Business Strategy of Climate Change

Empirical Study of the Steel Industry Sector

Masachika Suzuki

Business Strategy of Climate Change

Empirical study of the steel industry sector

De strategie van het bedrijfsleven inzake klimaatverandering

Een empirische studie over de staalindustrie

Thesis

to obtain the degree of Doctor from the
Erasmus University Rotterdam
by command of the
rector magnificus

Prof.dr. S.W.J. Lamberts

and in accordance with the decision of the Doctorate Board

The public defence shall be held on

Friday 31st of October 2008 at 09.00 hrs

by

Masachika Suzuki
born in Tokyo, Japan

Doctoral Committee

Promotors:	**Prof.dr. W.A. Hafkamp**
	Prof.dr. J.J. Bouma
Other members:	**Prof.dr.drs. F.H.A. Janszen**
	Prof.dr. J. Albrecht
	Prof.dr. R.J.M. van Tulder

Acknowledgements

Writing a Ph.D. thesis required much more work than I expected. Before the writing process, there was endless research process. Even after I started writing, my progress was very slow. At best, I could write one page a day. I accumulated frustrations at the end of the day. In this state of mind, I often read a story of the daffodil principle introduced by Donald Huisingh (attached at the end of this thesis). Reading the story somehow eased my mind in the small apartment in Kralingen. I learned (at least, I experienced) through this journey the significance of taking one small step at a time to achieve something that looks grand in the beginning.

This thesis did not come to reality without support from several persons. I would like to thank the faculty members of my small committee for reading this thesis patiently. Especially, I would like to thank my adviser, Jan Jaap (Professor Bouma) for giving me valuable comments and for guiding me at every stage of this research. Some of his comments required time for me to digest – I often had to think about them over and over. There were times when I disagreed with his points. Eventually, however, a moment arrived when I understood his points. Without his guidance, this thesis is not as good as it is. I would also like to thank Wim (Professor Hafkamp) for encouraging me in the course of this research. One time, Wim gave me a timely encouragement when I felt rejected by receiving harsh comments on my presentation in San Francisco. When I met Wim after the presentation to discuss my research topic, he suggested instead having beer and watching a world series baseball game between Boston Red Sox (which Wim supported) and New York Yankees (which I supported)! It was his way of giving me his support and it worked very well! (Incidentally, Hideki Matsui made a slide into the home plate and the New York Yankees won the game.)

I would like to thank Don (Professor Huisingh) for his formidable support. Don read my thesis manuscript literally sentence by sentence. Among all, I learned much from the way he communicates with his students. To put it simply, he treats us as if we were his own children. Now, I have my own students at university. When they come for my support, I think of how Don would communicate with them. Knowing him and learning from him became a real asset in my life. I would also like to thank Leo (Professor Baas) for his generous support in Rotterdam. Leo is the father who watches us from the distance. When necessary, however, he gives us a heart-warming support. Without his support, my research in Rotterdam was not possible. I also thank Trude for her tremendous support when I was in Rotterdam and when I was away from Rotterdam.

I would also like to express my gratitude to the distinguished scholars, the corporate managers and my colleagues who provided me with their knowledge, experiences, insights, and information on this research subject. Professor Albrecht (Gent University), Professor Kolk (University of Amsterdam), Professor Hoffman (University of Michigan) and Professor Hoffman (ETH Zurich) provided valuable comments. Their comments were priceless in formulating the theoretical framework of this thesis. I cannot thank enough for the corporate managers from the steel companies who shared their professional experience with me. In the midst of their busy schedule, many of them were willing to spare their time to sit with me and speak with me on the phone. Without their support, the empirical part of this research was not successful. In Europe, there is a good network of Ph.D. students studying issues on climate change. They organize small workshops to discuss the subjects of their interests informally. I participated in their discussion in Cologne, Groningen, and Zurich. I am thankful that they organized such nice events to share different ideas among us.

