor and report its emissions is confirmed. Additionally, the EC has issued a set of guidelines to be followed in the monitoring

[8] The EC recommends installations not to bank (i.e. save for the following years) allowances between the first and second trading period. Otherwise, the allowances are freely banked. (EU, 2003)

and reporting process. (EC, 2005; EU, 2006) Installations must thus report their CO_2 emissions on a yearly basis. These reports have to be then verified by an independent party, and are made public after the submission time limit (EC, 2005).

The allowances are held in accounts in electronic registries set up by the Member States. The registry system is similar to a banking system – the issue, holding, transfer, and cancellation of allowances are monitored. A central administrator at the EU level oversees the system of national registries. This administrator, the independent transaction log, checks the transactions for any irregularities that may prevent a transaction from being completed until they have been corrected. (EU, 2005) At the time of writing this thesis, approximately half of the national registries are operational and about half of the allocated credits have been issued to the installations' accounts. The rest of the Member States are still finalising the launch of their registries. (EU, 2006) The EU registry system is currently being integrated with the international registry system that is being built under the Kyoto Protocol. The integration of these two systems allows the transfer of emission reduction credits from CDM projects to installations' accounts. (EC, 2005)

3.1.4.5 LINKING DIRECTIVE

The so-called linking Directive (2004/101/EC) amending the earlier Directive on EU ETS in respect of the Kyoto Protocol's project mechanisms, JI and CDM, was established in October 2004. The Directive gives installations and operators the opportunity to use the emission credits accrued from the JI and CDM project activities to comply with their own emissions limits. The objective of the linking Directive is to increase the diversity of low-cost compliance options within the EU ETS, and to lead to a reduction in the overall costs of compliance with the Kyoto Protocol. Additionally, diversified options are believed to improve the liquidity of the EUA market. (EU, 2004) The linking Directive also offers a supplement to domestic actions within an industrialised country, and stimulates the transfer of environmental and sustainable technologies and know-how (EU, 2004; EC, 2005).

The main issues and principles related to the EU ETS are presented in *Figure 5*.

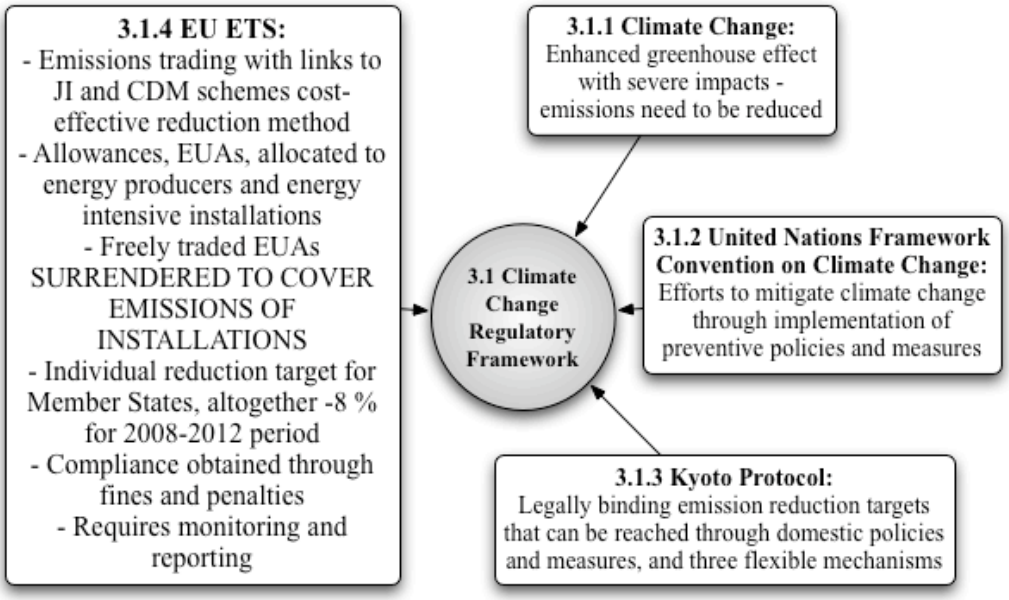

Figure 5 European Union Emissions Trading Scheme

3.1.5 IMPLICATIONS OF CLIMATE CHANGE REGULATORY FRAMEWORK

Climate change and the regulatory framework established for its mitigation have introduced several changes in the business environments of companies all over the world. Treaties aiming to reduce climate change, UNFCC and the Kyoto Protocol, have established quantified targets for emissions reductions, and emphasise the implementation of policies and measures to mitigate climate change. Both the EU and the individual EU Member States committed themselves to these treaties and have started active operations to reduce their emissions. As a part of this, the EU introduced its emissions trading scheme, shifting some of the responsibility on reductions to the emitting companies and installations at the EU area.

Thus, companies throughout the EU must contend with many new responsibilities and obligations related to their emissions and climate change. Amongst other issues, the EU ETS has introduced several new financial assets and instruments that the companies need to manage: emissions have obtained a financial value and need to be carefully controlled. Additionally, companies are now required to build systems for reporting and monitoring their emissions, and are punished for non-compliance with the emission limits and targets.

Together, these changes in the business environments and obligations have increased uncertainties and risks in the companies operations, as well as influenced long-term

decisions over, for example, investments and production patterns. The EU ETS has also forced companies to monitor their emissions and attend to their reduction.

The *Figure 6* sums up the climate change regulatory framework and its implications.

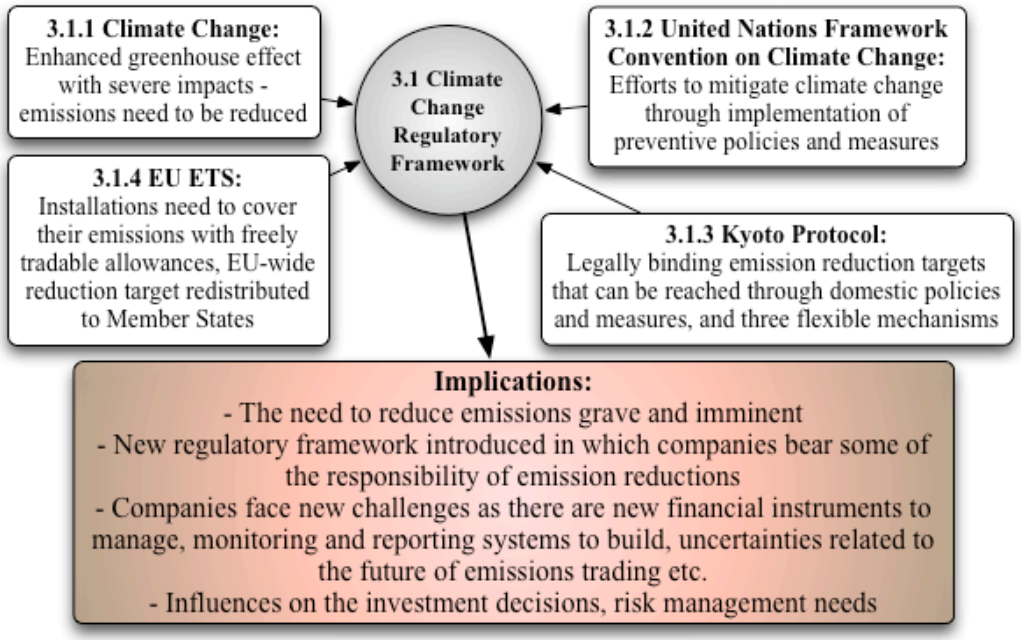

Figure 6 Implications of Climate Change Regulatory Framework

3.2 RISK MANAGEMENT

Several seemingly unique templates for risk management exist. Regardless of the template, though, the same core processes appear in all. First, the risk-return goals and objectives are set, and the causes of potential expense or revenue fluctuations are identified and evaluated. The methods and instruments to manage and control these causes are then chosen, and, further, implemented, monitored, and reviewed. (Barrese & Scordis, 2003) The following chapters map the process of risk management in relation to EU ETS; the sources of risks and rationale behind risk management are stated, together with some risk management instruments and tools.

3.2.1 SOURCES OF RISKS

In general, companies face at least three sources of risk: business risk, strategic risk, and financial risk.[9] Business risks are fundamental to the company and inherent in

[9] The risks related to corporate activities accrue from several different sources (legal frameworks, accidents), and the categorisation related to the sources is often relatively ambiguous.

the company's whole operations. These risks, often identified as operating risks, are usually technological, distributional, or informational risks that can affect the whole company and its competitive advantage. Strategic risks, on the other hand, encompass macro factors that affect the company and its value to the shareholders. Macro factors include major economic and political events, such as currency crises and surges in interest rates. Value consequences and duration of strategic risk factors are generally long-term. (Fatemi & Luft, 2002)

Financial risks arise from adverse short-term changes in interest rates, commodity prices, equity prices, and foreign currency values. Sudden adverse changes in these factors can translate into major losses in company value. (Fatemi & Luft, 2002) Financial risks generally comprise of four categories: market risk, credit risk, operational risk, and liquidity risk (Broughton, 1994). Market risks embody the fluctuations in market prices or rates including equity prices, commodity prices, interest rates, and exchange rates. Changes in company's value due to the market risks naturally depend on the amount of the company's holdings. Credit risk, on the other hand, is associated with the failure of creditors, from changes in the counterpart's financial performance to actual failure to follow the contract. Liquidity risk is generally defined as the risk accruing from thin markets; closing a position becomes difficult or more expensive. (Brealey et al., 2006; Copeland et al., 2005)

Risks are sometimes also categorised into different types. For instance, Schrand and Unal (1998) classify risks into two types: core-business risk and homogenous risk. Core-business risks, such as credit risks, enable companies to earn economic return, and homogenous risks, such as interest-rate risk, generate zero returns. (Schrand & Unal, 1998) Additionally, risks can be either pure or speculative; pure risk is associated with hazards that have only a negative consequence, while speculative risks can have both positive and negative consequences. Financial risks are generally classified under speculative risks, though some financial risks can include both pure and speculative risk components. (Wang, 2001; Barrese & Scordis, 2003)

The risks related to the EU ETS derive mainly from the operational and financial implications of the scheme; companies' emissions have obtained a financial value and require accurate monitoring and controlling. Business risks stem from changes in

technologies, as well as from the infrastructure needed for the EU ETS (monitoring, reporting, registries). Companies may lose some of their competitive advantage if they are unable to react to changes or to establish the required infrastructure. Additionally, uncertainty over the future of the scheme can enhance the business risks; investments and vital long-term strategic decisions are affected and possibly postponed when facing this uncertainty. Financial risk management, on the other hand, is needed to assess and manage the risks related to the value and amount of emissions and EUAs. Of the financial risks, it is mainly market risks and liquidity risks are that are related to the EU ETS, as the EUA market is still volatile and thin.

The sources of risks related to EU ETS are summarised in *Figure 7*.

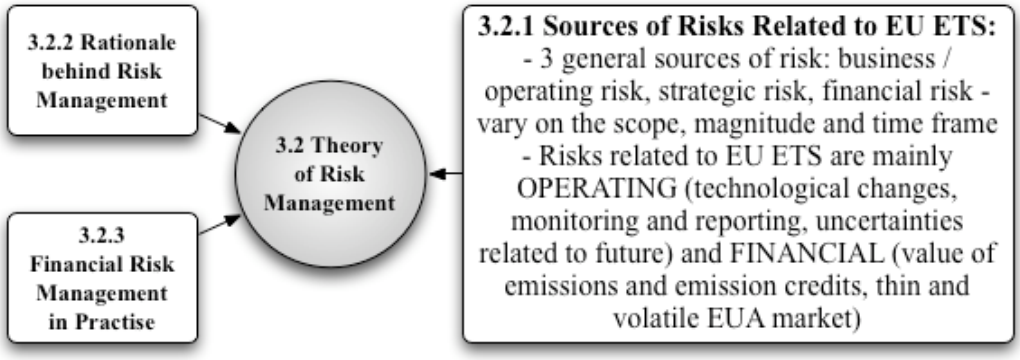

Figure 7 Sources of Risks Related to EU ETS

3.2.2 RATIONALE BEHIND RISK MANAGEMENT

Generally, two types of explanations for risk management activities within companies have been constructed: shareholder value maximization and the maximization of managers' private utility. (Tufano, 1996) Firms that aim to maximize shareholder value will engage in risk management activities only if the activities enhance firm's value and thus its shareholders' value. Alternatively, managers that seek the maximization of their private utility and wealth can engage in risk management activities that are designed to insulate their own personal wealth from changes related to market risks. (Fatemi & Luft, 2002)

The shareholder value maximization explanations can arise from several sources: minimization of financial distress and its costs, optimization of investment policies, and minimization of taxes (Tufano, 1996; Fatemi & Luft, 2002). Engaging in risk management practises can decrease the likelihood of costly financial distress and, further, increase the expected value of the firm. This value can be increased through

the reduction of deadweight costs and an increase in debt capacity; a company can obtain valuable tax shields or reduce the agency costs of excess free cash flows. (Smith & Stulz, 1985) Additionally, stakeholders, such as suppliers and employees, may anticipate the company's distress and therefore seek to reduce their long-term dependence on these companies (Shapiro & Titman, 1986 in Brown & Tuft, 2002).

Risk management activities can also minimize the possibility that a company may be forced to decline positive NPV projects because it lacks required funding. Companies with planned investment programs and costly external financing are often inclined to use risk management to avert the need for this external financing. Thus, companies that do not manage their risks may be forced to pursue suboptimal investment policies and further decrease the shareholder value. (Froot et al., 1993; Fatemi & Luft, 2002; Tufano, 1996) The tax-minimization explanation for risk management practises includes the reduction of expected taxes by using risk management. Managing risks can smooth the level of company's earnings and optimize its tax levels. (Smith & Stulz, 1985; Stulz, 1996)

The maximization of managers' private utility relates to managerial risk aversion and signalling managerial skills (Tufano, 1996). Managers whose wealth is poorly diversified prefer to reduce the risks to which they are exposed. Thus, if managers judge that it will be less costly for the company to manage these risks than to manage them on their own, they will engage their companies with risk management activities. (Smith & Stulz, 1985; Stulz, 1984; Tufano, 1996) For instance, managers with major stock ownership generally prefer more extensive risk management, than managers with option holdings. This risk aversion is due to the linear nature of stock payoffs compared to the convex payoffs of options. (Smith & Stulz, 1985; Tufano, 1996; Schrand & Unal, 1998) Managers may also adopt risk management in order to improve their own reputations. Managers' choices over optimal hedging policies can depend on the type of accounting information made available to shareholders; engaging in risk management activities affecting on this information is believed to better communicate the managers' skills. (DeMarzo & Duffie, 1995; Tufano, 1996)

In addition to shareholder value maximization and managers' utility, there are also other reasons for risk management. A change in the risk exposure of a company can

affect the demand of its products or services and thus its expected cash flows. Sometimes better risk management can also enable the realisation of profitable business opportunities that would otherwise be missed. (Copeland et al., 2005) Additionally, as risk management often increases the predictability and thus ensures greater budget control, it can improve employee morale and retention (Wang, 2001).

Many scholars have also argued that the company size is related to its use of risk management techniques, namely use of derivative instruments (Géczy et al., 1997; Mian, 1996). For instance, the use of some financial risk management techniques requires considerable investments in personnel, training, and IT infrastructure; investments that can discourage smaller companies from engaging in risk management (Stulz, 1996). Additionally, information and transaction considerations often have more influence on hedging activities than the cost of raising capital (Mian, 1996). Companies with greater growth opportunities and tighter financial constraints can also be more likely to use derivatives (Géczy et al., 1997).

The main reasons for companies' risk management activities are listed in *Figure 8*.

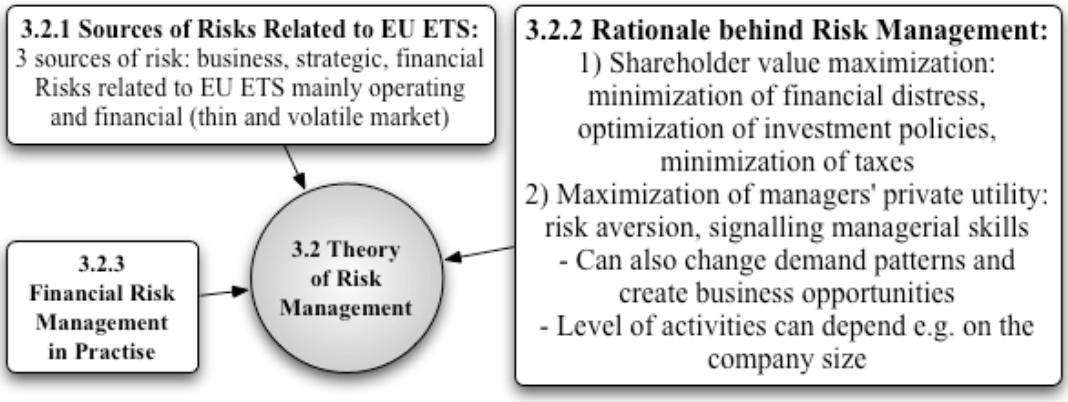

Figure 8 Rationale behind Risk Management

3.2.3 FINANCIAL RISK MANAGEMENT IN PRACTISE

The majority of the companies have adopted at least some financial engineering techniques to control their exposure to fluctuations in commodity prices, interest rates, and currencies, i.e. financial risks (Tufano, 1996). For instance, a 1998 survey of financial risk management by US non-financial firms revealed that approximately half of the respondent companies were using derivatives to manage their risks (Bodnar et al., 1998). Additionally, the popularity of risk management instruments has increased substantially over the recent decades (Basak & Shapiro, 2001).

Companies generally manage their financial risks through hedging and acquiring insurance. Hedging traditionally refers to the use of off-balance-sheet instruments – forwards, futures, options, and swaps – to reduce the volatility of firm value (Nance et al. 1993). Hedging, thus, includes the company's trading actions in a derivative market despite having no identifiable cash position in the underlying commodity (Smith & Stulz, 1985). Those derivative instruments that are used in relation to the EU ETS and EUA market are presented in detail in *Chapter 3.3.2.2 Financial Instruments*. Alternatively, a company can hedge by altering its real operating decisions, with on-balance-sheet strategies. Hedging with on-balance-sheet strategies encompasses, for instance, the relocation of production facilities, mergers, and change of funding currencies. The effects of these strategies can be similar to those of traditional financial hedging. (Smith & Stulz, 1985; Nance et al., 1993)

Insurance, on the other hand, is generally defined as a risk management instrument to manage the pure risks that companies face; insurance preserves the corporate value when there is a probability of a sudden accident with major negative impacts (Wang, 2001). Thus, when taking insurance, a company simply transfers the risk of such events to the insurance company. Companies generally buy insurance against large potential losses and self-insure against routine ones. (Brealey et al., 2006) Traditionally, insurance has been seen as somewhat separate from other financial risk management instruments such as derivatives, though a growing amount of companies include them among the main instruments to manage their financial risks. (Wang, 2001; Barrese & Scordis, 2003)

Table 5 lists the variety of ways that a company may manage its financial risks. Few of the theories and frameworks developed around these risk management techniques are introduced in the following chapters.

Table 5 Financial Risk Management Techniques (Adopted from Copeland et al., 2005)

Natural Techniques	Financial Hedges
Borrow in the same currency that your asset is denominated in	Futures: commodities, securities
Engineer flexibility into operations	Forwards: commodities, securities
Diversify	Options
Improve forecasting	Swaps
Match operating costs and revenues in the same currency	
Optimize insurance policy	
Share risks: joint ventures, sales agreements	

3.2.3.1 MODERN PORTFOLIO THEORY AND CAPITAL ASSET PRICING MODEL

The foundation of modern portfolio theory was laid out by Harry Markowitz (1952) in his article about optimal portfolio selection. The article drew attention to the mathematics of diversification and proposed that an investor can reduce the standard deviation of his portfolio returns by choosing stocks and projects that do not fluctuate together. Investors should thus base their portfolio selection on the overall risk-reward characteristics instead of merely compiling portfolios of individually attractive investments. (Markowitz, 1952; Brealey et al., 2006) Since its inception, the modern portfolio theory has profoundly shaped the management of all investment portfolios. Additionally, the mathematics behind the portfolio theory is extensively used in companies' financial risk management efforts.

The modern portfolio theory relies on the fact that even a little diversification can provide a substantial reduction in portfolio variability. Diversification works because the prices of different assets in the portfolio do not fluctuate evenly together. (Brealey et al., 2006) The expected return on a portfolio can simply be defined as the weighted average of the expected returns on the individual assets in the portfolio. This can be written as: (Brealey et al., 2006; Copeland et al., 2005)

$$Portfolio\ variance = \sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j \sigma_{ij} \qquad (1)$$

$$x_{i,j} = proportion\ invested\ in\ an\ asset$$

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j = covariance\ between\ assets\ i\ and\ j$$

When the number of assets in the portfolio increases, its variance steadily approaches the average covariance. This covariance is the limit to the benefits of diversification; all the assets, for instance common stocks, in the portfolio are somehow tied together preventing the elimination of all portfolio risk. (Brealey et al., 2006) This risk that cannot be diversified is generally known as the market risk or unsystematic risk. The risk is affected by economy-wide events and perils that threaten all businesses. Diversification can, however, potentially eliminate a risk related to portfolio's assets called unique risk or systematic risk. This risk stems from the fact that even many similar companies and immediate competitors from the same industry are relatively unknown to each other. (Brealey et al., 2006; Copeland et al., 2005) The total risk of an asset or portfolio includes both unique and market risk (Copeland et al., 2005).

As the unique risk related to portfolios can often be eliminated through diversification, the risk of a well-diversified portfolio depends only on the market risk of the assets included in the portfolio. In order to measure the market risk, the sensitivity of the asset towards market movements need to be determined. This sensitivity is called beta (β), and is generally defined as the relation between the covariance of the market return and individual asset's return, and the variance of the market return.[10] (Brealey et al., 2006; Copeland et al., 2005) The exact equation for an asset's beta is the following (Brealey et al., 2006):

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2} \tag{2}$$

σ_{im} = *covariance between assets return and the market return*

σ_m^2 = *variance of the market return*

The systematic risk of the whole portfolio can be derived from the betas of individual assets; the portfolio beta is simply the sum of all the assets' betas weighted by the relative size of the assets' corresponding holding. Portfolio beta can be presented mathematically as follows: (Brealey et al., 2006; Copeland et al., 2005)

$$\textit{Portfolio beta} = \beta_p = \sum_{i=1}^{N} x_i \beta_i \tag{3}$$

x_i = *proportion invested in an asset*

β_i = *asset beta*

Over a short period of time, the past rates of return of any asset conform closely to a normal distribution. These distributions can be completely defined by two numbers: the average or expected return and the standard deviation, i.e. the risk. Thus, each individual asset is provided by a unique combination of expected risk and return that needs to be considered when mixing investments in the assets. Combinations of assets widen the selection of risk and return; even a combination of two assets can, for instance, decrease the risk substantially whilst keeping the return on a nearby level. Including more assets in the portfolio widens the selection even further. Two examples of how expected return and standard deviation change according to the combination are presented in *Figure 9*. Among all the possibilities to select portfolio

[10] To calculate the beta relative to certain portfolio, one simply divides the asset's covariance with the portfolio by the portfolio variance.

assets, there are combinations that offer the highest return for each level of risk. These portfolios lie along the thicker line and are clearly better than those inside the area of combinations. The portfolios are generally called the efficient portfolios and the line on which they are located is the efficient frontier. (Brealey et al., 2006)

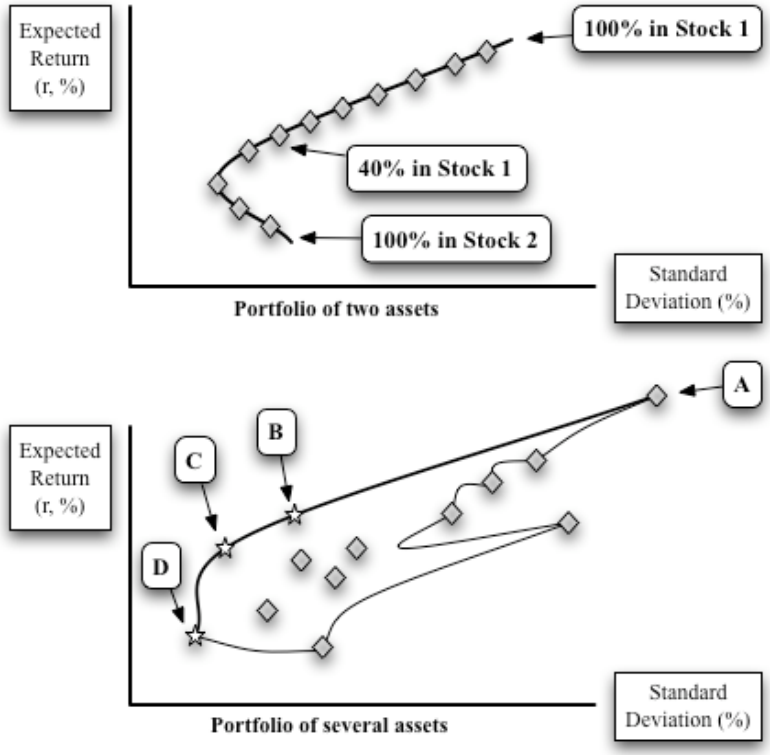

Figure 9 Returns and Standard Deviations for Two Portfolios (Brealey et al., 2006)

The portfolio theory of Markowitz was completed in the mid-1960s by three economists – William Sharpe (1964), John Lintner (1965), and Jack Treynor (1961). They developed an economic model to clarify the market equilibrium concept, called the capital asset pricing model (CAPM). (Brealey et al., 2006; Copeland et al., 2005) The model leans on the risk-aversion of investors; rational investors avoid taking unnecessary risks and require a higher return from a market portfolio than from a low-risk asset. The difference between the return on the market (r_m) and the risk-free return (r_f) is generally termed as the market risk premium. (Brealey et al., 2006) The CAPM shows that the equilibrium rates of return on all risky assets are a function of their covariance with the market portfolio. Thus, in a competitive market, the expected risk premium varies in direct proportion to asset's beta. According to CAPM all investments can be plotted along a sloping line, known as the security market line (please see *Figure 10*). (Copeland et al., 2005; Brealey et al., 2006)

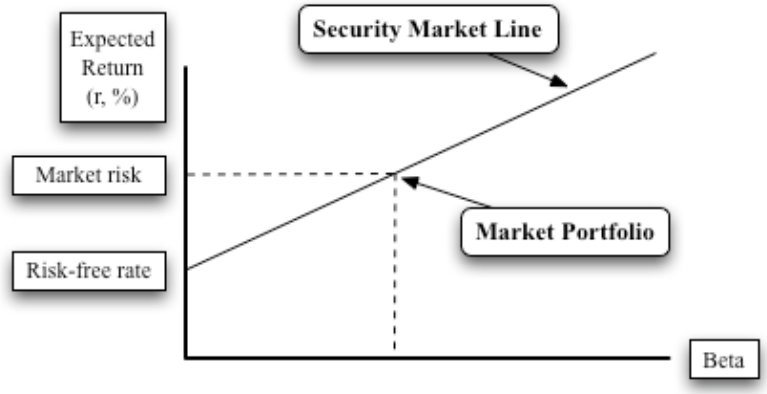

Figure 10 Security Market Line (Brealey et al., 2006)

According to the CAPM the expected risk premium of an asset can be mapped mathematically as the product of beta and the expected risk premium on the market: (Copeland et al., 2005; Brealey et al., 2006)

$$r - r_f = \beta(r_m - r_f) \tag{4}$$

r = *expected return on investment*

r_f = *risk – free return*

r_m = *market return*

β = *beta*

This can further be written as:

$$E(r_j) = r_f + \beta_p(E(r_m) - r_f) \tag{5}$$

$E(r_j)$ = *expected rate of return on investment*

r_f = *risk – free return*

$E(r_m)$ = *expected rate of market return*

β_p = *portfolio beta*

Once the expected return of an asset is calculated using the CAPM, the future cash flows of the asset can be discounted to their present value and, further, a price for the asset can be established. The model can thus be used when comparing the asset prices; CAMP observes differences in prices and can detect overvaluation or undervaluation. Additionally, the usefulness of CAPM relies on its benefits when decision-makers estimate the required rate of return for projects and investments with different risk. The model also improves the managers' observation over underlying themes such as the market movements, and it is therefore found to be a convenient tool for mapping risks. (Copeland et al., 2005)

Despite its popularity, though, CAPM has encountered several challenges: there is some evidence that the model is not as convincing as initially thought. (Brealey et al., 2006) Due to the deficiencies of CAPM, other models concerned with the market equilibrium have also been developed. Perhaps the most important of these models is the arbitrage pricing theory (APT) by Ross (1976). The ATP model expands the narrow limitations of CAPM and allows numerous factors to explain the equilibrium of a risky asset. (Copeland et al., 2005; Brealey et al., 2006)

3.2.3.2 RISK MANAGEMENT TOOLS AND FRAMEWORKS

Value-at-Risk (VaR) has become one of the essential tools for risk management, especially when quantifying market risks. For instance, within oil markets, VaR can be used to quantify the maximum oil price changes associated with a likelihood level. This quantification can further be used when designing risk management and hedging strategies. VaR is generally defined as the maximum amount of money that may be lost on a portfolio over a given period of time, with a given level of confidence. (Sadeghi & Shavvalpour, 2005) VaR, thus, describes the loss that can occur over a given period due to exposure to market risk (Sadeghi & Shavvalpour, 2005; Basak & Shapiro, 2001). VaR is especially useful when interpreting the measure of risk, and also appeals as it allows its users to focus their attention on normal market conditions (Basak & Shapiro, 2001). Several VaR quantification methods exist, generally based on historical information. These methods include the Historical Simulation Approach, the Monte Carlo Simulation method, and Variance-Covariance methods (Sadeghi & Shavvalpour, 2005).

Another well-known risk management tool is a simple form of scenario analysis, called stress testing. Closely resembling VaR, stress testing considers changes in different risk factors over a single time horizon to gauge the company's potential vulnerability to exceptional but plausible events. The scenarios are built either by drawing on a significant past events or by thinking through the consequences of future market events. Estimated impacts and values are then compared to the company's current portfolios. Several stress testing techniques exist, ranging from simple scenarios with few variables to more exhaustive scenario analysis methods. Stress testing often complements VaR in companies' risk management. (BIS, 2000)

Of the risk management frameworks, one of the most popular is Enterprise Risk Management (ERM). The approach aims at assessing the business risks and to develop programmes for managing those risks (O'Donnell, 2005). Unlike traditional approaches to corporate risk management, ERM enables companies to benefit from an integrated, enterprise-wide approach to managing risks (Liebenberg & Hoyt, 2003). Additionally, in order to fully benefit from ERM, companies must expand their narrow concepts of risk to include more general economic and political factors, such as reputation, ethics, and data integrity (O'Donnell, 2005). This integrated ERM approach benefits companies by decreasing earnings and stock-price volatility, increasing capital efficiency, and creating synergies between the different risk management activities. ERM is also believed to promote management awareness and translate it into better operational and strategic decision-making. (Liebenberg & Hoyt, 2003) Several processes and tools around the ERM approach exist, including a framework by the Committee of Sponsoring Organizations of the Treadway Commission (COSO). This framework encompasses key principles and concepts, clear steps, and guidance for the utilization of ERM in a company. (COSO, 2004)

The main financial risk management practises are summarised in *Figure 11*.

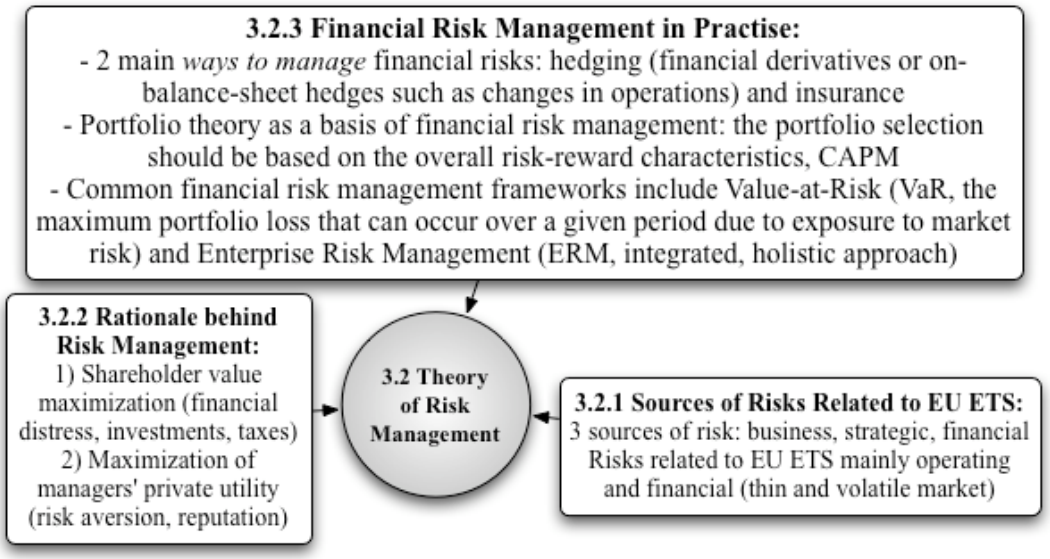

Figure 11 Financial Risk Management in Practise

3.2.4 Implications of Risk Management Theory

The implications of risk management theory are numerous. Risks related to EU ETS were shown to be wide-ranging; business risk arose from the uncertainties of the implementation of the scheme, and financial risks – mainly market and liquidity

risk – from the thinness and underdeveloped nature of the market. The complexity of these risks requires risk management; the traditional risk management can sometimes be too little, as especially the business risks require more robust management practises. Of the financial risk management techniques presented, the most relevant with the EU ETS and EUA trading seem to be hedging through trading, and on-balance-sheet activities, such as improved forecasting and monitoring.

The risk management models and frameworks are abundant. Portfolio theory and capital asset pricing model map the premises behind financial risk management, and models, such as Value-at-Risk and stress testing, are instruments designed to improve and ease companies' risk management activities. As the financial risks related to the EU ETS are somewhat general in nature – the EUA market resemble any other market – the theories and tools around financial risk management techniques can be extended to include also the risks related to the EU ETS.

The implications deriving from risk management theory are presented in *Figure 12*.

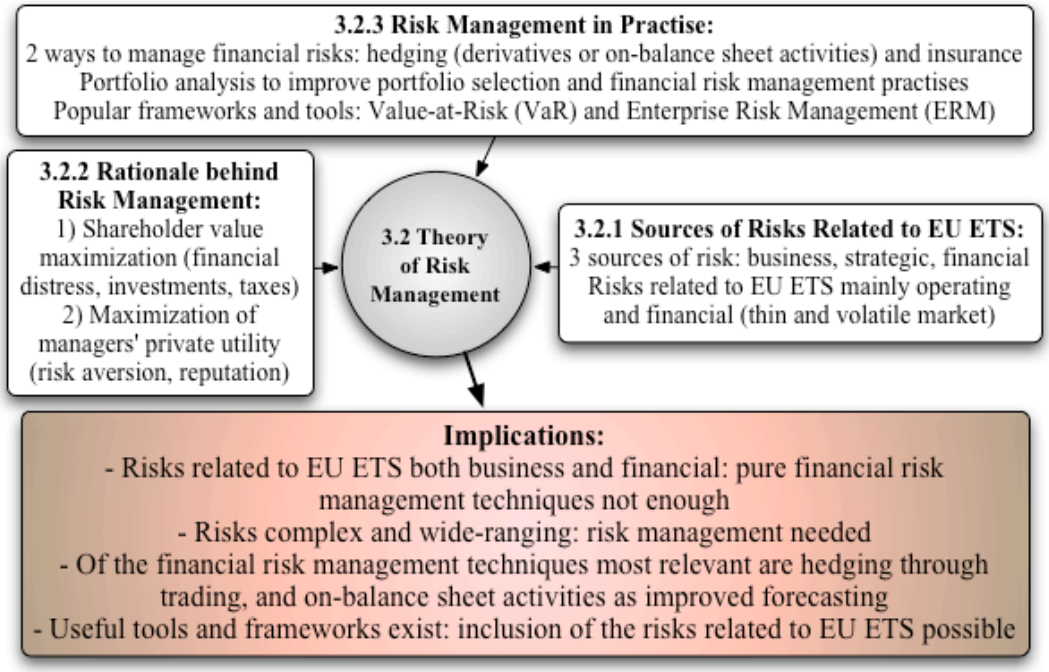

Figure 12 Implications of Risk Management Theory

3.3 EMISSIONS TRADING IN PRACTISE

3.3.1 COMPLIANCE STRATEGIES

Individual emitting companies themselves are responsible for ensuring that they hold a sufficient amount of EUAs to offset their emissions; the companies have the

flexibility to administer their emission levels in the most cost-effective way possible (Subramanian, 2005). Generally, companies complying with the EU ETS can use various approaches to meet their targets. These approaches and compliance strategies can contain internal compliance options, such as internal abatement and production halts, and external options including emissions trading, investments in carbon funds, and participation in the Kyoto project mechanisms (Rogge et al., 2005).

Internal compliance strategies emphasise the possibilities to reduce the companies' emissions in the EU area. Internal abatement is perhaps the most discussed internal compliance strategy; fuel substitution towards low-carbon fuels, mainly switching from coal to natural gas, is seen as one of the key options for emission reductions in the whole EU area. Achieving significant reductions in emissions usually requires substantial capital investment in new equipment. Due to the somewhat high estimated costs of abatement, many companies depend on interim solutions such as production reductions or halts, or even decide to divest or relocate the emitting installations permanently.

External compliance strategies, on the other hand, concentrate on obtaining more allowances or emission reduction credits to match the companies' emissions. Companies can obtain the needed allowances or credit through trading; EUAs already have a sophisticated market organisation. Additionally, companies may invest in carbon funds or set up projects related to Kyoto Protocol's flexible mechanisms to obtain more credits to cover their emissions.

The individual compliance strategies are summarized in *Figure 13*. Carbon Funds are explained in detail in *Chapter 3.3.3 Carbon Funds* and the Kyoto Protocol's project mechanisms in *Chapter 3.1.3 The Kyoto Protocol*.

Figure 13 Compliance Strategies

3.3.2 MARKET ORGANISATION

The legal framework of the EU ETS does not regulate how and where the trading of carbon assets (mainly EUAs) takes place. Installations with commitments may trade assets directly with each other, buy or sell them via a broker, bank or other market intermediary, or even use the organised markets, namely exchanges, to trade assets. (EU, 2006) The following chapters introduce the tradable carbon assets, the market organisation around these assets, and the financial instruments on the market.

3.3.2.1 CARBON ASSETS

It has been recognised that emission reduction projects have a measurable advantage over other types of projects in terms of their positive contribution to climate change mitigation (Tang, 2005). This potential of greenhouse gas emission reductions, that a project is able to generate and sell, is generally referred to as a carbon asset (CFU, 2006). Many types of carbon assets exist; assets are created under international and national local regimes or through private contracts outside these legal frameworks. Most of these carbon assets share a common base – they are usually based on a common unit of one t CO_2 reduced, or an allowance to emit one t CO_2. Emissions trading can be simplified to cover the creation and sale of these assets. (Tang, 2005)

Carbon assets that are related to this thesis derive from the Kyoto Protocol and EU ETS; thus they are statutory-based rights gaining their existence from statutes or treaties (Tang, 2005). These assets are presented in *Table 6*. As the AAUs are only issues to Annex I Parties and RMUs are not yet used in everyday trading, the focus of the trading procedures and market organisation outlined in the following chapters will be on the credits used within the EU ETS, on CERs, ERUs, and EUAs.

Table 6 Carbon Assets under the Kyoto Protocol and the EU ETS

Carbon Asset	Description
Assigned Amount Unit, AAU	Units that are issued to Annex I Parties to the Kyoto Protocol; amount of AAUs determine how much the Party is entitled to emit
Certified Emission Reduction, CER	Unit of emissions reductions created through CDM projects
Emission Reduction Unit, ERU	Unit of emissions reductions generated through JI projects
European Union Allowance, EUA	Units that are issued to liable installations under the EU ETS; represent an allowance to emit one tonne of carbon dioxide
Removal Unit, RMU	Unit of emissions reductions created through investments in sinks (deforestation, afforestation etc.)

3.3.2.2 FINANCIAL INSTRUMENTS

Carbon assets, mainly EUAs, can be traded according to five basic financial structures: immediate (spot) settlements, forward contracts, futures contracts, option settlements, and swaps. Of these instruments, spot settlements, forwards, and futures are the most used at the moment; options and swaps are still in their emerging stage.

In spot settlements the terms of a bid and offer are set on the day of the trade with a delivery and payment occurring shortly after the trade. Spot price represents the current market price of the commodity or asset. (Copeland et al., 2005; IETA, 2006)

Forward contracts, on the other hand, are cash contracts in which the seller agrees to deliver a specific amount of the underlying asset with a set price to a buyer at a specified time and place in the future. At the time of the delivery the buyer then receives the asset and pays the contract price. As the delivery and payment of the assets are deferred to a future date, the parties may gain profit (or loss) from the difference between the market value of the asset and the contract price. (Copeland et al., 2005; IETA, 2006) Forward contracts are themselves usually highly unique, with varying terms even between similar forward contracts (Brealey et al., 2006).