I have two great mentors who have had a great influence on my way of thinking, my way of feeling, and my way of managing things. Usui sensei (Keio University) is one of them. Usui sensei taught me that climate change is an important global challenge as early as 1995. I received intensive and extensive training in international relations and economics from him. He is the most thoughtful scholar that I have ever met in my life. He is also a great educator who offers open-handed supports to his students. He supported me in every possible way even when I lived abroad. Hatano san from Mitsubishi UFJ Securities is also my great mentor. Hatano san (my old boss at Clean Energy Finance Committee at the company) is an amazing business manager with incredible strategic thinking skills. I learned so much by watching the way he conducts business. I owe so much to Usui sensei and Hatano san for who I am now.

I have had wonderful people at every stage in my life. Taking this opportunity, I would like to thank them. They are Scott Gartner (University of California Davis), David Downie (Columbia University), Hewson Baltzell (Innovest Strategic Value Advisors), Eric Olson (United Nations Secretariat), Mukul Sanwal (United Nations Framework Convention on Climate Change), Jay Rajasekera and Philip Sugai (International University of Japan).

This thesis is dedicated to my family, Faden family, and van der Esch family. Especially, the dedication goes to my grandmother, Tsugie, who passed away this year at the age of eighty-seven. Tsugie taught me how to keep thinking of someone even after the person does not exist any more in this world. She was quiet and modest – she did not talk about the war, she did not marry again, she did not want anything but peace in mind. Her only wish was to visit the battlefield in the Philippines where her husband died long time ago. A hot sunny day in spring 2005, on the seashore of Damortis on the Luzon Island, I saw her fulfilling the wish after fifty years.

This journey will continue. Thank you, Margalit, for being with me, encouraging me, and supporting me always. Your smile is the lighthouse in my journey.

Executive Summary

Climate change negotiation

There is a broad scientific consensus that our plant is warming and that post industrial revolution human activities are contributing significantly to the process. If global warming continues at the present and projected pace, it will cause significant damages to the global eco-system upon which humans are dependent. There is also a consensus that in order to limit the temperature rise to 2 degrees Celsius and prevent risky anthropogenic interference with the climate system, it is critical to stabilize carbon dioxide (CO_2) concentration at no more than 550 parts per million (ppm).

The latest report published by the Intergovernmental Panel on Climate Change (IPCC) in 2007 calls for the developed countries to reduce their CO_2 emissions 60% by 2050 relative to the present level and for the developing countries to control their emissions starting around 2030.

As the first tangible step to cope with global climate changes, countries adopted the UN brokered, 'Kyoto Protocol,' that was developed in 1997. Under the Protocol, the European Union (EU) and Japan established targets to reduce greenhouse gas (GHG) emissions by 8% and 6% respectively between 2008 and 2012 relative to 1990. The developing countries including China, Brazil and India ratified the Protocol without specific emission reduction targets. Two countries with the highest CO_2 emission releases per capita, the United States and Australia did not ratify the Protocol (In December 2007, however, Australia ratified the Protocol as soon as Rudd was elected as the prime minister). Intensive discussion has begun among policymakers and policy-minded social scientists with regard to how to include these countries in the post Kyoto regime. At Conference of the Parties (COP) 13 which took place in Bali, Indonesia in December 2007, the negotiators attempted to agree on the schedule for the discussion of the post Kyoto regime. As we know, the Kyoto Protocol is only the starting point of the forthcoming marathon-like multilateral negotiations.

The roles of the private sector in the climate change regime

The issue of global climate change involves different stakeholders at different levels. Thus far, the groups of scientists forming institutions such as the IPCC are presenting scientific evidence about climate change. Their information is the primary source of increasing concerns about future climate change among the public. The national governments are involved in the climate change negotiations and are working on the linkage between the international and domestic arenas. In the international arena, they negotiate with other national governments to consider international agreements such as the Kyoto Protocol. In the domestic arena, they consider policy instruments such as carbon tax, emissions trading schemes and voluntary measures. The industry sectors are then required to respond to the policies. Enlightened industrial leaders realize that they have a moral responsibility as well as economic responsibilities to be part of the "solution" to mitigating climate change emissions.