Also futures contracts are legally binding agreements to buy or sell commodities or assets sometime in the future. The contracts themselves are standardized with specified quantity and delivery time, leaving the price as the only variable item; price is generally settled on the final trading day of the contract, usually summing up the spot price of the trade date and a pre-determined margin. Futures contracts are generally traded on exchanges. (Brealey et al., 2006; Copeland et al., 2005)

Option settlements are derivative products in which the trading parties settle the right, not obligation, to buy or sell allowances at a certain price for a limited length of time. Thus, the owner of an option settlement can decide to buy or sell, i.e. to exercise on or prior to the pre-determined option expiration date. An American option allows the option to be exercised at any time up to the expiration date; a European option can be exercised only on a specific future date. Two basic structures of options exist: call options allow buyers the right to purchase allowances at a specified date at a specified price, and put options allow sellers the right to sell allowances at a set price. (Copeland et al., 2005; Brealey et al., 2006)

Swap settlements enable companies to change floating rates or cash flows as fixed; they exchange streams of payments over time according to specified terms (Brealey et al., 2006). A simple swap can thus be defined as "an agreement whereby a floating price is exchanged for a fixed price over a specified period". The agreement itself is off-balance-sheet financial arrangement that involves no transfer of physical products: both parties settle their obligations by means of a cash transfer. Swap settlements usually define the volume, duration, fixed price and floating price of the instrument in question. Swap settlements in the trading of EUAs are still relatively rare; only simple forms of swaps exist, and the market is almost nonexistent. As the markets for carbon assets continue to grow, though, the emergence of a true swap market on these new assets also likely to follow (Kaminski, 2004).

Of the financial instruments used for EUA trading, forwards, futures, options, and swaps are known as derivative instruments or derivatives as their value generally depends on the value of another assets including other commodities, interest rates, currencies, stocks, and stock indices. Derivatives are generally considered as a basic financial risk management instruments at companies' disposal. (Brealey et al., 2006)

The financial instruments used in EUA trading are summarised in *Table 7*.

Table 7 Financial Instruments for EUA Trading

Instrument	Description
Spot	Terms are set on the trade date with a delivery and payment occurring shortly after the trade
Forward	Seller agrees to deliver a specific amount of allowances with a set price to a buyer sometime in the future; delivery and payment deferred to future time
Futures	Contracts that are standardized with specified quantity and delivery time, leaving the price as the only variable item
Option	Settle the right, not obligation, to buy or sell allowances at a certain price for a limited time
Swap	Agreement whereby a floating price is exchanged for a fixed price over a specified period; no transfer of actual physical product

3.3.2.3 TRADING PLATFORMS

There are three basic trading platforms through which companies that have obligations under EU ETS can trade their EUAs: bilateral trading, commodity exchanges, and over-the-counter (OTC) brokers. Bilateral trading encompasses direct trading between two parties, on a company-to-company basis. Around one fourth of

the total traded volume of EUAs in 2005, 100 Mt CO_2, corresponding to € 1.8bn, was estimated to take place in the bilateral market (Point Carbon, 2006a).

At the moment, a majority of EUA trading takes place in exchanges or through wholesale or retail OTC brokers. The brokered and exchange market of EUAs in 2005 totalled to 262 Mt CO_2, corresponding to € 5.4bn. (Point Carbon, 2006a) Wholesale OTC brokers provide mainly EUA forward trading for companies and installations with defined contracts, established credit relationships with trading partners, and defined delivery dates. Retail OTC brokers, on the other hand, provide more customised transactions and flexible structures for buyers who seek to address their compliance shortfall. (Capoor & Ambrosi, 2006)

Over the last years, exchange platforms and auctions have increased their popularity over the OTC brokers. Exchanges simplify the transactions, reduce risks, and help make the trading prices more transparent. (Capoor & Ambrosi, 2006) Currently six exchange platforms trade EUAs in the EU area. Of these exchanges European Climate Exchange (ECX), Nord Pool, and Powernext have the biggest trading volumes, ECX having a share of 63 % of the traded volume. (Point Carbon, 2006a) Some of the exchanges also trade other commodities such as power (Nord Pool, Powernext), and several of the exchanges are preparing to trade CERs (Capoor & Ambrosi, 2006). In 2005 79 % of the traded volume went through the OTC brokers, but the share of trading through exchanges is approaching 50 % already in 2006 (Point Carbon, 2006a; Capoor & Ambrosi, 2006).

3.3.2.4 SERVICE PROVIDERS AND EXTERNAL PARTIES

Several external parties and service providers support the EU ETS and EUA market activities. These external parties cover several product segments, including financial intermediaries, carbon market consultants and advisors, law firms, and carbon funds (IETA & CFU, 2006). The services provided include EUA market analyses and information, price models, consultancy, and actual trading.

The market organisation – carbon assets, market intermediaries, financial structures, and external parties – related to EU ETS is summarized in *Figure 14*.

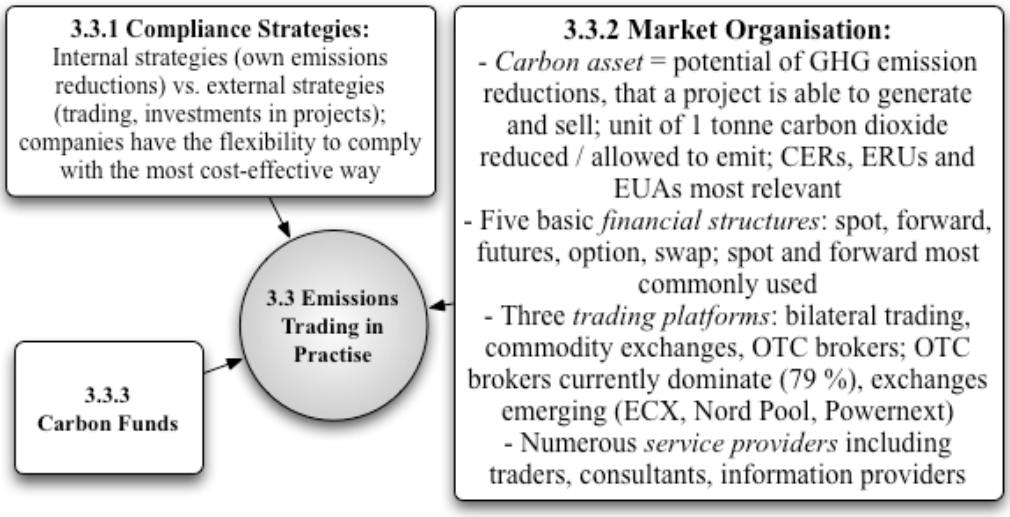

Figure 14 Market Organisation

3.3.3 CARBON FUNDS

The era of carbon funds began when the first carbon fund, the World Bank Prototype Carbon Fund (PCF) became operational in April 2000. Since then the amount of funds has increased; today there are a significant number of funds, in both the public and private sector, spurred by the companies' and countries' need to meet their targets under Kyoto Protocol or EU ETS. (CFU, 2006; Tang, 2005) The fund participants are generally seeking secured offsets that will become available through the various CDM/JI projects that the funds are investing in (Tang, 2005). Currently, carbon funds are relatively popular: total fund investments are already in billions, and several funds have exceeded their targets for obtained investments. Funds also equate to almost 43 % of the purchases in the CDM/JI market. (Point Carbon, 2006a)

The premise behind the carbon fund concept is the assumption that a joint effort when purchasing CERs and ERUs, i.e. participating in the Kyoto Protocol's project mechanisms, introduces the advantages of large investment portfolios. Even the most basic form of carbon funds, purchasing pool or buyers' pool, can improve the diversification of portfolios, bring economies of scale and decrease fixed costs, as well as enable the hiring of an expert manager. (Tang, 2005) Additionally, despite the potentially inexpensive nature of participating in CDM/JI projects, the full utilization of the mechanisms includes several risks, such as project and counterparty risks. Carbon funds decrease these risks and increase the potential return. (Korthuis, 2005) The value of the funds essentially relates to their often-superior performance compared to the price of credits delivered (Tang, 2005).

There are various operating models for carbon funds; most are closed-end funds or investment trusts that sell a fixed number of shares during a limited time without any obligations to buy back the fund shares. Carbon funds can also be pure purchasing pools without a formal fund structure, or mutual funds with more freely traded fund shares. (Tynjälä, 2005) Funds usually invest in emission reduction projects in the developing world or in EIT countries, and pay on delivery of the verified emission reductions (CFU, 2006). Deliverables of the funds are typically emission reduction credits, CERs or ERUs, or, in some cases, also cash (Tynjälä, 2005).

Details regarding carbon funds are summarised in *Figure 15*.

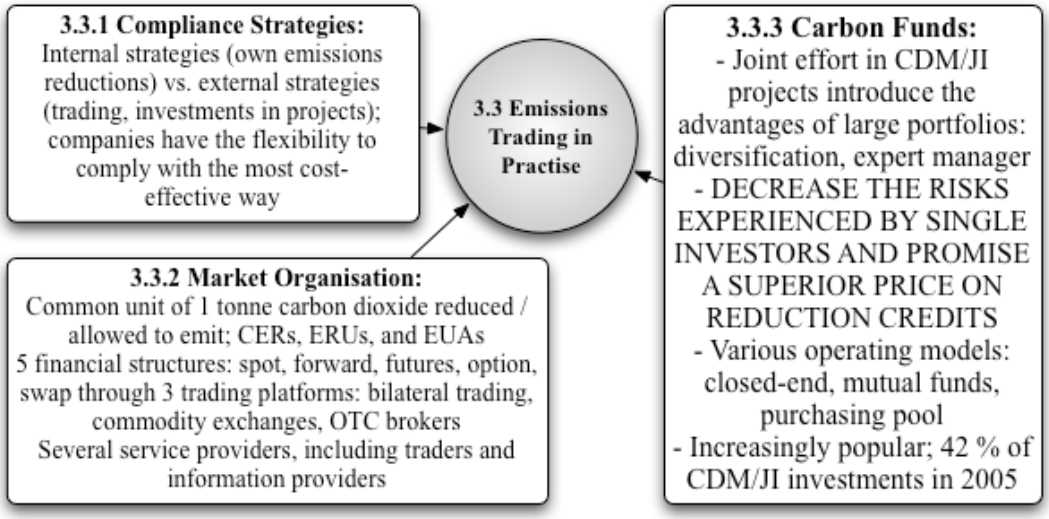

Figure 15 Carbon Funds

3.3.4 Implications of Emissions Trading in Practise

The implications of the EU ETS for companies with emission targets are numerous. Companies are required to monitor and control their emissions, to report them to the authorities and to cover them with tradable credits. Companies have, though, several ways to comply with the emission targets set by the EU ETS. These ways include internal compliance strategies aimed at emission reductions and external strategies which aim to obtain more emission credits. Building a suitable portfolio of compliance strategies enable the companies to comply with the emission targets flexibly, in the most cost-effective way.

Despite the numerous new assets – CERs, ERUs, and EUAs – introduced by the EU ETS, the market organisation around them is relatively traditional and resembles other commodities markets. The financial instruments and the trading platforms

related to actual EUA trading are very similar to those used, for instance, in the power market; assets are traded in spot prices or derivative instruments through bilateral trading, OTC brokers or exchanges. The similarity to trading of other commodities helps those EUA trading companies who do also trade with these other commodities. Additionally, the numerous service providers and external parties related to EUA trading can improve the trading of the companies unused to it.

The implications derived from emissions trading practises are outlined in *Figure 16*.

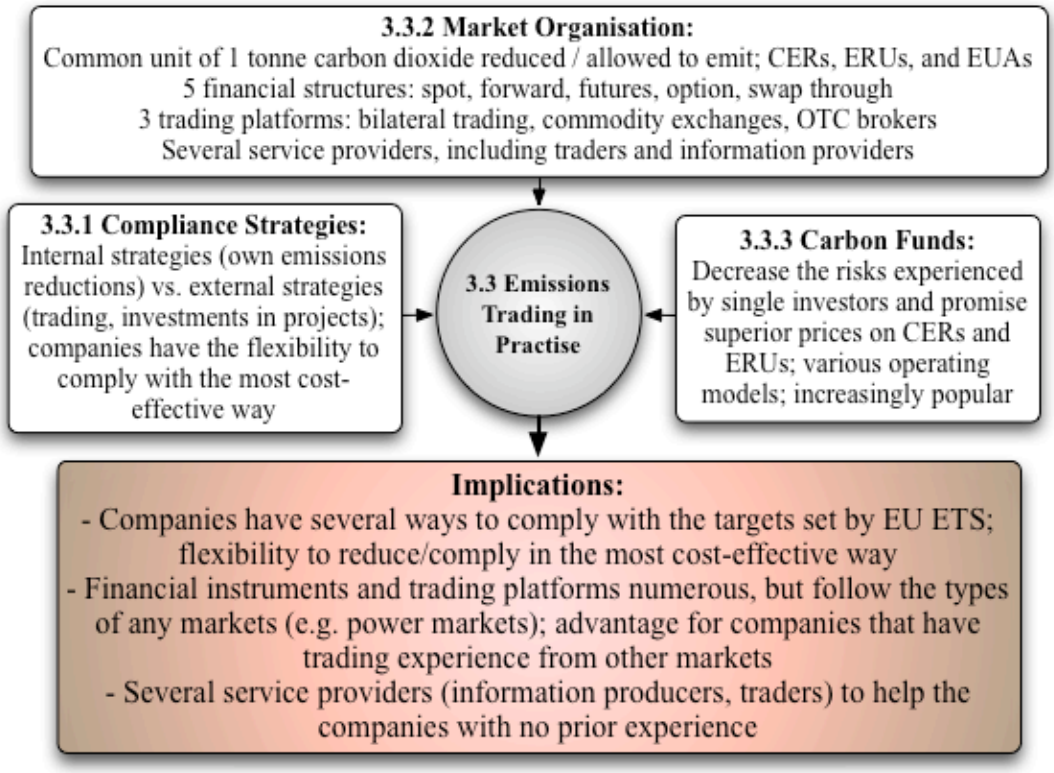

Figure 16 Implications of Emissions Trading in Practise

4 RESULTS

The survey results of this thesis are presented in this section. The results are presented according to the themes outlined in the survey questionnaire (please see *Chapter 2.2.2.2 Survey Questionnaire*). Firstly, the results regarding the whole data set are laid out, after which the results according to the different categories created are listed. As a synthesis, findings related to the survey results are concluded and discussed in the end of the section.

4.1 WHOLE DATA SET

4.1.1 BACKGROUND INFORMATION

Of the 47 approved respondent companies, a clear majority (60 %) represented energy activities and therefore had combustion installations, mineral oil refineries or coke ovens in their possession. The rest of the respondents were from energy-intensive industries, mainly from the mineral industry. Six of the respondent companies (13 %) were from industries not included in the EU ETS as such, from food processing and the chemical industry, but who mentioned energy production including in their operations. These companies were grouped under the category "Other". The shares of respondent companies divided by EU ETS activities are presented in *Figure 17*.

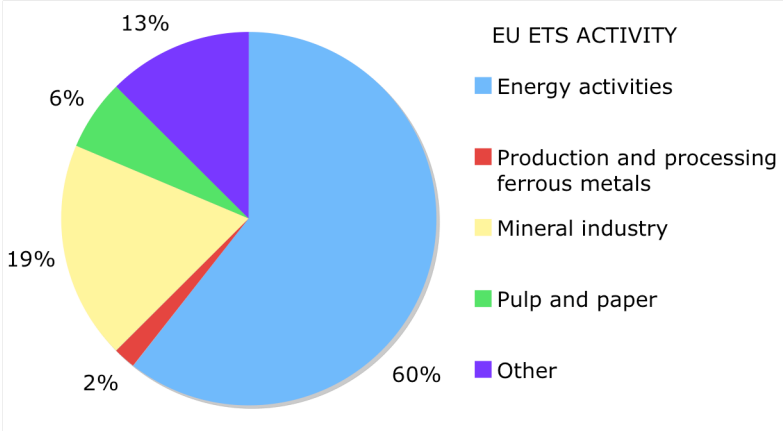

Figure 17 Respondent Companies by EU ETS Activities

A high proportion of the respondent companies (29 %) had their domicile in Finland. This was natural, as a large proportion of the 192 selected companies to whom the questionnaire was sent were Finnish (56 companies). All respondent companies had their domiciles in Europe, including one respondent company that had its domicile in

Norway, in a non-EU country. Of the major countries under the EU ETS, only Spain and Italy lacked respondent companies. The domiciles of the respondent companies are presented in the *Figure 18* together with the amount of questionnaires sent.[11]

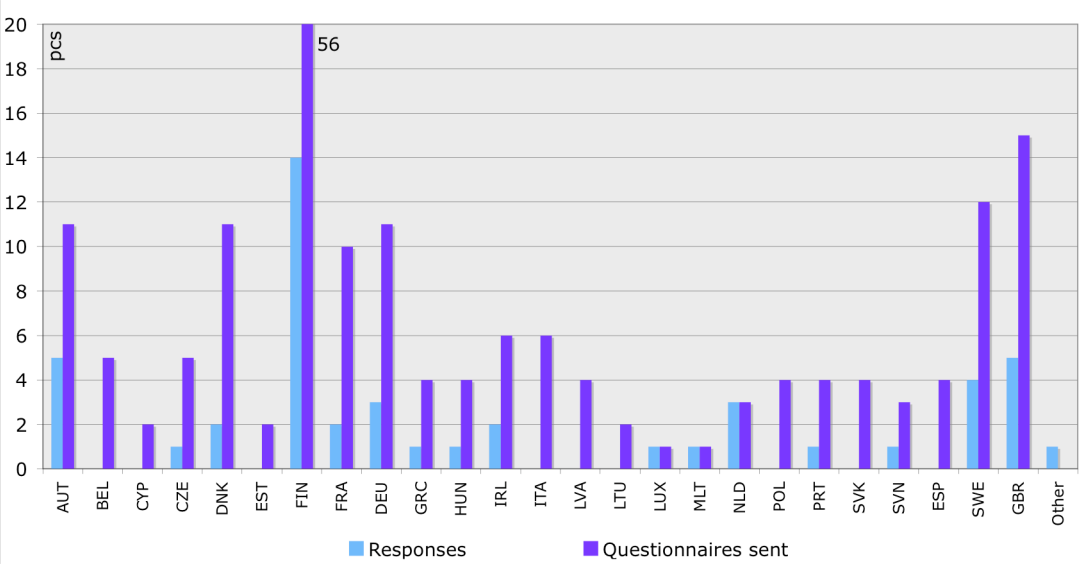

Figure 18 Amounts of Sent Questionnaires and Domiciles of the Respondent Companies

The respondent companies were generally large in size; no companies with sales of less than € 20m, or fewer than 20 employees participated in the survey. The absence of smaller companies may be explained by the thresholds of the EU ETS Directive – smaller companies are often unable to exceed these thresholds. Additionally, contacting smaller companies was generally harder in the company selection phase, as information about the companies was usually very scarce. The shares of respondent companies according to different size categories are shown in *Figure 19.* The size categories both in respect of sales and personnel were equal to the categories in the original survey questionnaire. Categories that did not receive any responses were omitted.

[11] Note that companies that were mentioned in multiple NAPs were marked under their assumed domicile (please see *Chapter 2.2.2 Primary Data Sources*).

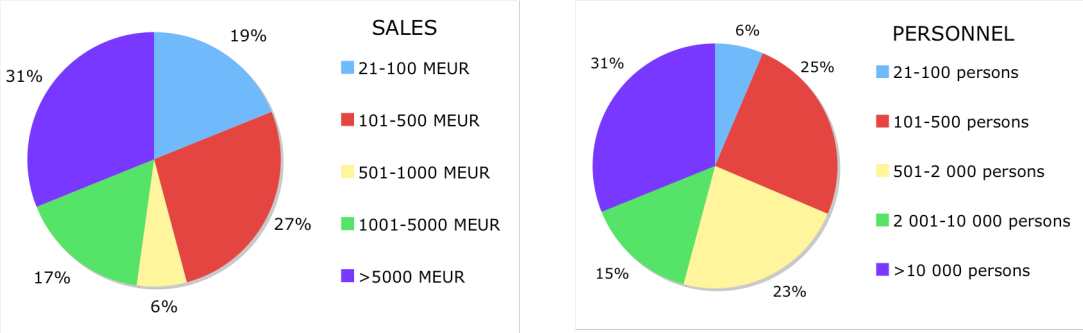

Figure 19 Sizes of the Respondent Companies (Sales and Personnel)

The ownership structures of the respondent companies fell into three main categories: limited (Ltd.) or incorporated (Inc.) companies, listed companies, or public limited companies (plc), and state- or municipality-owned companies. Few of the respondent companies had other ownership structures, such as a single private owner or private limited company. The division according to the different ownership structures is presented in *Figure 20*.

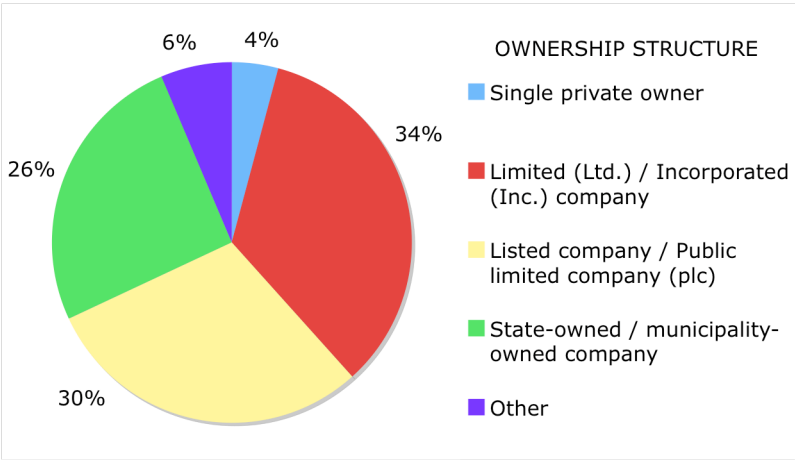

Figure 20 Ownership Structures

Over two thirds of the respondent companies operated in non-domestic markets, with almost half of the companies (48 %) operating internationally. The majority of the respondent companies (54 %) had less than 10 installations that were covered by the EU ETS. Only four companies (8 %) possessed more than 50 installations that were included in the EU ETS. The amounts of installations of the respondent companies are presented in *Figure 21*.

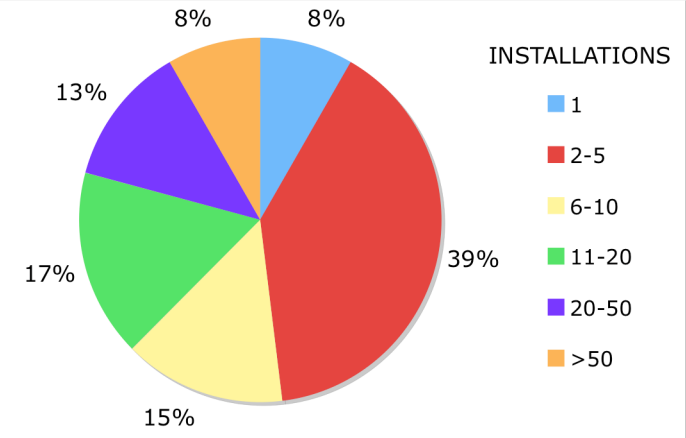

Figure 21 Amounts of Installations Covered by the EU ETS

The locations of the respondent companies' installations included all EU Member States except Cyprus. Countries named by the highest amount of respondents were Austria (9 respondent companies had installations in the Member State), Finland (16), Germany (15), Italy (8), Sweden (11), and the UK (12). Thus, despite the absence of Italian and Spanish companies from the group of respondents, several of the respondent companies had installations situated in Italy (8 respondents) and Spain (6).

A majority of the respondent companies had annual emissions lower than 5 Mt CO_2, for the first trading period in 2005-2007; 35 % of the companies had their yearly emissions between 0-0.5 Mt CO_2 and 38 % between 1-5 Mt CO_2. Almost half of the companies estimated that they would have either a slight surplus of 0-0.5 Mt CO_2 in their amount of EUAs for the same period, or would have neither a surplus nor deficit. Only 28 % of the companies were estimated to have a deficit during the first trading period. None of the respondent companies expected their emissions to change substantially for the second trading period, 2008-2012. The emissions were expected to remain at the same level or increase or decrease slightly. The estimated annual emissions of the respondent companies, together with the annual surplus / deficit for 2005-2007 are presented in *Figure 22*.

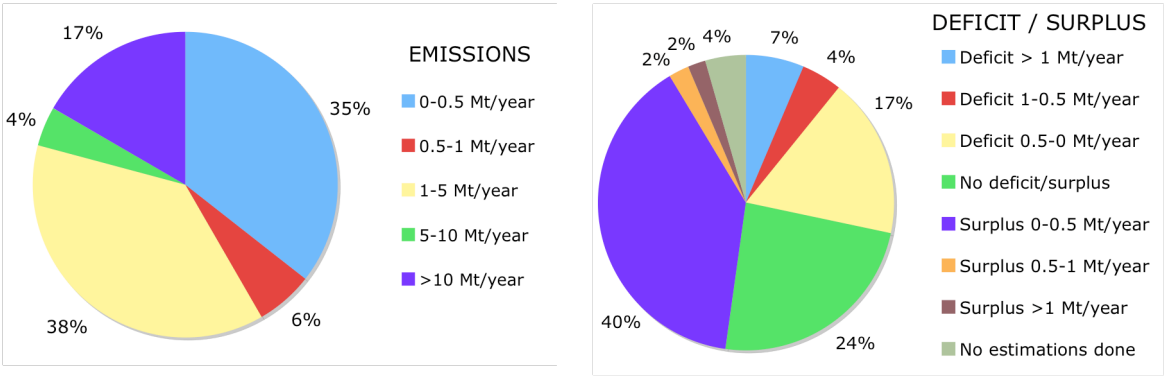

Figure 22 Annual Emissions and Surplus / Deficit (2005-2007)

4.1.2 EU ETS Operations

All of the respondent companies had determined functions or departments that have the overall responsibility for EU ETS affairs within the company. The majority of the companies considered the affairs as the responsibility of Environmental or HSE functions, or of operations and production of the company. Only few companies had given the responsibility over EU ETS affairs to their strategy and business development functions or to their trading department. Eight companies detailed the responsibility lying within several functions (e.g. trading and production) or mentioned their energy purchasing or product development functions. *Figure 23* presents the shares of the functions bearing the responsibility for EU ETS operations.

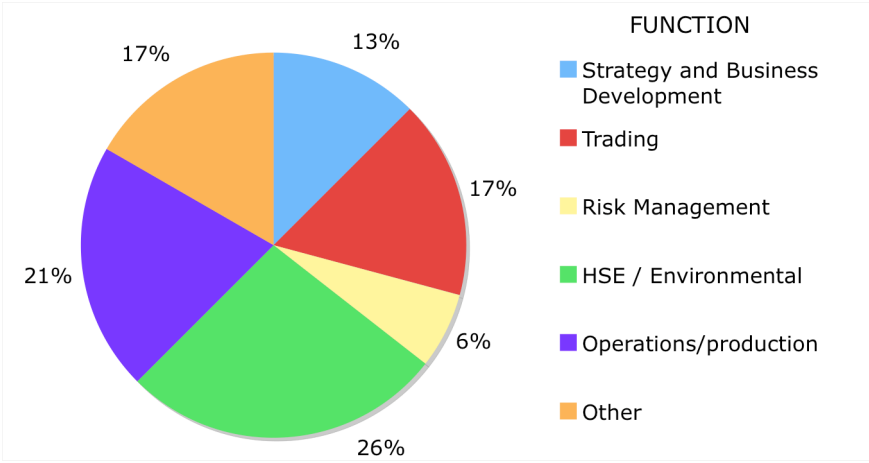

Figure 23 Functions Responsible for EU ETS Operations

All of the respondent companies had employees working on issues related to the EU ETS. One fifth of the companies had full-time employees supplemented by employees working partly on the EU ETS affairs, and another one fifth had only full-time employees. Thus, almost 60 % of the respondent companies had employees

working only part-time on issues related to the EU ETS. Of the companies having full-time employees responsible for the EU ETS, majority (10 companies, 50 %) had 2-4 employees. One fourth had only one full-time employee and another fourth had 5-10 employees. Companies having part-time employees had mainly 2-4 employees (46 %) or 5-10 employees (30 %). Two companies had 10-20 part-time employees, and three companies had more than 20 part-time employees working on the EU ETS affairs. The amounts of full-time and part-time employees in the 47 approved respondent companies are presented in *Figure 24*.

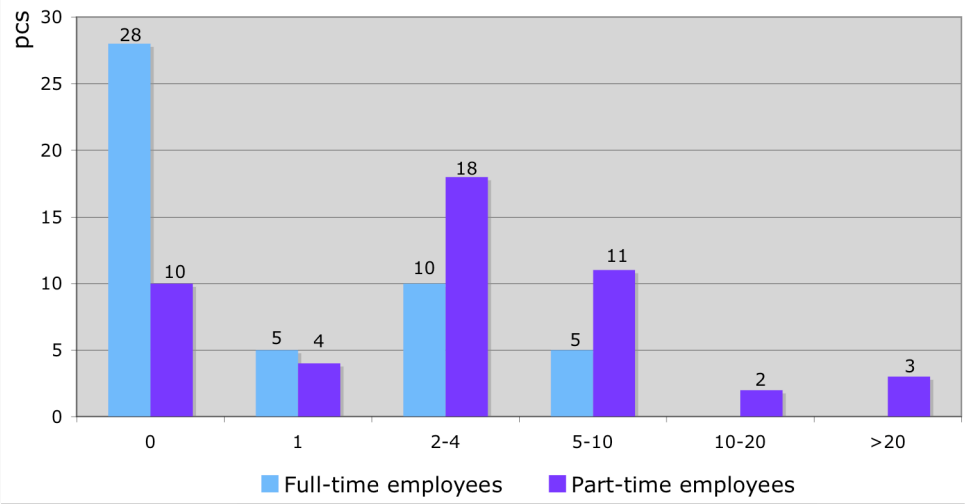

Figure 24 Full-time and Part-time Employees for the EU ETS Affairs

The organisation of the EU ETS operations within the respondent companies varied slightly. Three general structures were distinguishable: overall responsibility held by one or few persons, central coordination and decision making on all EU ETS areas, and central coordination combined with decentralising part of the EU ETS operations. Companies that had one or few persons responsible for their whole EU ETS operations typically relied on them in monitoring, reporting, and even trading activities. Companies having central coordination for EU ETS affairs usually had several different administrative functions responsible for different parts of the EU ETS affairs. Companies with central coordination and decentralised parts, on the other hand, relied on central coordination and decision making on bigger issues, but had shifted the day-to-day operations regarding monitoring and reporting to lower levels, usually to operations or individual business units. Few of the companies also allowed decentralised trading, and few had established steering committees or groups to handle their EU ETS affairs.

A majority of the respondent companies started their official EU ETS operations in 2004 or 2005. Only one fifth of the companies mentioned that they had started their operations before the year 2003. Some companies mentioned that they had been actively involved already in the concept building stage of EU ETS, and some had started their initial preparations by the end of the 1990's. *Figure 25* outlines the different start years of the EU ETS operations among the respondent companies.

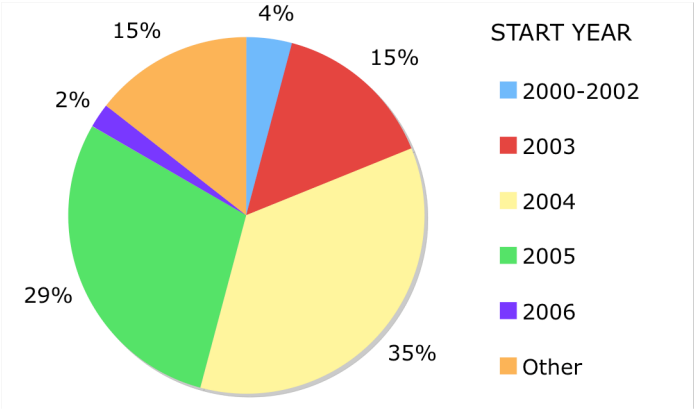

Figure 25 Start Years of the EU ETS Operations

A clear majority, over 75 % of the respondent companies, cooperated with external parties in their EU ETS operations. Of the companies having cooperation partners, the majority had at least one (36 %) or two (33 %) external parties that they cooperated with. One fourth cooperated with three external parties and two companies (6 %) with four different parties. Of the external parties used, market information providers and brokers were the most popular. 63 % of the companies cooperating with external parties used the market information providers, and 51 % used brokers. Other external parties included mainly trading partners, other companies, and the subsidiaries and mother companies of the company in question. Only two of the respondent companies cooperated with external price model providers. Those companies having cooperation with two parties usually relied on market information providers and brokers or cooperated with market information providers and banks. Companies having cooperation with a single external party cooperated most often with market information providers, brokers or banks. External parties and their popularity among the 47 respondent companies are listed in the *Figure 26*.

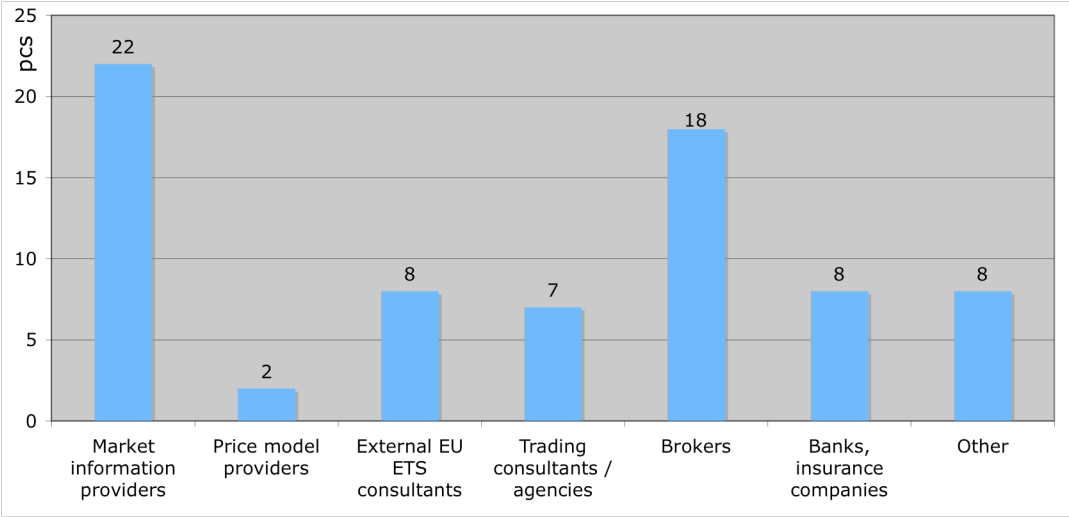

Figure 26 Cooperation with External Parties

Of the external parties mentioned by the respondent companies, information providers, and consultants such as the Norwegian Point Carbon, and the Finnish GreenStream Network Ltd. were mentioned several times. Additionally numerous different banks, verifiers, traders, and even national registries were mentioned at least once.

4.1.3 Risk Management Strategies and Practises

More than three quarters of the respondent companies had specified a risk management strategy for EU ETS. A majority of these companies (83 %) had formulated a single strategy for their EU ETS risk management, whilst the rest had a combination of two different strategies. The most common type of EU ETS risk management strategy was a clear, separate strategy. Companies having a combination of strategies usually had a separate EU ETS risk management strategy as part of their risk management strategy for power markets. Half of the companies that had not defined a risk management strategy especially for EU ETS used their general risk management strategy with the issues related to EU ETS. Altogether 5 respondent companies (11 %) neither had an EU ETS risk management strategy nor used their general risk management strategy with EU ETS affairs. *Figure* 27 lists the different EU ETS risk management strategies in the respondent companies.

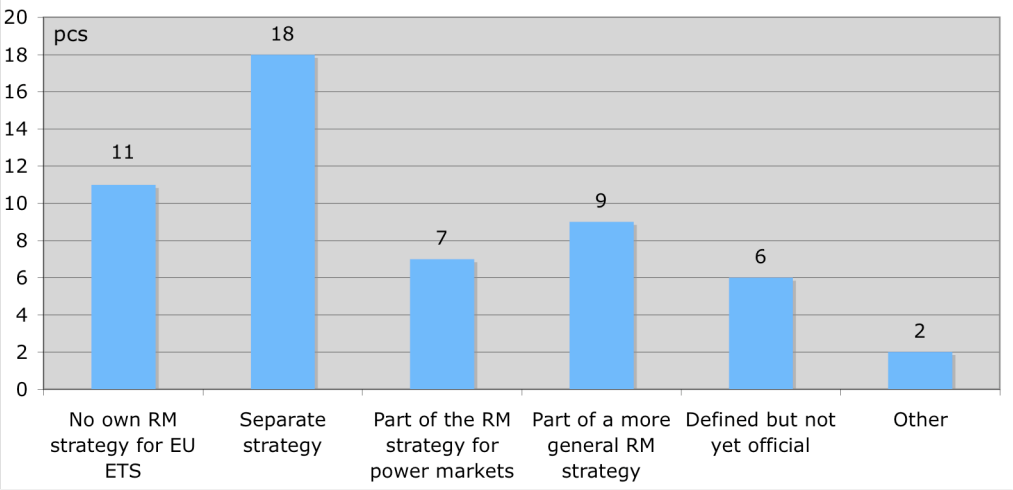

Figure 27 Risk Management Strategies for EU ETS

The majority of those respondent companies that had a risk management strategy for EU ETS had determined risk limits or positions (56 % of the companies), persons responsible for EU ETS issues (78 %), and the schedules of adjustments or updates in their portfolio (53 %) in their risk management strategy. Additionally, a majority of the companies (78 %) had also determined the nature of their EUA trading, i.e. if the trading can be carried out speculatively or not. At least two items in the EU ETS risk management strategy had 86 % of the companies, one fifth having two items and 43 % having three items. Those having two items had usually included responsibilities over EU ETS and the nature of trading, and companies with three items in their EU ETS risk management strategy added also schedules of adjustments or updates in their strategy. The different items included in the EU ETS risk management strategies of the respondent companies are outlined in *Figure 28*.

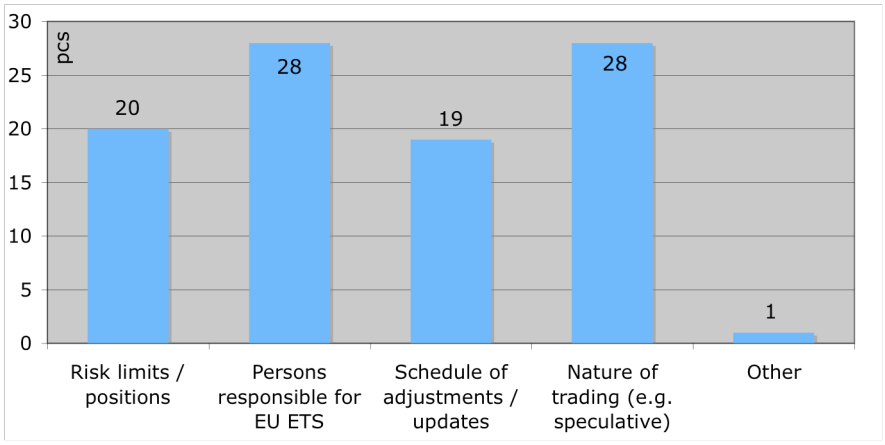

Figure 28 Items Included in the EU ETS Risk Management Strategies

When describing their EU ETS risk management strategies in detail, respondent companies revealed themselves to be relatively careful. A majority of the companies

tried to balance their emissions to allow a slight surplus in the number of EUAs in their disposal at all times. Additionally, most of the companies had defined a clear non-speculative trading policy, and were only allowed to trade within certain time and amount limits. Some companies also emphasised the importance of accurate information about past and future levels of emissions.

Most respondent companies having an EU ETS risk management strategy stated that their strategy aimed for moderate return with low risks. Only one of the companies characterised its strategy as giving higher return with higher risks. Four respondent companies (11 %) had a risk neutral or risk minimisation strategy, and did not value the possible return. The shares of the different risk and return combinations of the EU ETS risk management of the respondent companies are presented in *Figure 29*.

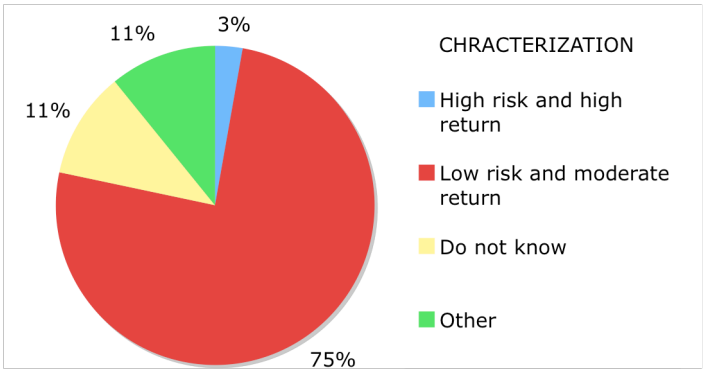

Figure 29 Characterisations of the EU ETS Risk Management Strategy

When asked about the factors that influenced the choice of the particular EU ETS risk management strategy that companies used, a majority expressed a wish to minimise the possible effects deriving from the EU ETS, e.g. the compliance costs. Additionally, the companies generally felt that EU ETS has a little impact on their operations and thus wanted to choose a less risky and lower-cost strategy. Only few of the respondent companies that answered the questions felt that EU ETS has a greater impact on their operations and, with their EU ETS risk management strategy, wanted to protect their future operations.

The advantages of the chosen EU ETS risk management strategies were mainly related to their simplicity and the ability to minimise risks and financial impacts accruing from the EU ETS. Additionally, clear definitions of risks related to the EU ETS were seen as being advantageous, as well as insights into the emission levels. One company emphasised centralised trading and balancing of emissions as some of

the advantages of its EU ETS risk management strategy. The main disadvantages of the chosen strategies were related to the possible returns: most of the strategies prevented major wins and speculative returns. Some companies also regretted the bureaucratic nature of their strategies, as flexible trading was impossible.