This thesis focuses on the roles and responsibilities of industry with a special focus upon the steel industry sector. The industry sector is responsible for a large part of the global anthropogenic GHG emissions release. The role of the industry sector is critical in the climate change regime. It can provide technological solutions to help reduce GHG emissions. On the other hand, it can also interfere with political initiatives to reduce emissions releases. Since the climate negotiations officially began in 1992, the degree of involvement of the industry sector in the negotiations has increased greatly.

This thesis is based upon a theoretical and empirical study of climate change strategy of the industry sector. This thesis author examines how firms in the energy-intensive industry sectors formulate their strategy and management with regard to their responsibilities on global climate change. The thesis addresses three research questions: [1] What are the similarities and differences in corporate strategies and management on GHG emissions among firms; [2] What are the similarities and differences in corporate responses to the climate change policy instruments among firms; [3] What are the main factors that contribute to the formulation of their responses to the climate change policy instruments? This thesis addresses these questions with a view to finding a common strategic platform among firms towards the post-Kyoto period.

Theoretical discussions about corporate climate change strategies

In order to understand how firms make a decision on global climate change, this thesis author examined three dimensions: economic, technological and institutional.[1] In the course of the preliminary literature review, he began to recognize that corporate leaders are increasingly realizing that all three dimensions are crucial in order to understand how and why firms formulate their climate change strategies. There are many research initiatives to analyze corporate climate change strategies in individual dimensions. However, few of the research studies attempt to look into other dimensions or to bridge the gaps among them. This research is an attempt to develop and to test a framework to examine, simultaneously, the three dimensions of corporate climate change strategy.[2]

This thesis author began to explore the economic dimensions of corporate climate change strategy in Chapter 2. It is not surprising that when governments propose a new policy for GHG emissions reduction, that firms pay attention to economic and financial consequences of that policy. For example, this is the case with the “emissions trading scheme”, in the EU (EU ETS). There are several studies that have examined the economic impacts of the scheme. The findings of the studies underscore that there are four areas of economic impacts to address: 1) costs to reduce GHG emissions internally and/or via purchase of emission allowances, 2) increase in electricity prices, 3) demand reduction and 4) loss in competitiveness in the international market. This thesis author reviewed the theoretical framework of the economic analysis.

This thesis author then examined the technological dimensions of corporate climate change strategies. Technological innovation is another essential issue that firms consider under the emerging pressure for GHG emissions reduction. When firms develop cost-effective technological options to reduce GHG emissions, they may be more willing to accept the introduction of a new climate change policy. When firms have limited technological options to reduce GHG emissions, however, they are likely to oppose such changes. This thesis author contended that a firm’s prospect for technological innovation plays an important role in the formation of their corporate climate change strategies. In doing so, particular attention was given to the argument presented by George Stigler that with certain market and technological conditions, some firms may, in fact, support an introduction of GHG emissions reduction regulations. A theoretical discussion on the interface between technology and regulations is presented to address these issues.

The author then shifted the focus of attention into the institutional dimensions of corporate climate change strategy.

[1] In fact, the gaps between the economic, technological and institutional “dimensions” are not so clear and there are many overlaps or common issues among them. The author used the term “dimensions” in this thesis to indicate three areas that are vaguely separated.

[2] With this respect, the approach that the author took in this research is similar with the Triple Bottom Line approach. The Triple Bottom Line approach attempts to capture three different dimensions (economic, environmental and social) in assessing organizational performance. The concept was introduced by John Elkington.

Through review of the literature, the author addressed non-economic and non-technological elements of corporate decision-making. He came to the conclusion that industrial firm's responses to climate change policy instruments are not solely formulated by their economic and technological considerations. He contends that the "institutional environment" also influences firm's strategies and stances on the policy instruments.[3] Firms receive external pressures from their diverse stakeholders. For example, they receive regulatory pressures from the government. The author notes that the characteristics of the institutional environment differ from one country to another. He argues that the country-specific (or region-specific) natures of the institutional environment, the so-called "country of origin factors" turn into divergent pressures on the firm's climate change strategies within and among countries. The empirical part of this thesis research examines, individually, the institutional environment of each region including the EU, Japan, the U.S. and South Korea.