Most of the respondent companies had practises for complying with the limitations set by the EU ETS; only five companies (11 %) had not specified compliance strategies. The most commonly used strategies were internal abatement (51 % of the respondent companies answered using), as well as trading of EUAs (68 %). Other relatively popular strategies included carbon funds, CDM/JI projects, and production halts. Two respondent companies mentioned having energy efficiency projects as part of the compliance strategy. The EU ETS compliance strategies used and their popularity are outlined in *Figure 30*.

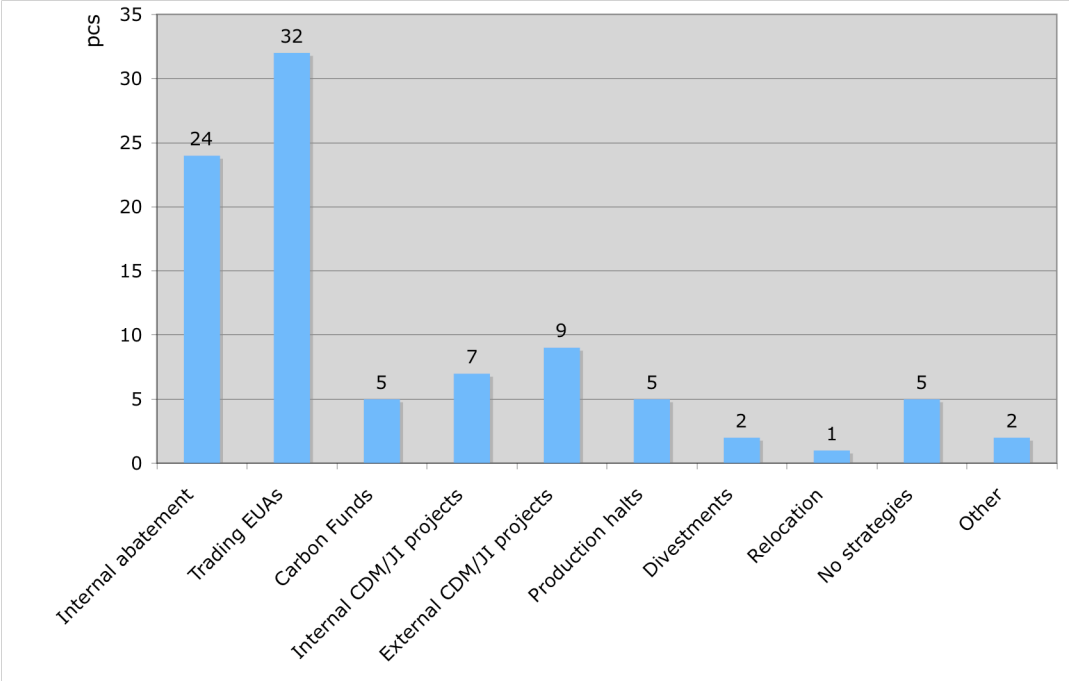

Figure 30 EU ETS Compliance Strategies

Most respondent companies had at least two different strategies for compliance with EU ETS. Half of the companies having compliance strategies had two different strategies, most often a combination of internal abatement and trading of EUAs. One fifth had three strategies, usually including internal abatement, EUA trading, and either carbon funds or investments in CDM/JI projects. Those having more than three strategies usually had more investments in carbon funds and CDM/JI projects, or considered also production halts, relocation and divestments.

The two most used primary compliance strategies for EU ETS among the companies having compliance strategies were trading of EUAs and internal abatement. Few companies mentioned carbon funds, CDM/JI projects, or production halts as their primary compliance strategy. For three companies, energy efficiency projects were the primary compliance strategy for EU ETS. The shares of different primary compliance strategies are presented in *Figure 31*.

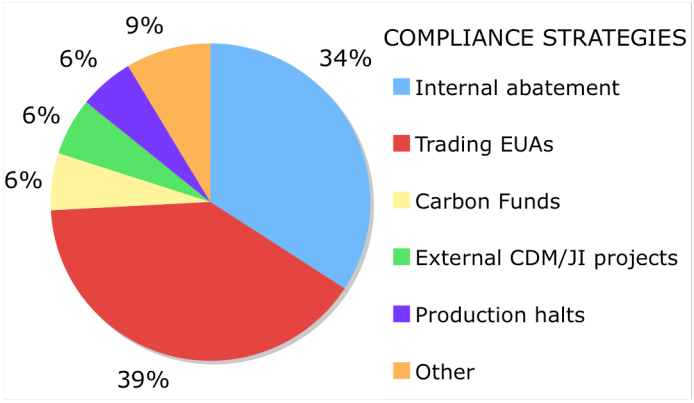

Figure 31 Primary EU ETS Compliance Strategies

When asked, close to half of the respondent companies (44 %) confirmed using portfolio analysis as a part of their EU ETS risk management. Of these companies, one fifth had a long position at the moment, and one third a short position. Other companies were in a stable position, having neither a long nor short position, and two of the respondents did not know the current position of their company. Of the companies using portfolio analysis, a majority adjusted their portfolios 1-2 times in a month or every 2-4 months. Four respondent companies adjusted their portfolios daily, and one company only when needed. None of the companies adjusted their portfolios on a half-yearly or yearly basis. The schedules of the portfolio adjustments in the respondent companies using portfolio analysis are presented in *Figure 32*.

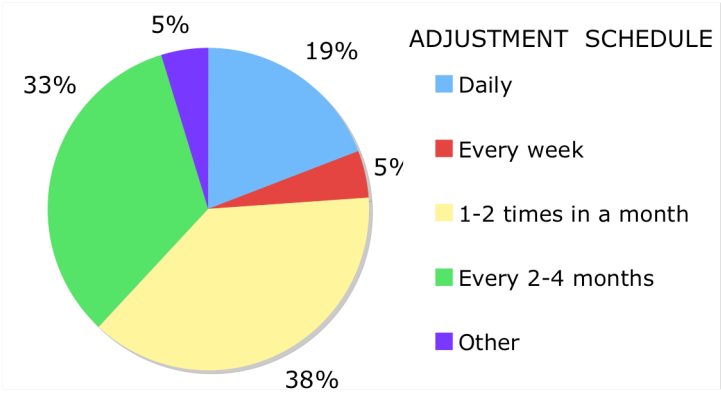

Figure 32 Schedules of Portfolio Adjustments

One fourth of the companies also revealed that they had compiled their own models for EUA prices or markets. These models were adjusted at least every 2-4 months; one fourth of companies constructing models adjusted them daily, and another one fourth 1-2 times a month. One third of the companies adjusted them weekly.

A majority of the respondent companies used financial instruments in conjunction with the EU ETS and EUA trading; only 12 companies were not using any financial instruments. The most popular instruments were spot settlements and forwards. Of the companies that were using financial instruments, the majority were using only one of the instruments listed, usually either spot settlements or forward contracts. One company solely used internal trading agreements. Half of the companies using financial instrument used either two or three different instruments in their EUA trading, and three companies were using four or more. The instruments used are listed in *Figure 33*.

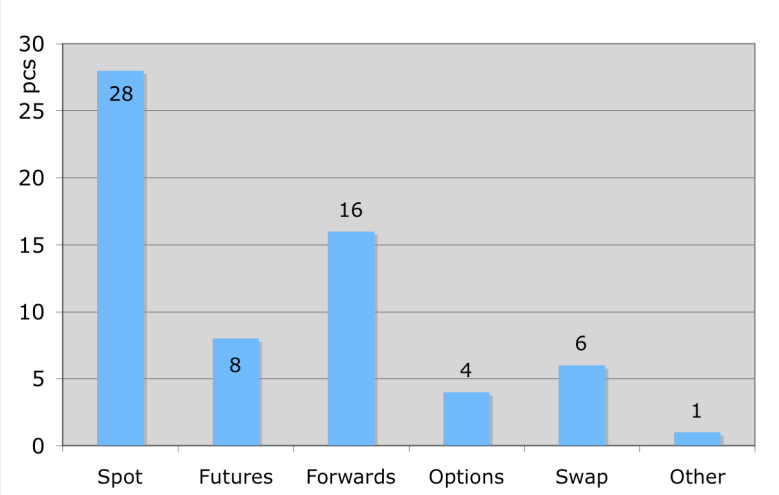

Figure 33 Financial Instruments Used

Also, when asked about trading platforms used in the trading of EUAs, 12 of the respondent companies indicated that they were not using any platforms. Companies that were using trading platforms favoured bilateral trading and OTC brokers. Additionally, one fourth of the total respondent companies used commodity exchanges in their EUA trading. Of the companies using trading platforms, 42 % were using a single platform in their trading, most often either bilateral trading or OTC brokers. Three respondent companies used only commodity exchanges as their single trading platform. The rest of the respondents used either two different platforms (29 % of those using platforms) or three platforms (29 %). Companies that

were using two different platforms most often used both bilateral trading and OTC brokers. *Figure 34* presents the trading platforms that were used.

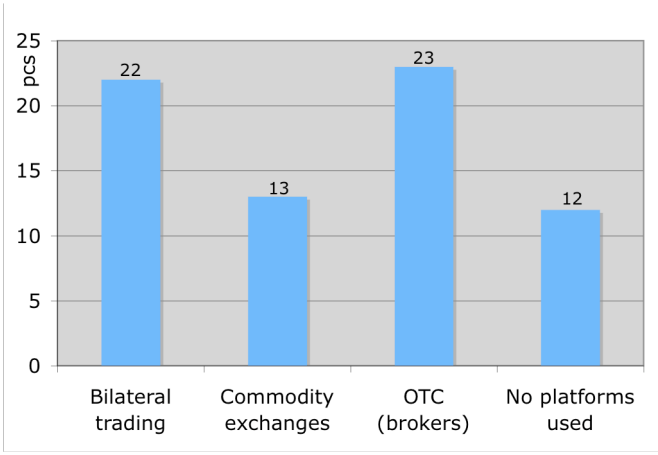

Figure 34 Trading Platforms Used

Five of the respondent companies mentioned having some additional risk management practises or tools for EU ETS issues. Those that were mentioned were: bookkeeping and forecast practises, trading rules and instructions, senior management involvement, and developing long-term CDM/JI positions. Additionally, ad hoc multiple bid comparisons and stress tests were mentioned from the financial risk management discipline.

The reason behind the chosen EU ETS risk management practises and tools were few. Most often practises were selected as they supported the aim to minimise risks and optimise trading positions. Few companies also emphasised their non-trading aims; trading was not considered as the main compliance strategy but merely a supplementing activity.

4.1.4 Role of Carbon Funds and JI/CDM Projects

Nearly all the respondents were familiar with the CDM/JI projects linked to the EU ETS; only two respondents were unfamiliar with the project schemes. Of the respondent companies, close to one fourth (11 companies) had invested in CDM/JI projects. More than half of these (55 %) had invested in only one type of project, most often in corporate internal or external CDM project. Almost one fifth of the companies with investments had invested in both internal and external CDM and JI projects. Altogether 21 companies, 44 % of the respondents, expressed that they had considered investing in CDM/JI projects. Projects that were most often considered

were either internal or external CDM projects. At the moment, only one third of the companies were considering investing or reinvesting in CDM/JI projects. The majority of the companies (70 %) that were considering such projects were companies that had already invested in CDM/JI projects. *Figure* 35 lists respondent companies' investments and investment considerations on CDM/JI projects.

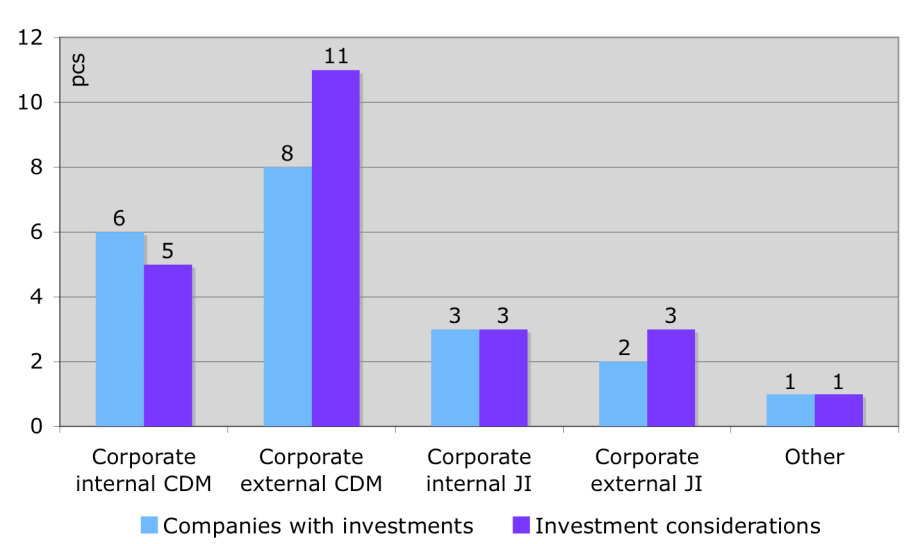

Figure 35 Investments and Investment Considerations on CDM/JI Projects

Only seven respondent companies (15 %) had invested in carbon funds. Two of the companies had invested less than € 1m, one company € 1-5m, and one € 5-10m. Two of the companies had invested more than € 10m in carbon funds. The remaining company did not specify the amount invested. The majority of the companies that had invested in carbon funds believed that they created a moderate return with low risk. One of the investor companies expected higher risk but also a higher return on its investment. Three responses were also obtained from companies that had not invested in carbon funds; all of the respondents believed carbon funds to have high risk and to create only moderate return. Of the respondent companies that had not invested in carbon funds, a clear majority (54 %) were familiar with the concept of carbon funds. Only one of these companies had considered investing in carbon funds. Three respondent companies were currently considering investments in carbon funds, two of the companies with earlier investments.

Companies with investments in CDM/JI projects and/or carbon funds expected varying returns on their investments. Three companies expected to accrue more than 1.5 million CDM/JI credits, and four companies expected the return to be between

100 000-800 000 credits. Two of the invested companies estimated a return of less than 50 000 credits. Reasons for investing in CDM/JI projects or carbon funds were varied. Some companies stated the need for more carbon assets, especially in the second trading period. Additionally, investments were seen as an opportunity to improve profits and diversify carbon portfolios. Investments were also considered as ways to gain experience of the flexible mechanisms related to the Kyoto Protocol, and further increase the focus on sustainable development. One company mentioned investments in CDM/JI projects as a good opportunity to transfer technology to the more developing operations of the company.

4.1.5 UNCERTAINTIES RELATED TO EU ETS

The last section of the survey questionnaire concentrated on the uncertainties and aspirations companies have related to EU ETS. When asked about the threats and opportunities deriving from the EU ETS and climate change regulatory framework in general, the companies were relatively unanimous. A majority of the companies that answered the question saw the EU ETS as threatening to increase their costs (purchase of EUAs, administrative costs, energy prices), lower their profits, and distort the competition. Other major threats were possible regulatory changes, and the allocation for the second trading period. Despite these apparent threats, many of the companies also listed opportunities related to EU ETS: investments in abatement technologies, and development of new products for the market. Some of the companies also promoted the increased power prices and their profits, as well as the additional support that energy efficiency investments are getting.

Almost 63 % of the respondent companies were actively following the post-2012 discussion of future climate change regulatory framework. Few companies also revealed their preparations for the possible regulatory changes. Most often companies were evaluating and forecasting their future emissions, investing in abatement or energy efficiency projects, or investigating and developing new technologies. Some companies had deferred their preparations until they know the allocations for the second trading period. Few companies were regularly following the news and participating in selected industry conferences and political dialogue. Just over one third of the respondent companies were also involved in the creation of future climate change regulation. This involvement was usually carried out through

the industry associations or as a general political dialogue. Some companies mentioned that they participated in different working groups.

Companies were also asked about the greatest uncertainties related to the EU ETS framework. Majority of respondents expressed their concern over the long-term future of the whole framework: changes related to allocation methods and the amount of emissions and industries included, and increased reduction targets. Few companies mentioned the volatility of the EUA prices, and the infancy of the market itself as great short-term threats. Uncertainties also concerned implementation procedures, the somewhat unclear rules of the current mode of the scheme, and distorted competition which the EU ETS has created.

4.2 CATEGORISED DATA SET

4.2.1 DOMICILE

The data analysis according to the domiciles of the respondent companies was conducted following two categories: companies that had their domicile in Finland and other companies. This was done, as the amount of companies in individual countries was relatively small and only Finland was represented by over 10 respondent companies. This categorisation was also felt to portray the differences between general EU-wide risk management strategies, and the practises within a single country, Finland. The group of Finnish companies contained 14 companies, and the group of non-Finnish companies 34.

The Finnish respondent companies were generally smaller both in size and emissions; only one of the companies had annual sales higher than € 5bn or emissions higher than 5 Mt CO_2. Additionally, the proportion of the non-Finnish companies having over 20 installations covered by the EU ETS was higher (25 %). The expectations over future emissions were slightly more pessimistic in Finland. Half of the companies expected their emissions to increase, and only one fourth expected them to decrease. Among non-Finnish companies, one third believed that the emissions would decrease and 43 % believed that they would to remain the same.

The EU ETS operations of the non-Finnish companies differed slightly from those of Finnish companies. Almost half of the Finnish companies relied on operations with

the overall responsibility over EU ETS affairs, as the strategy development, trading, and HSE functions were the responsible parties within the non-Finnish companies. Additionally, almost all Finnish companies had employees working only part-time over EU ETS affairs, as one third of the non-Finnish companies had both full-time and part-time employees. Those Finnish companies that cooperated with external parties (78 %), cooperated mainly with market information providers and brokers. The non-Finnish companies used external consultants more extensively, as well as banks and insurance agencies.

More than 70 % of the companies in both groups had defined a risk management strategy for their EU ETS affairs. Finnish companies relied mainly on a separate strategy, whereas the non-Finnish companies also used combination strategies, connecting separate strategies mainly with other risk management strategies within the companies. The items included in the strategies were relatively similar; Finnish companies emphasized the nature of trading more than non-Finnish, and the non-Finnish companies included more often risk limits and positions in their strategies. Both Finnish and non-Finnish companies relied on versatile compliance strategies. The most popular primary compliance strategy among the Finnish companies was trading of EUAs, as among the non-Finnish companies it was internal abatement. Portfolio analysis and construction of models were equally popular in both groups; only the schedule of adjustments in non-Finnish companies was tighter. In their EUA trading, the Finnish companies used mainly spot settlements and forwards, though one company used also futures, options, and swaps. The use of different financial instruments was therefore more common among the non-Finnish companies. Of the trading platforms, the non-Finnish companies used exchanges more extensively.

4.2.2 EU ETS SECTOR

When analysing the data according to the different EU ETS sectors, the initial categories of the survey question were regrouped into three categories: energy activities, energy intensive industries, and others. The group of other companies was included, as the companies within that group were not having their core of operations covered by the EU ETS and it was therefore felt that they merited an own group. The group of energy activities contained 29 companies and the group of energy intensive industries 13 companies; the other companies included the remaining six companies.

The sizes of the respondent companies somewhat varied according to the three groups. Both the groups of energy activities and energy intensive industry had a great variety of companies of different sizes included in them, as the other companies were mainly large companies with sales of more than € 1bn and personnel more than 2,000 employees. Though the company sizes within the group of other companies were relatively big, the amounts of installations per company were low; four companies had less than 10 installations. Two of the other companies (33 %) had 20-50 installations. The greatest amount of installations per respondent company was in the group of energy intensive industries; 54 % of the companies within the group had more than 10 installations covered by the EU ETS. The amount of installations also corresponded the estimated annual emissions of the companies within the groups. A clear majority of the companies (77 %) from energy intensive industries had their emissions over 1 Mt CO_2 per year, while in the two other groups only half of the companies had emissions over 1 Mt CO_2. Respondent companies within the different groups were relatively unanimous in their expectations of the change in their emissions in the future; for instance one third of the companies within each group estimated their emissions to increase for the 2008-2012 period.

The EU ETS operations of the companies within different groups varied only slightly. A majority of the companies with energy activities relied on strategy and business development, trading or risk management functions to have responsibility for EU ETS affairs. Energy intensive industries, on the other hand, concentrated the responsibility mainly in environmental or HSE functions, or on operations. The composition of the EU ETS activities in terms of employees was relatively similar between all the groups of companies. Group of other companies had the biggest proportion of companies having persons working both full-time and part-time on EU ETS affairs, and the group of energy activities relied on people working part-time. Respondent companies of energy activities were the most eager to cooperate with external parties; half of the companies in other groups had no cooperation.

The EU ETS risk management strategies differed between the groups of companies. Half of the other companies did not have a risk management strategy for EU ETS affairs, as only about one fourth of the two other groups did not have a defined strategy. Groups of companies from energy activities and energy intensive industries

had equal amount of instruments defined in the EU ETS risk management strategies. The group of companies with energy activities had, however, a greater interest in including the nature of trading in their risk management strategy.

Also the EU ETS compliance strategies varied to some extent between the groups. All groups relied on trading of EUAs, though especially the other companies emphasized internal abatement as a way to reach compliance. Groups of companies from energy activities and energy intensive industries also considered other strategies, such as CDM/JI projects and carbon funds; the companies from energy intensive industries also relied on production halts in their compliance strategies. Trading of EUAs was the main compliance strategy for companies of energy activities, as the two other groups relied on internal abatement strategies. The majority of the other companies (67 %) were using portfolio analysis in their EU ETS risk management; the method was also popular among the energy companies (45 %). The adjustment was done in shorter intervals in the companies from energy activities, as majority of the other companies adjusted their portfolio daily or at least 1-2 times in a month. The use of financial instruments was most common in the group of companies from energy activities; less than one fifth of the companies were using no instruments. The group also used different trading instrument most extensively. Groups of other companies and companies from energy intensive industries both relied mainly on spots and forwards. The other companies carried out trading bilaterally, whilst the two other groups used also the other trading platforms.

4.2.3 COMPANY SIZE

When analysing the data according to the company size, the size was determined by the total yearly amount of company's sales. Two categories were formed: companies that had sales of less than € 1bn and companies having their sales over that threshold. 23 respondent companies had their sales over € 1bn and 25 companies under € 1bn. A majority (72 %) of the smaller companies were energy producers, as the companies from the energy intensive industries and other industries are the majority among the bigger companies. All the companies in the group of smaller companies have relatively low estimated emissions of less than 5 Mt CO_2. The companies (48 %) also estimated to have a slight surplus in the amount of allocated EUAs for 2005-2007. No differences in expectations over future emissions were to be noted.

The EU ETS organisation varied slightly between the two groups of company sizes; bigger companies gave the responsibility of the EU ETS affairs to their HSE department or operations, or divided the responsibility among several functions. Smaller companies also highlighted the HSE function, but had bigger proportions in trading, strategy development and risk management functions. Both groups operated with several external parties in their EU ETS affairs, differences were mainly found in the popularity of individual external parties. Market information providers were more popular among the smaller companies, as were the trading consultants. Bigger companies leant more on brokers, banks, and insurance companies, though finding also the market information providers useful.

The EU ETS risk management strategies of smaller companies were mainly separate strategies. Additionally, almost 30 % of the companies did not have a risk management strategy for their EU ETS affairs. Over 80 % of the bigger companies, on the other hand, had defined an EU ETS risk management strategy. The strategies were mainly combinations of strategies, for instance a separate risk management strategy within the strategy for power markets. The instruments included in the risk management strategies were slightly different within the two groups. Smaller groups emphasized nature of trading as bigger companies risk limits and positions, persons responsible and schedules of adjustments.

The compliance strategies of smaller companies were mainly internal abatement and EUA trading, as the bigger companies also considered CDM/JI projects, carbon funds, and production halts. The use of portfolio analysis was somewhat more popular among the bigger companies, and the portfolios were adjusted more frequently. Slightly more companies (30 % compared to 25 %) in the group of bigger companies also constructed price or market models for EUA market. Companies in both groups used mainly spot settlements and forwards in their EUA trading. Forwards, as options and swaps, were more popular among the bigger companies. Trading bilaterally and through brokers was somewhat more common among the bigger companies; both groups utilized exchanges equally. Bigger companies dominated the investments into CDM/JI projects and carbon funds. Only two smaller companies had investments in projects of funds.

4.2.4 USE PORTFOLIO ANALYSIS AND/OR CONSTRUCT PRICE MODELS

Of all the respondent companies, 24 were using portfolio analysis methods and/or constructing price models. Nine were using both portfolios and constructing models, and three companies constructed only price or market models but did not use portfolios. A majority of the companies using portfolio analysis and/or constructing models were energy companies; more than half of all the energy companies that responded to the survey. Companies of all sizes used portfolio analysis or constructed models; only half of the companies had sales exceeding € 1bn or more than 2 000 employees. Additionally, less than 30 % of the companies had annual emissions greater than 5 Mt CO_2. Almost 38 % of the companies estimated that they would have a deficit for the first trading period, and 29 % envisioned a surplus. Half of the companies expected their emissions to increase for the second trading period.

The EU ETS operations of the companies that used portfolio analysis and/or constructed models were relatively small-scale: 14 companies (58 %) had only employees working on part-time basis on the EU ETS affairs. The responsibility over the affairs was most often given to the strategy development or trading functions, or to the operations of the companies. Four companies did not cooperate with any external service providers and five companies with only one external party. Most companies (62 %) had, therefore, more than two external parties that they cooperated with. The most common parties were market information providers and brokers.

Two of the companies using portfolio analysis and/or constructing models had no risk management strategy for EU ETS. Four companies had a combination of two strategies and the rest, 71 % of the companies, a single strategy. The EU ETS risk management strategy was most often a separate strategy or part of a more general risk management strategy. All of those who had a risk management strategy had included at least one item in their strategy; a majority of the companies (75 %) had included all of the four items listed.

Companies that were using portfolio analysis and/or constructing models also used various compliance strategies for EU ETS; a majority of the companies (88 %) used at least two different strategies. The most popular strategies were internal abatement and trading of EUAs, in addition to which investments in CDM/JI projects were

relatively popular. The most popular primary compliance strategies were internal abatement (primary in 33 % of the companies) and trading of EUAs (38 %). In their EUA trading, companies generally used spot settlements and forwards. Nine companies conducted all of their trading with a single instrument and three companies were not using any instruments. The most popular trading platforms were bilateral trading and OTC brokers; only one third were using exchanges. A majority of the companies (54 %) used two different platforms in their EUA trading.

One third of the companies that used portfolio analysis or constructed models had also had invested in CDM/JI projects, most often in either corporate internal or external CDM projects. 13 companies had considered investing in CDM/JI projects and nine companies were currently considering investments or reinvestments in projects. Five companies (21 %) had also invested in carbon funds.

4.2.5 Invested in CDM/JI Projects and/or Carbon Funds

Altogether 13 respondent companies had invested in CDM/JI projects or carbon funds, five companies having invested in both the projects and funds. Seven of the companies with investments were energy producers and the rest were from process, chemical or mineral industry, or producers of ferrous metals. The majority of the companies were relatively big, having sales exceeding € 5bn, and more than 10,000 employees. Only one of the companies with investments had annual emissions lower than 0.5 Mt CO_2, as eight companies reported annual emissions exceeding 5 Mt CO_2. Four companies estimated that they would have a deficit during the first trading period and five companies predicted an increase in their emissions for the second trading period. Two companies estimated both a deficit in the first period and an increase in their emission in the second.

Perhaps due to the size of the companies with investments on CDM/JI projects or carbon funds, the EU ETS operations of the companies were relatively exhaustive. Eight of the companies had full-time employees working on EU ETS issues, three of the companies with 5-10 employees. Six companies had both full-time and part-time employees working on EU ETS issues. Additionally, a majority of the companies operated with at least one external party in their EU ETS operations, most often with market information providers, traders or banks.

Only one of the companies that had invested in CDM/JI projects and/or carbon funds had not defined an EU ETS risk management strategy. Three companies had defined a strategy but had not yet made it official. The most common strategies among the investors were separate strategies, often also included as part of strategy for power markets or a general risk management strategy. The company having no single strategy for EU ETS issues used its general risk management strategy to cover the issues. All the companies having an EU ETS risk management strategy had included at least two items in their strategy, most often the risk limits, persons responsible for EU ETS, and the nature of trading. Seven companies had also included the schedules for adjustments in their strategy.

Companies that had invested in CDM/JI projects and/or carbon funds had also selected numerous compliance strategies for EU ETS. A majority of the companies had a combination of at least two strategies, six companies using more than four strategies. Two companies mentioned investments in carbon funds as their primary compliance strategy, and two companies relied on external CDM projects. Seven companies (54 %) were using portfolio analysis in their EU ETS risk management, and another seven companies constructed models of EUA prices and markets, five companies using both. Only one of the companies that had investments did not use financial instruments with its EU ETS risk management, and two companies used no trading platforms. The majority of the companies used spot settlements and forwards, trading them through bilateral trading, exchanges and OTC brokers.

Companies that had invested in carbon funds were also active with the investments in CDM/JI projects. Five companies had already invested in CDM/JI projects and six of the companies were currently considering investments or reinvestment in the projects. Most companies had invested in corporate external CDM projects, though one company had invested in both internal and external CDM and JI projects.

4.3 FINDINGS AND DISCUSSION

The EU ETS operations of the companies ranged from minor operations, in which one person had overall responsibility, to relatively extensive operations with a staff of tens of employees dealing with complex EU ETS affairs. The functions having the overall responsibility were numerous, the most popular being the HSE or

environmental functions, as well as operations and trading functions of the company. The actual organisation of the EU ETS operations fell into three general categories varying according to the amount of persons responsible, central coordination and functions included. Additionally, as part of their EU ETS operations, a majority of the companies cooperated with external parties. The most popular external parties were market information providers and brokers, as well as other trading partners.

The composition of the EU ETS organisation varied to some extent according to the different variables analysed. For instance, companies from Finland preferred that operations or production had responsibility for EU ETS matters, whereas companies from energy activities relied on strategy development and trading functions. Additionally, HSE functions and operations were used extensively by the companies from energy intensive industries. The function having the responsibility of the EU ETS affairs thus seemed to depend on the industry of the company in question; for instance the importance of EU ETS may have led the energy producers to rest the responsibility on their strategy development functions.

The amount of employees working for EU ETS affairs was mainly determined by the company size: bigger companies had generally more people working on the EU ETS affairs, both full-time and part-time. Also the cooperation with external parties followed the size of the company, though companies that were also using portfolio analysis and constructing market models generally cooperated with many external parties despite the size of the company.

A majority of the respondent companies had specified a risk management strategy in response to the EU ETS. The strategy itself was generally either separate as such or part of some related risk management strategy. Some companies also used their general risk management strategy with the EU ETS affairs. Items included in the strategies were usually risk limits or positions, persons responsible for EU ETS issues, schedules of portfolio adjustments, and nature of EUA trading practises. The popularity of an EU ETS risk management strategy seemed to be of similar proportion within the different categories of the analysed variables. Categories, though, differed slightly according to the items included in the strategy. Companies with energy activities emphasized the nature of trading, as did also the Finnish

companies and companies of smaller size. Bigger companies, on the other hand, emphasized the persons responsible, as well as risk limits and positions.

Most respondent companies had at least two different strategies for compliance under the EU ETS. Generally these strategies included internal abatement and trading of EUAs, which were also the most used primary compliance strategies among the companies. The popularity of the compliance strategies varied to some extent between the different variables. Companies from Finland complied mainly through EUA trading, whereas the other companies relied on internal abatement. Companies from energy activities also concentrated on trading of EUAs. This concentration on trading among the Finnish companies and energy producers may indicate the lack of internal abatement opportunities, as well as familiarity with the trading procedures. Bigger companies in terms of annual sales, however, also explored other compliance options, for instance engaging in CDM/JI projects and investing in carbon funds.

Almost half of the respondent companies (24 companies) used portfolio analysis and/or constructed market models as a part of their EU ETS risk management; 21 companies were using portfolio analysis and 12 companies constructed models. Both the portfolios and models were adjusted relatively often; a majority of the companies adjusted their portfolios 1-2 times in a month or every 2-4 months. The companies using portfolio analysis and building models were mainly heterogeneous and followed the general composition of the group of respondent companies.

Three quarters of the respondent companies were using trading platforms in their EUA trading, generally both bilateral trading and OTC brokers. Additionally, one fourth of the companies used platforms and exchanges. The use of platforms was most common with companies from energy activities, and companies of large size. Of the financial instruments used in EUA trading, the respondent companies most often used spot settlements and forwards. Some companies – mainly bigger companies and companies from energy activities – used also futures, options, and swaps. A majority of the companies using financial instruments used a combination of two instruments, namely spot settlements and forwards.

Nearly all the respondents were familiar with the CDM/JI projects linked to the EU ETS; only two respondents were unfamiliar with the project schemes. One fourth of

the respondent companies had also invested in CDM/JI projects, most often in one project type. Carbon funds as an EU ETS compliance strategy were relatively unfamiliar; one fourth of the respondents had not heard about the investment funds. Despite this, 15 % of the respondent companies revealed investments in carbon funds. Investments in CDM/JI projects or carbon funds were made mainly by companies of greater size; a majority of the companies had their sales of over € 5bn. Additionally, companies that had invested in projects or funds generally expected their emissions to increase in the future.

The respondent companies felt that the main threats related to the EU ETS were its inclination to increase their costs, lower their profits, and distort competition. Additionally, regulatory changes were seen as one of the major threats posed by the scheme. EU ETS were also seen to provide some opportunities, such as the increase of abatement technologies and their demand. Almost two thirds of the respondent companies were actively following the post-2012 discussion of future climate change regulatory framework. Few companies had also already prepared for the possible changes in regulations, for instance by improving their evaluation and forecasting methods. One third of the companies were involved in the creation of the future climate regulations, generally through industry associations or working groups.

5 CONCLUSIONS

The purpose of this thesis was to provide an in-depth understanding of the risk management strategies and practises as responses to the European Union Emissions Trading Scheme (EU ETS). Through the literature review, the thesis has given a detailed overview both of the regulatory framework controlling climate change and the different risk management strategies and practises available for EU ETS. This overview has also included an introduction to the market organisation related to the EU ETS – carbon assets, trading practises, and financial instruments – and to the compliance strategies of companies. Additionally, the implications deriving from the climate change regulatory framework, theories of risk management, and emissions trading practises for companies' operations were examined.

The empirical part of this thesis, survey among the EU ETS participant, reviewed the actual EU ETS risk management strategies and practises within the companies. The survey results revealed that a majority of the companies had specific risk management strategies that they use for EU ETS; that three quarters of the respondent companies had established an own EU ETS risk management strategy and that one tenth used their general risk management strategy. These strategies generally determined the persons responsible for EU ETS affairs, risk limits and positions, schedules of portfolio adjustments, and the nature of trading. Risk management strategies were most often selected to minimize the costs accruing from compliance with the EU ETS.

The survey results also revealed some of the risk management practises that companies were using to assess and manage the risks related to the EU ETS. The most common compliance strategies were EUA trading and internal abatement, though especially among the bigger companies, other options, such as investments in CDM/JI projects and carbon funds, were used. Half of the companies also supported their EU ETS risk management by using portfolio analysis, or by constructing price or market models. Of the financial instruments, spots and forwards were the most popular, though some companies, generally those of bigger size, were also using futures, options and swaps.

The surveyed EU ETS risk management strategies and practises followed some of the general risk management theories and practises presented in the literature review part of this thesis. A majority of the respondent companies considered the risks and uncertainties related to the EU ETS relatively important and thus had risk management strategies for them. Additionally, companies utilized the different EU ETS compliance strategies extensively. Of the financial risk management methods presented in the literature review, the companies were largely only using portfolio analysis. Only one company mentioned also using stress testing. The risk management strategies and practises that companies had chosen revealed, therefore, a combination of some traditional techniques, such as portfolio analysis and construction of models, and of some EU ETS specific techniques, including the different compliance strategies.

Generally, the results of this thesis revealed a great degree of variety in the EU ETS risk management strategies and practises that companies are using. Nearly all companies consider managing the risks that EU ETS poses as important, though the level of EU ETS risk management activities differs between companies. Currently, risk management practises related to the EU ETS concentrate on minimizing the impact EU ETS has, and mainly follow the basic compliance strategies available.

5.1 RELIABILITY AND VALIDITY

The reliability of this thesis contains only some considerations, the majority of which relate to the data collection procedures. Even though these procedures are believed to be reliable as such, the biases, for instance in the company selection phase, can affect the overall reliability of the thesis results. Additionally, some non-response bias is believed to have occurred, as the respondents to the survey questionnaire might have been more motivated to answer as opposed to those who did not respond. This bias is not, though, considered relevant, as the collected data was generally of heterogeneous nature and thus reliable indication of the group of respondents. Data collection suffered also from some respondent fatigue, as some of the respondents left the survey incomplete. This fatigue was decreased by the design of the survey questionnaire, and by deleting incomplete answers during the data analysis phase. The reliability of the thesis is thus considered satisfactory.

The validity of this thesis is believed to be good. The purpose of the thesis was to explore and assess the risk management strategies and practises companies have for EU ETS. The selected research methods, literature review and survey, are believed to support this purpose and provide accurate data over the researched EU ETS risk management of companies. Thus, the methods of data collection and data analysis that were used are considered to be valid methods to measure the risk management strategies and practises of companies.

As the intention of the thesis was to describe the risk management strategies and procedures as responses to the EU ETS, no formal tests of the reliability and validity of the thesis was conducted. Therefore, the results and findings presented in this thesis cannot be generalised, but only depict the risk management strategies and practises of the companies that responded to the survey. The reliability and validity considerations of the data collection and data analysis processes were presented earlier in *Chapters 2.2.5 Reliability and Validity of Data Collection* and *2.3.4 Challenges Related to Data Analysis*.

5.2 SUGGESTIONS FOR FUTURE RESEARCH

Corporate risk management and its research have already half a century of history. This thesis increased the understanding of corporate risk management in response to the risks introduced by the EU ETS. This understanding, however, could be deeper and therefore the following suggestions for future research topics are presented:

- Further study explaining the differences within the EU ETS risk management strategies and practises between different geographic and economic areas within the EU (Nordic countries compared to Southern Europe),
- An extensive case study of risk management strategies and practise among forerunners of the EU ETS risk management,
- Testing of the different risk management strategies and practises within companies in order to find the best practises and methods that can be used for the EU ETS risk management, and
- Building an integrated and comprehensive model for EU ETS risk management in companies.

6 REFERENCES

LITERARY REFERENCES

Bank for International Settlements (BIS). 2000. Stress Testing by Large Financial Institutions: Current Practise and Aggregation Issues. Basel, Switzerland. 44 pgs.

Barrese, J. & N. Scordis. 2003. Corporate Risk Management. *Review of Business*. Fall 2003. pp. 26-29.

Basak, S. & A. Shapiro. 2001. Value-at-risk-based risk management: Optimal policies and asset prices. *The Review of Financial Studies*. 14(2). pp. 371-405.

Bodnar, G.M., G.S. Hayt & R.C. Marston. 1998. 1998 Wharton Survey of Financial Risk Management by US Non-financial Firms. *Financial Management*. 27(4). pp. 70-91.

Brealey, R.A., S.C. Myers & F. Allen. 2006. Principles of Corporate Finance. 8th edition. McGraw-Hill, New York, USA. 1,028 pgs.

Broughton, P. 1994. Managing Market Risk. *Corporate Finance Foreign Exchange Yearbook 1994/95*. October 1994. pp. 7-10.

Brown, G.W. & K.B. Toft. 2002. How Firms Should Hedge. *The Review of Financial Studies*. 15(4). pp. 1283-1324.

Capoor, K. & P. Ambrosi. 2006. State and Trends of the Carbon Market 2006. Washington DC, USA. 57 pgs.

Commission of the European Communities (COM). 2000. Communication from the Commission to the Council and the European Parliament on EU Policies and Measures to Reduce Greenhouse Gas Emissions: Towards a European Climate Change Programme. Brussels, Belgium. COM(2000) 88. 13 pgs.

The Committee of Sponsoring Organizations of the Treadway Commission (COSO). 2004. Enterprise Risk Management – Integrated Framework. Executive Summary. New York, USA. 16 pgs.

Copeland, T.E., J.F. Weston & K. Shastri. 2005. Financial Theory and Corporate Policy. 4th edition. Pearson Addison Wesley, New York, USA. 1,000 pgs.

Council of the European Union (CE). 2002. Council Decision Concerning the Approval, on Behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the Joint Fulfillment of Commitments thereunder (2002/358/CE). *Official Journal of the European Communities*. 15.5.2002. 20 pgs.

Culnan, M.J. 1987. Mapping the Intellectual Structure of MIS, 1980-1985. A Co-Citation Analysis. *MIS Quarterly*. September. pp. 341-353.

DeMarzo, P.M. & D. Duffie. 1995. Corporate Incentives for Hedging and Hedge Accounting. *The Review of Financial Studies*. 8(3). pp. 743-771.

European Commission (EC). 2005. EU Action against Climate Change. EU Emissions Trading – an Open Scheme Promoting Global Innovation. Brussels, Belgium. 24 pgs.

European Commission (EC). 2006. EU Action against Climate Change. The European Climate Change Programme. Brussels, Belgium. 24 pgs.

European Union (EU). 2003. Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. *Official Journal of the European Communities*. 25.10.2003. 15 pgs.

European Union (EU). 2004. Directive 2004/101/EC of the European Parliament and of the Council 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms. *Official Journal of the European Communities*. 13.11.2004. 6 pgs.

Fatemi, A. & C. Luft. 2002. Corporate Risk Management – Costs and Benefits. *Global Finance Journal*. 13 (2002). pp. 29-38.

Froot, K.A., D.S. Scharfstein & J.C. Stein. 1993. Risk Management: Coordinating Corporate Investment and Financing Policies. *The Journal of Finance*. 48(5). pp. 1629-1658.

Géczy, C., B.A. Minton & C. Schrand. 1997. Why Firms Use Currency Derivatives. *The Journal of Finance*. 52(4). pp. 1323-1354.

Gmür, M. 2003. Co-citation analysis and the search for invisible colleges: A methodological evaluation. *Scientometrics*. 57(1). pp. 27-57.

Holton, GA. 2004. Defining Risk. *Financial Analysts Journal*. 60(6). pp. 19-25.

IPCC. 2001a. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell & C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, UK and New York, USA. 881 pgs.

IPCC. 2001b. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken & K.S. White (eds.)]. Cambridge University Press, Cambridge, UK and New York, USA. 1,032 pgs.

Järvenpää, E. & K. Kosonen. 2000. Johdatus tutkimusmenetelmiin ja tutkimuksen tekemiseen. (In Finnish) HUT Industrial Management and Work and Organizational Psychology. Teaching Material No 1. Espoo, Finland. 105 pgs.

Kaminski, V. (ed.). 2004. Managing Energy Price Risk. The New Challenges and Solutions. 3rd edition. Risk Books, London, UK. 700 pgs.

Kyrö, P. 2004. Tutkimusprosessi valintojen polkuna. (In Finnish) Saarijärvi, Finland. 164 pgs.

Liebenberg, A.P. & R.E. Hoyt. 2003. The Determinants of Enterprise Risk Management: Evidence from the Appointment of Chief Risk Officers. *Risk Management and Insurance Review*. 6(1). pp. 37-52.

Lintner, J. 1965. The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets. *The Review of Economics and Statsitics*. 47(1). pp. 13-37.

Markowitz, H. 1952. Portfolio Selection. *The Journal of Finance*. 7(1). pp. 77-91.

McCain, K.W. 1988. The Paper Trails of Scholarship: Mapping the Literature of Genetics. *Essays of an Information Scientist: Science Literacy, Policy, Evaluation, and other Essays*. 11(4). pp. 21-28.

Mian, S.L. 1996. Evidence on Corporate Hedging Policy. *The Journal of Financial and Quantitative Analysis*. 31(3). pp. 419-439.

Nance, D.R., C.W. Smith, Jr. & C.W. Smithson. 1993. On the Determinants of Corporate Hedging. *The Journal of Finance*. 48(1). pp. 267-284.

O'Donnell, E. 2005. Enterprise Risk Management: A Systems-thinking Framework for the Event Identification Phase.

Osareh, F. 1996. Bibliometrics, citation analysis and co-citation analysis: A review of literature, I. *Libri*. 46(3). pp. 149-158.

Point Carbon. 2006. Carbon 2006. [Hasselknippe, H. & K. Røine (eds.)]. 60 pgs.

Ramos-Rodríguez, A.-R. & Ruíz-Navarro, J. 2004. Changes in the Intellectual Structure of Strategic Management Research: A Bibliometric Study of the *Strategic Management Journal*, 1980-2000. *Strategic Management Journal*. 25. pp. 981-1004.

Ross, S.A. 1976. The Arbitrage Theory of Capital Asset Pricing. *Journal of Economic Theory*. 13. pp. 343-362.

Sadeghi, M. & S. Shavvalpour. 2005. Energy Risk Management and Value at Risk Modelling. *Energy Policy*. Article in press. 7 pgs.

Schildt, H. & A. Sillanpää. 2004. The Field of Entrepreneurship: A Bibliometric Assessment. Helsinki University of Technology, Institute of Strategy and International Business. Working Paper No. 2004/1. 29 pgs.

Schmit, J.T. & K. Roth. 1990. Cost Effectiveness of Risk Management Practices. *The Journal of Risk and Insurance*. 57(3). pp. 455-470.

Schrand, C. & H. Unal. 1998. Hedging and Coordinated Risk Management: Evidence from Thrift Conversions. *The Journal of Finance*. 53(3). pp. 979-1013.

Sharpe, W.F. 1964. Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *The Journal of Finance*. 19(3). pp. 425-442.

Small, H. 1973. Co-citation in the scientific Literature: A New Measure of the Relationship Between Two Documents. *Journal of the American Society for Information Science*. 24(4). pp. 265-269.

Smith, L.C. 1981. Citation Analysis. *Library Trends*. 30(1). pp. 83-106.

Smith, C.W. & R.M. Stulz. 1985. The Determinants of Firms' Hedging Policies. *The Journal of Financial and Quantitative Analysis*. 20(4). pp. 391-405.

Stulz, R.M. 1984. Optimal Hedging Policies. *The Journal of Financial and Quantitative Analysis*. 19(2). pp. 127-140.

Stulz, R.M. 1996. Rethinking Risk Management. *Journal of Applied Corporate Finance*. 9 (1996). pp. 8-24.

Subramanian, R. 2005. Emissions Compliance Strategies: A Permit Auction Model. The MSOM Society Student Paper Competition: Extended Abstracts of 2004 Winners. *Manufacturing & Service Operations Management*. 7(1). pp. 85-89.

Tang, K. (ed.). 2005. The Finance of Climate Change. A Guide for Governments, Corporations and Investors. Risk Books, London, UK. 404 pgs.

Treynor, J. 1961. Towards a Theory of the Market Value of Risky Assets. Unpublished manuscript.

Tufano, P. 1996. Who Manages Risk? An Empirical Examination of Risk Management Practises in the Gold Mining Industry. *The Journal of Finance*. 51(4). pp. 1097-1137.

United Nations (UN). 1992. United Nations Framework Convention on Climate Change. New York, USA. 25 pgs.

United Nations (UN). 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change. Kyoto, Japan. 21 pgs.

United Nations Framework Convention on Climate Change (UNFCCC). 2003. Caring for Climate – A guide to the Climate Change Convention and the Kyoto Protocol. [Depledge, J. & Lamb, R. (eds.)]. Bonn, Germany. 33 pgs.

Wang, M. 2001. Financial Derivatives in Corporate Risk Management. Dissertation, University of Texas at Austin. 153 pgs.

REFERENCES ON THE INTERNET

Borgatti, S.P., Everett, M.G. & Freeman, L.C. 2002. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies. Available in www-form: http://www.analytictech.com/downloaduc6.htm [Referred on 08/09/2006.]

European Union (EU). 2006. Emissions Trading Scheme (EU ETS). Website. Available online at: http://ec.europa.eu/environment/climat/emission.htm [Referred on 08/09/2006.]

International Emissions Trading Association (IETA) & World Bank Carbon Finance Unit (CFU). 2006. Carbon Expo. Website. Available online at: http://www.carbonexpo.com/ [Referred on 08/09/2006.]

IPCC. 2006. About IPCC. Website. Available online at: http://www.ipcc.ch/about/about.htm [Referred on 08/09/2006.]

Oxford English Dictionary. 2006. Online Dictionary. Website. Available online at: http://dictionary.oed.com/ [Referred on 08/09/2006.]

United Nations Framework Convention on Climate Change (UNFCCC). 2006a. Essential Background. Website. Available online at: http://unfccc.int/essential_background/items/2877.php [Referred on 08/09/2006.]

United Nations Framework Convention on Climate Change (UNFCCC). 2006b. United Nations Climate Change Conference (COP 11 and COP/MOP 1). Website. Available online at: http://unfccc.int/meetings/cop_11/items/3394.php [Referred on 08/09/2006.]

World Bank Carbon Finance Unit (CFU). 2006. Website. Available online at: http://carbonfinance.org/ [Referred on 08/09/2006.]

PRESENTATIONS

Korthuis, A. 2005. Interpreting EU ETS as JI/CDM Pricing Trends. Environmental Finance 2005 conference. London, UK. 10/31/2005.

Rogge, K., J. Schleich, C. Faure & A. Hildebrandt. 2005. Reputational Impact of Businesses' Compliance Strategies under EU ETS. 3rd International Workshop – Climate Change, Sustainability and Risk. Wittenberg, Germany. 11/16/2005.

Tynjälä, T. 2005. Hiilirahastomarkkinat ja tulevaisuuden trendit (In Finnish). Carbon Funds Workshop of MARMET project. Espoo, Finland. 12/16/2005.

APPENDIX 1. ABBREVIATIONS

AAU	Assigned Amount Unit
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH_4	Methane
CO_2	Carbon dioxide
COP	Conference of the Parties to UNFCCC
COP/MOP	Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
EEC	European Economic Community
EC	European Commission
EC	European Community, European Communities
ECCP	European Climate Change Programme
EIT	Economies in Transition
ERU	Emissions Reduction Unit
ET	Emissions Trading
EU	European Union
EU ETS	European Union Emissions Trading Scheme
EUA	European Union Allowance
GHG	Greenhouse gas
HFCs	Hydrofluorocarbons
IETA	International Emissions Trading Association
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
MOP	Meeting of the Parties (please see COP/MOP above)
Mt CO_2	Million tonnes of carbon dioxide
N_2O	Nitrous oxide
NAP	National Allocation Plan
OECD	Organisation for Economic Co-operation and Development
OTC	Over-the-counter
PFCs	Perfluorocarbons
RMU	Removal Unit
SF_6	Sulphur hexafluoride
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change

APPENDIX 2. SURVEY QUESTIONNAIRE

Risk Management Strategies and Tools for EU ETS

Introduction

Thank you for agreeing to take part in this survey!

This survey is designed to provide more information about how companies manage the risks involved in the EU Emissions Trading Scheme (EU ETS). The survey is conducted as a part of a larger research project by the Helsinki University of Technology, and the University of Helsinki. The project is financed by five Finnish companies together with Finnish Funding Agency for Technology and Innovation, Tekes.

The survey results will be used in a Master's thesis study, as well as in subsequent journal articles. More information on the research project; "Market Analysis and Risk Management of EU Emissions Trading", can be found at:
http://honeybee.helsinki.fi/mmtal/ye/pomar/marmet.html

By participating in the survey, you will help us to understand the general state of risk management practises for EU ETS, and increase our knowledge of the general views of EU ETS throughout the whole EU area. A summary of the survey results will be available for all those who have participated and wish to receive them.

The questionnaire contains six sections covering issues connected to the EU ETS operations and risk management strategies of your company. Additionally, we also ask some background information about your company in order to improve the analysis of the survey results. This information is used only during the analysis, and cannot be linked to a specific answer. Similarly, the results that are given to the participating companies will not contain details about the risk management strategies and policies of specific companies.

The survey takes approximately 15 minutes to complete. If you wish to exit the survey at any time, please click the button in the upper right-hand corner. You may return to the survey after leaving it through the link sent to your via e-mail.

Thank you for your participation!

Best Regards,

Eeva Lappalainen

B.Sc. (Tech.), Research Assistant
Helsinki University of Technology
Environmental and Quality Management
E-mail: eeva.lappalainen@tkk.fi
Tel: +358 500 999 330
Mailing address: P.O. Box 5500, 02015 TKK, Finland
Visiting address: Otaniementie 17, 02150 Espoo, Finland
http://www.tkk.fi/ & http://www.tuta.hut.fi/

Background Information (1/6)

1. In which EU ETS sector is your company?

- ☐ Energy activities
- ☐ Production and processing ferrous metals
- ☐ Mineral industry
- ☐ Pulp and paper
- ☐ Other (please specify)

2. Where is the domicile / registered office of your company?

- ☐ Austria
- ☐ Belgium
- ☐ Cyprus
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ France
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Ireland
- ☐ Italy
- ☐ Latvia
- ☐ Lithuania
- ☐ Luxembourg
- ☐ Netherlands
- ☐ Malta
- ☐ Poland
- ☐ Portugal
- ☐ Slovak Republic
- ☐ Slovenia
- ☐ Spain
- ☐ Sweden
- ☐ UK
- ☐ Other (please specify)

3. What were the total sales of your company in 2005?

- ☐ 0-5 MEUR
- ☐ 6-20 MEUR
- ☐ 21-100 MEUR
- ☐ 101-500 MEUR
- ☐ 501-1 000 MEUR
- ☐ 1 001-5 000 MEUR
- ☐ >5 000 MEUR

4. How many personnel does your company have?

- ☐ 0-20 persons
- ☐ 21-100 persons
- ☐ 101-500 persons
- ☐ 501-2 000 persons
- ☐ 2 001-10 000 persons
- ☐ >10 000 persons

5. Please select the ownership structure which best describes your company.

- ☐ Single private owner
- ☐ Limited (Ltd.) / Incorporated (Inc.) company
- ☐ Listed company / Public limited company (plc)
- ☐ State-owned company
- ☐ Other (please specify)

6. In which market areas is your company?

- ☐ Domestic
- ☐ Regional
- ☐ EU
- ☐ International
- ☐ Other (please specify)

7. How many installations in your company are covered by the EU ETS?

- ☐ No installations
- ☐ 1
- ☐ 2-5
- ☐ 6-10
- ☐ 11-20
- ☐ 20-50
- ☐ >50
- ☐ Do not know

8. Please select those EU member states in which your company has installations that are covered by the EU ETS (you may select multiple options).

- ☐ Austria
- ☐ Belgium
- ☐ Cyprus
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ France
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Ireland
- ☐ Italy
- ☐ Latvia
- ☐ Lithuania
- ☐ Luxembourg
- ☐ Netherlands
- ☐ Malta
- ☐ Poland
- ☐ Portugal
- ☐ Slovak Republic
- ☐ Slovenia
- ☐ Spain
- ☐ Sweden
- ☐ UK
- ☐ No installations under EU ETS

9. In which single country are the most installations from your company that are covered by the EU ETS?

- ☐ Austria
- ☐ Belgium
- ☐ Cyprus
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ France
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Ireland
- ☐ Italy
- ☐ Latvia
- ☐ Lithuania
- ☐ Luxembourg
- ☐ Netherlands
- ☐ Malta
- ☐ Poland
- ☐ Portugal
- ☐ Slovak Republic
- ☐ Slovenia
- ☐ Spain
- ☐ Sweden
- ☐ UK
- ☐ No installations under EU ETS
- ☐ Several coutnries (please specify)

10. What is the estimated level of your company's annual emissions for 2005-2007?

- [ ] 0-0.5 Mt/year
- [ ] 0.5-1 Mt/year
- [ ] 1-5 Mt/year
- [ ] 5-10 Mt/year
- [ ] >10 Mt/year
- [ ] No estimations done

11. What is the estimated annual deficit / surplus of the EUAs allocated to your company for 2005-2007?

- [ ] Deficit > 1 Mt/year
- [ ] Deficit 1-0.5 Mt/year
- [ ] Deficit 0.5-0 Mt/year
- [ ] No deficit/surplus
- [ ] Surplus 0-0.5 Mt/year
- [ ] Surplus 0.5-1 Mt/year
- [ ] Surplus >1 Mt/year
- [ ] No estimations done

12. How do you expect the emissions of your company to change for 2008-2012?

- [ ] Increase substantially
- [ ] Increase
- [ ] No change
- [ ] Decrease
- [ ] Decrease substantially
- [ ] Other (please specify)

EU ETS Operations (2/6)

1. Which department or function in your company has overall responsibility for the EU ETS operations?

- ☐ Strategy and Business Development
- ☐ Trading
- ☐ Risk Management
- ☐ Analysis
- ☐ HSE / Environmental
- ☐ Consultancy
- ☐ Operations/production
- ☐ Responsibility not specified
- ☐ Other (please specify)

2. How many personnel are involved in the EU ETS operations in your company?

Full-time	Part-time
☐ 0	☐ 0
☐ 1	☐ 1
☐ 2-4	☐ 2-4
☐ 5-10	☐ 5-10
☐ 10-20	☐ 10-20
☐ >20	☐ >20

3. Please briefly describe the organisation of EU ETS operations in your company.

4. When were the EU ETS operations launched in your company?

5. Does your company cooperate with external parties in EU ETS operations? If yes, with which external parties (you may choose multiple options)?

- ☐ No external parties are used
- ☐ Market information providers
- ☐ Price model providers
- ☐ External EU ETS consultants
- ☐ Trading consultants / agencies
- ☐ Brokers
- ☐ Banks, insurance companies
- ☐ Other (please specify)

6. Please list the external parties (companies, organisations) that your company cooperates with in EU ETS operations.

Risk Management Strategies (3/6)

1. Has your company defined a risk management strategy for EU ETS?

- ☐ Yes
- ☐ No
- ☐ Do not know

If your company has not defined a risk management strategy for EU ETS, please skip the following questions and go to question number 6.

---

2. What is the nature of the risk management strategy for EU ETS of your company (you may select multiple options)?

- ☐ Separate strategy
- ☐ Part of the risk management strategy for power markets
- ☐ Part of a more general risk management strategy
- ☐ Defined but not yet official
- ☐ No risk management strategy for EU ETS
- ☐ Other (please specify)

3. What of the following items has your company included in the risk management strategy for EU ETS (you may select multiple options)?

- ☐ Risk limits / positions
- ☐ Persons responsible for EU ETS
- ☐ Schedule of adjustments / updates
- ☐ Nature of trading (speculative etc.)
- ☐ No items included
- ☐ Other (please specify)

4. Please briefly describe the risk management strategy that your company has for EU ETS.

5. Would you characterize the risk management strategy for EU ETS of your company as being:

- ☐ High risk and high return
- ☐ Low risk and moderate return
- ☐ Do not know
- ☐ Other (please specify)

Please skip the following question and go to question number 7.

---

6. Is your general risk management strategy used for EU ETS (if your company does not have a specific risk management strategy for EU ETS)?

- ☐ Yes
- ☐ No
- ☐ Do not know

7. What factors led to the choice of the risk management strategy for EU ETS your company has (even if your company does not have a specific risk management strategy for EU ETS)? Please briefly describe the reasoning behind the choice.

8. What are the advantages and disadvantages of the chosen risk management strategy for EU ETS in your company? Please briefly describe the advantages and disadvantages.

Risk Management Practises for EU ETS (4/6)

1. What strategies for compliance with the EU ETS is your company using (you may select multiple options)?

- ☐ Internal abatement
- ☐ Trading EUAs
- ☐ Carbon Funds
- ☐ Corporate internal CDM/JI projects
- ☐ Corporate external CDM/JI projects
- ☐ Production halts
- ☐ Divestments
- ☐ Relocation
- ☐ No strategies
- ☐ Other (please specify)

2. What is the primary strategy for compliance with the EU ETS in your company?

- ☐ Internal abatement
- ☐ Trading EUAs
- ☐ Carbon Funds
- ☐ Corporate internal CDM/JI projects
- ☐ Corporate external CDM/JI projects
- ☐ Production halts
- ☐ Divestments
- ☐ Relocation
- ☐ No strategies
- ☐ Other (please specify)

3. Is your company using portfolio management for EU ETS?

- ☐ Yes
- ☐ No
- ☐ Do not know

If not, please skip the following questions and go to question number 6.
---

4. What is the current position of your company?

- ☐ Long
- ☐ Not long or short
- ☐ Short
- ☐ Do not know

5. How often is the portfolio of your company adjusted?

- ☐ Daily
- ☐ Every week
- ☐ 1-2 times in a month
- ☐ Every 2-4 months
- ☐ Half-yearly
- ☐ Yearly
- ☐ Other (please specify)

6. Does your company construct models of the EUA markets and / or prices?

- [ ] Yes
- [ ] No
- [ ] Do not know

If not, please skip the following questions and go to question number 8.
---

7. How often is the price / market model of your company adjusted?

- [ ] Daily
- [ ] Every week
- [ ] 1-2 times in a month
- [ ] Every 2-4 months
- [ ] Half-yearly
- [ ] Yearly
- [ ] Other (please specify)

8. What financial instruments does your company use in the risk management of EU ETS (you may select multiple options)?

- [ ] Spot
- [ ] Futures
- [ ] Forwards
- [ ] Options (when become available)
- [ ] Swap
- [ ] No instruments used
- [ ] Other (please specify)

9. What trading platforms does your company use for EUAs?

- [ ] Bilateral trading
- [ ] Commodity exchanges
- [ ] OTC (brokers)
- [ ] No platforms used

10. Does your company have other risk management practises and tools for EU ETS? Please briefly describe the practises and tools.

11. Why did your company select these risk management practises for EU ETS? Please briefly describe the motivation behind the decision.

Role of Carbon Funds and CDM/JI Projects (5/6)

1. Are you familiar with the emission reduction mechanisms linked to the EU ETS (Clean Develoment Mechanisms, CDM / Joint Implementation, JI)?

- ☐ Yes
- ☐ No
- ☐ Do not know

2. Has your company invested in CDM/JI projects?

- ☐ Yes
- ☐ No
- ☐ Do not know

If no, please skip the following question and go to question number 4.

---

3. If yes, which CDM/JI projects has your company invested in (you may select multiple answers)?

- ☐ Corporate internal CDM
- ☐ Corporate external CDM
- ☐ Corporate internal JI
- ☐ Corporate external JI
- ☐ Do not know
- ☐ Other (please specify)

Please skip the following questions and go to the question number 6.

---

4. Has your company considered investing in CDM/JI projects?

- ☐ Yes
- ☐ No
- ☐ Do not know

5. If yes, which CDM/JI projects has your company considered?

- ☐ Corporate internal CDM
- ☐ Corporate external CDM
- ☐ Corporate internal JI
- ☐ Corporate external JI
- ☐ Do not know

6. Is your company considering investing or reinvesting in CDM/JI projects?

- ☐ Yes
- ☐ No
- ☐ Do not know

7. Has your company invested in Carbon Funds?

- ☐ Yes
- ☐ No
- ☐ Do not know

If no, please skip the following questions and go to question number 11.

---

8. Which Carbon Fund(s) has your company invested in?

9. What was the magnitude of your company's investment in Carbon Funds?

- ☐ 0.25-1 MEUR
- ☐ 1-5 MEUR
- ☐ 5-10 MEUR
- ☐ >10 MEUR
- ☐ No investments

10. What is your perception on the relationship between risk and return with the investments in Carbon Funds?

- ☐ High risk and moderate return
- ☐ High risk and high return
- ☐ Low risk and high return
- ☐ Low risk and moderate return
- ☐ Do not know

Please skip the following questions, and go to question number 14.

---

11. Are you familiar with Carbon Funds; funds that invest in CDM/JI projects?

- ☐ Yes
- ☐ No
- ☐ Do not know

12. Has your company considered investing in Carbon Funds?

- ☐ Yes
- ☐ No
- ☐ Do not know

13. If yes, please specify the Carbon Funds that your company has considered?

14. Is your company considering investing or reinvesting in Carbon Funds?

- ☐ Yes
- ☐ No
- ☐ Do not know

15. If yes, please specify the Carbon Funds your company is considering?

16. How many CDM/JI credits through projects or Carbon Funds is your company estimated to obtain?

- ☐ No investments in projects or Carbon Funds
- ☐ 0-50 000
- ☐ 50 001-100 000
- ☐ 100 001-300 000
- ☐ 300 001-800 000
- ☐ 800 001-1 500 000
- ☐ >1 500 000

17. If your company has invested in CDM/JI projects or Carbon Funds: What was the motivation behind the investment for your company? Please briefly describe this motivation.

Uncertainties related to EU ETS (6/6)

1. What are the greatest threats and opportunities for your company deriving from the EU ETS and other climate change mitigation policies?

2. Is your company actively following the post-2012 discussion regarding climate policy (conferences, workshops, etc.)?

- ☐ Yes
- ☐ No
- ☐ Do not know

3. How is your company preparing for the post-2012 climate change regulation? Please briefly describe this preparation.

4. Is your company involved in the creation of future climate change regulation?

- ☐ Yes
- ☐ No
- ☐ Do not know

5. If yes, please briefly describe the involvement of your company.

6. What do you consider to be the greatest area of uncertainty related to the EU ETS framework? What short-term and long-term uncertainties do you consider important for your company?

7. Please feel free to leave general comments on the future of different fuels and fuel mixes due to the EU ETS.

8. Please feel free to leave general comments regarding the Kyoto Protocol and EU ETS and the uncertainties and risk related to them.

Thank you!

Thank you for participating in this survey!

Please leave your e-mail address if you wish to obtain the results of this survey. The results will be sent latest in June 2006.

Additionally, if you have some general comments regarding the study and/or the questionnaire, you can write them down below or contact the research group via e-mail. Please send your e-mail to Ms. Eeva Lappalainen (eeva.lappalainen@tkk.fi).

1. Please leave your e-mail address here.

2. Please leave your comments here.

APPENDIX 3. SURVEY THEMES

Table 8 Surveyed Themes and Reasons for Their Selection

Background Information	Reasoning
EU ETS sector, domicile	Information for categorisation
Size (sales, personnel)	Information for categorisation
Ownership structure	Information for categorisation
Market area	Information for categorisation
Installations (number of, locations)	Information for categorisation and about the importance of EU ETS
Emissions and surplus / deficit	Information for categorisation and about the importance of EU ETS
In total 12 questions	
EU ETS Operations	
Function responsible, personnel, launch year	Information about the importance of and preparation for EU ETS
Cooperation with external parties	Indications of the level of EU ETS activity
In total 6 questions	
Risk Management Strategies	
Defined strategy for EU ETS	Indications of the level of EU ETS activity and risk management for the scheme
Nature of the strategy, description	Information about the selected strategy
Reasons behind the selection of the type of strategy	Information about the selected strategy, background information about the nature of the selected strategy
Advantages / disadvantages	Information about the selected strategy
In total 8 questions	
Risk Management Practises for EU ETS	
Compliance strategies	Indications of the level of EU ETS activity, information about the selected risk management strategy for EU ETS
Use of portfolio analysis	Indications of the level of EU ETS activity, information about the selected risk management strategy for EU ETS
EUA market / price models	Indications of the level of EU ETS activity, information about the selected risk management strategy for EU ETS
Use of financial instruments	Indications of the level of EU ETS activity, information about the selected risk management strategy for EU ETS
Use of trading platforms	Indications of the level of EU ETS activity, information about the selected risk management strategy for EU ETS
Reasons behind the risk management practises	Background information about the nature of the selected strategy, indications of the level of EU ETS activity
In total 11 questions	
Role of Carbon Funds and CDM/JI Projects	
Investments in CDM/JI projects	Indications of the level of EU ETS activity
Investments in carbon funds	Indications of the level of EU ETS activity
Investment considerations	Indications of the level of EU ETS activity
Reasons behind investments	Background information about the investments, indications of the level of EU ETS activity
In total 17 questions	
Uncertainties related to EU ETS	
Threats and opportunities deriving from EU ETS	Indications of the level of EU ETS activity, information about the aspirations companies have regarding EU ETS
Preparations for post-2012	Indications of the level of EU ETS activity
General comments of fuel mixes and EU ETS	General information
In total 8 questions	

APPENDIX 4. BIBLIOMETRIC REVIEW

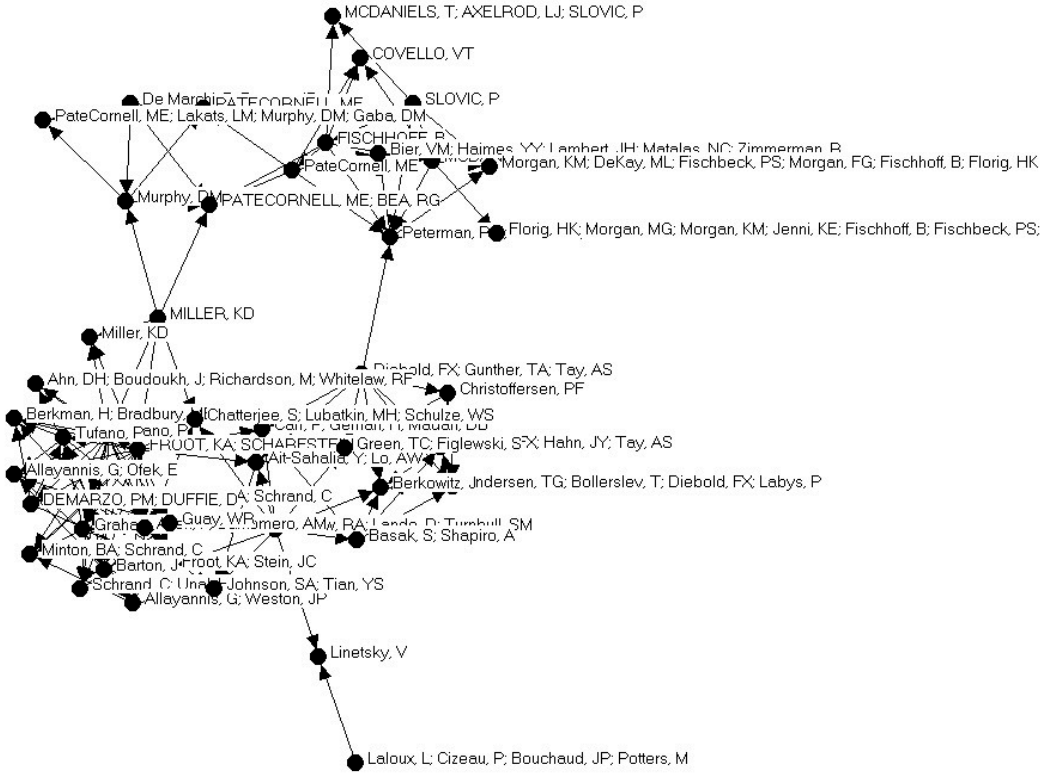

Figure 36 Bibliographic Coupling with Three or More References Common

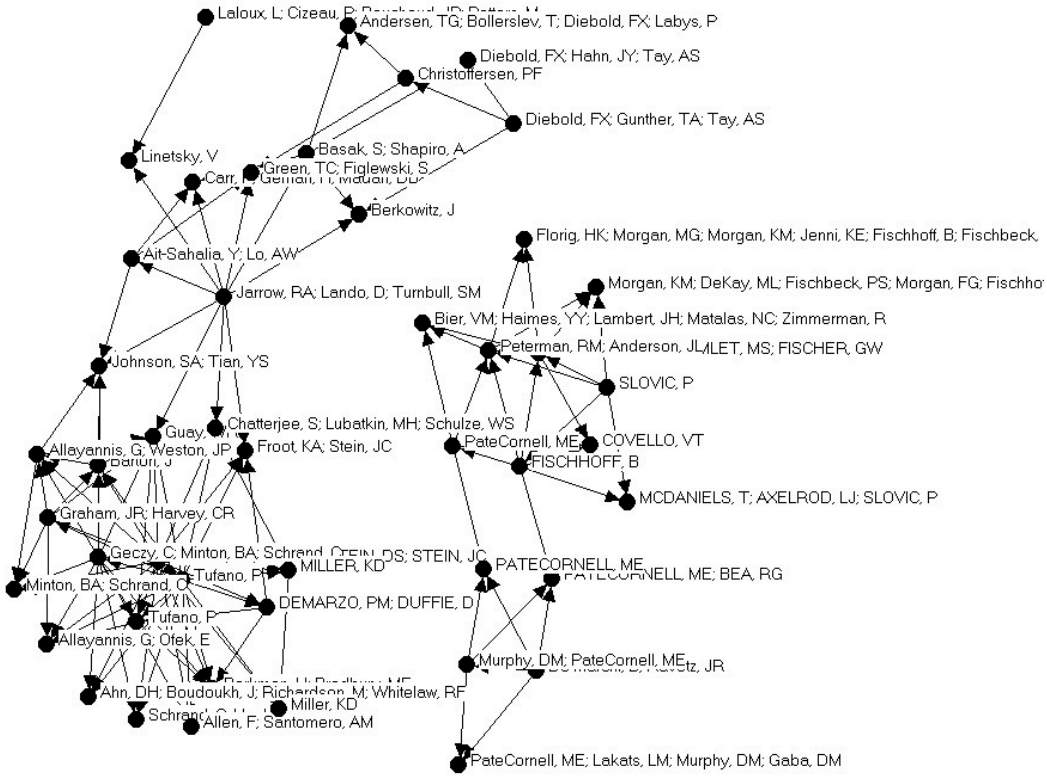

Figure 37 Bibliographic Coupling with Four or More References Common

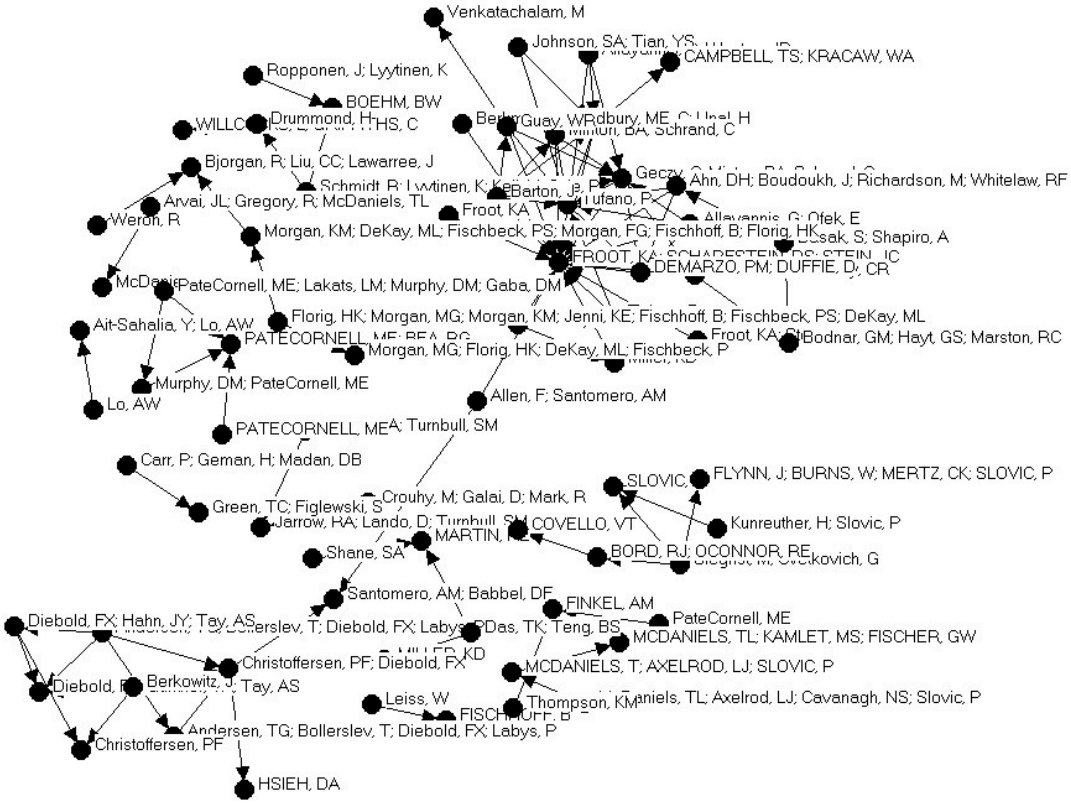

Figure 38 Linkages between the Articles in the Data Set

Table 9 Main Articles of the Identified Clusters

Cluster 1
Slovic, P (1993)
Fischhoff, B (1995)
Flynn, J; Burns, W; Mertz, CK; Slovic, P (1992)
Siegrist, M; Cvetkovich, G (2000)
Bord, RJ; O'Connor, RE (1992)
Flynn, J; Slovic, P; Mertz, CK (1993)
MacGregor, D; Slovic, P; Mason, RG; Detweiler, J; Binney, SE; Dodd, B (1994)
Cluster 2
Froot, KA; Scharfstein, DS; Stein, JC (1993)
Tufano, P (1996)
Geczy, C; Minton, BA; Schrand, C (1997)
DeMarzo, PM; Duffie, D (1995)
Froot, KA; Stein, JC (1998)
Schrand, C; Unal, H (1998)
Bodnar, GM; Hayt, GS; Marston, RC (1998)
Cluster 3
Diebold, FX; Gunther, TA; Tay, AS (1998)
Christoffersen, PF (1998)
Basak, S; Shapiro, A (2001)
Diebold, FX, Hahn, JY; Tay, AS (1999)
Christoffersen, PF; Diebold, FX (2000)
Allayannis, G; Weston, JP (2001)

Table 10 Cluster Characteristics

Cluster 1	Related Key Words
Slovic, P (1993)	Perceived risk, trust, risk communication
Fischhoff, B (1995)	Risk perception, risk communication, environment
Flynn et al. (1992)	Risk perception, trust
Siegrist & Cvetkovich (2000)	Risk perception, benefit perception, social trust
Bord & O'Connor (1992)	Risk perception, communication
Flynn et al. (1993)	Risk perception, risk management
MacGregor et al. (1994)	Risk perception, trust, communication
Risk perceptions, risk communication	
Cluster 2	
Froot et al. (1993)	Hedging policies, determinants, options, debt
Tufano, P (1996)	Hedging policies, corporate, deteminants
Geczy et al. (1997)	Financial policies, risk management, corporate, determinants
DeMarzo & Duffie (1995)	Financial hedging, policies
Froot & Stein (1998)	Corporate, investment, debt
Schrand & Unal (1998)	Insurance, savings, determinants
Determinants, hedging policies	
Cluster 2	
Diebold et al. (1998)	Density forecasting
Christoffersen, PF (1998)	Interval forecasts, evaluations
Basak & Shapiro (2001)	Portfolio insurance, equilibrium, options
Diebold et al. (1999)	Product definition, innovation
Christoffersen & Diebold (2000)	Exchange rate volatility, term structure, models, dynamics
Allayannis & Weston (2001)	Hedging policies, determinants, corporate, diversification
Forecasting, evaluations	

Table 11 Selected Articles through Bibliometric Review

Author	Title, Source
Basak, S; Shapiro, A (2001)	Value-at-risk-based risk management: Optimal policies and asset prices. *The Review of Financial Studies*.
Bodnar, GM; Hayt, GS; Marston, RC (1998)	1998 Wharton survey of financial risk management by US non-financial firms. *Financial Management*.
DeMarzo, PM; Duffie, D (1995)	Corporate Incentives for Hedging and Hedge Accounting. *The Review of Financial Studies*.
Froot, KA; Scharfstein, DS; Stein, JC (1993)	Risk Management: Coordinating Corporate Investment and Financing Policies. *The Journal of Finance*.
Geczy, C; Minton, BA; Schrand, C (1997)	Why firms use currency derivatives. *The Journal of Finance*.
Nance, DR; Smith, CW; Smithson CW (1993)	On the Determinants of Corporate Hedging. *The Journal of Finance*.
Mian, SL (1996)	Evidence on Corporate Hedging Policy. *The Journal of Financial and Quantitative Analysis.*
Schrand, C; Unal, H (1998)	Hedging and Coordinated Risk Management: Evidence from Thrift Conversions. *The Journal of Finance*.
Smith, CW; Stulz RM (1985)	The Determinants of Firms' Hedging Policies. *The Journal of Financial and Quantitative Analysis*.
Stulz, RM (1984)	Optimal Hedging Policies. *The Journal of Financial and Quantitative Analysis*.
Stulz, RM (1990)	Rethinking Risk Management. *Journal of Applied Corporate Finance*.
Tufano, P (1996)	Who Manages Risk? An Empirical Examination of Risk Management Practises in the Gold Mining Industry. *The Journal of Finance*.

APPENDIX 5. CONTENT ANALYSIS - QUESTIONS

Table 12 Questions Analysed with Content Analysis

EU ETS Operations
Please briefly describe the organisation of EU ETS operations in your company.
Risk Management Strategies
Please briefly describe the risk management strategy that your company has for EU ETS.
What factors led to the choice of the risk management strategy for EU ETS your company has (even if your company does not have a specific risk management strategy for EU ETS)? Please briefly describe the reasoning behind the choice.
What are the advantages and disadvantages of the chosen risk management strategy for EU ETS in your company? Please briefly describe the advantages and disadvantages.
Risk Management Practises for EU ETS
Does your company have other risk management practises and tools for EU ETS? Please briefly describe the practises and tools.
Why did your company select these risk management practises for EU ETS? Please briefly describe the motivation behind the decision.
Role of Carbon Funds and CDM/JI Projects
If your company has invested in CDM/JI projects or Carbon Funds: What was the motivation behind the investment for your company? Please briefly describe this motivation.
Uncertainties related to EU ETS
What are the greatest threats and opportunities for your company deriving from the EU ETS and other climate change mitigation policies?
How is your company preparing for the post-2012 climate change regulation? Please briefly describe this preparation.
If yes, please briefly describe the involvement of your company. (When asked about the involvement in climate change regulation)
What do you consider to be the greatest area of uncertainty related to the EU ETS framework? What short-term and long-term uncertainties do you consider important for your company?

APPENDIX 6. INSTALLATIONS AND EUAS ALLOCATED

Table 13 Installations under the EU ETS and EUAs allocated (EU, 2006)

Member State	EUAs (mio. tonnes)	Share of total EUAs	Installations covered	Reduction Commitment
Austria	99.0	1.5 %	205	-13%
Belgium	188.8	2.9 %	363	-7.5 %
Czech Republic	292.8	4.5 %	435	-8%
Cyprus	17.0	0.3 %	13	-
Denmark	100.5	1.5 %	378	-21%
Estonia	56.9	0.9 %	43	-8%
Finland	136.5	2.1 %	535	0%
France	469.5	7.1 %	1,172	0%
Germany	1,497.0	22.8 %	1,849	-21%
Greece	223.2	3.4 %	141	25%
Hungary	93.8	1.4 %	261	-6%
Ireland	67.0	1.0 %	143	13%
Italy	697.5	10.6 %	1,240	-6.5 %
Latvia	13.7	0.2 %	95	-8%
Lithuania	36.8	0.6 %	93	-8%
Luxembourg	10.1	0.2 %	19	-28%
Malta	8.8	0.1 %	2	-
Netherlands	285.9	4.4 %	333	-6%
Poland	717.3	10.9 %	1,166	-6%
Portugal	114.5	1.7 %	239	27%
Slovak Republic	91.5	1.4 %	209	-8%
Slovenia	26.3	0.4 %	98	-8%
Spain	523.3	8.0 %	819	15%
Sweden	68.7	1.0 %	499	4%
UK	736.0	11.2 %	1,078	-12.5 %
Total	**6,572.3**	**100%**	**11,428**	**-**