On the other hand, there are simultaneously convergent pressures among firms. Economic globalizations of firm's operations as well as the emergence of climate change as a "global issue area" are part of the globally convergent pressures. The thesis author investigates the interface between the convergent and divergent trends among firms.

The research framework for the analysis of corporate climate change strategies

Through the literature review this thesis author performed, he extracted theoretical insights into firm's behaviors in the three dimensions and as a result he proposed a research framework. Under that framework, he examined the three dimensions: economic, technological and institutional. As stated above, this is a unique effort since research attempts to analyze corporate climate change strategy have been conducted separately among the three dimensions. The author addressed the following questions:

1. What are the similarities and differences in corporate strategies and management on GHG emissions reductions among firms?
2. What are the similarities and differences in corporate responses to the climate change policy instruments among firms (including both Kyoto and post-Kyoto policy instruments)?
3. What are the main factors that contribute to the formulation of a firm's responses to the climate change policy instruments? Are they economic, technological or institutional factors? Or do all three play crucial and different roles?

This is one of the first research attempts that propose a framework to examine the three different factors. There have not been investigations that address the three dimensions from a holistic perspective. While the author considered that firms are open systems and are subject to institutional pressures in the formulation of their strategies and their management responses, he acknowledged that economic and technological factors also play important roles. It is also important to note that the three dimensions are not completely separated or independent. The author elaborated on how the three dimensions are interrelated.

There are two levels of subject area for analysis. Corporate strategy and management in climate change is the first level of analysis (Research question 1). At this level, the author examined firm's overall strategic and management responses. A question arises: what constitute corporate strategy and management on climate change? Scholars

[3] In this thesis, this author investigated several institutional forces influencing corporate decision-making. Among them are government regulations and social pressures. The author uses the term "institution" consistently with the definition provided by R. Scott, who defined institutions in 1995 as "social structures that have attained a high degree of resilience. [They] are composed of cultural-cognitive, normative, and regulative elements that, together with associated activities and resources, provide stability and meaning to social life."

and managers have different ideas about the subject area of climate change strategy and management. The author reviewed different models and systems that were proposed by scholars. Based on the investigation, the author decided to focus on the following subject areas in this research; 1) policy statement, 2) organizational structure, 3) information disclosure, 4) measurement, 5) accounting, 6) product development, 7) technological innovation, 8) integrated chain management/life cycle assessment and 9) partnership/membership. The second level of analysis addresses the firm's approaches on specific climate change policy instruments (Research question 2). The policy instruments include both Kyoto schemes and post-Kyoto schemes. As for post-Kyoto schemes, there are several schemes under discussion including the scheme to establish industry-specific GHG emissions targets rather than country-specific GHG emissions targets under the Kyoto Protocol and the scheme to establish targets for each technology. This thesis looks into how firms respond to each scheme.

Based on the research framework, the author conducted empirical research on the steel industry sector. The steel industry sector is considered to be a key sector among the industrialized countries. Steel is used as an essential material in numerous other major industry sectors including the automobile, construction and engineering sectors. Based on the research framework, the author analyzed six steel companies in the four different countries (regions): Japan, the EU and the U.S. and South Korea. The author selected the steel companies in Japan and the EU because of the strong regulatory pressures on the companies under the Kyoto Protocol to reduce GHG emissions. The decision to analyze a U.S. steel company was made based on the consideration that the U.S. is the largest GHG emissions producer and that the U.S. is one of only two major countries that has not signed the Protocol nor has it established "binding" emission limits for its companies. In the design of the post-Kyoto instruments, it is important to investigate how the U.S. steel company formulates its climate change strategy and management. The author similarly selected a Korean steel company because of Korea's anticipated context within the post Kyoto regime. While South Korea is a non-Annex I Party under the Kyoto Protocol, it became an OECD member country in 1996. It is becoming harder to conceive of Korea as a developing country. How to include companies in countries such as South Korea in the post-Kyoto regime is becoming an increasingly important issue in the climate change policy-making arena.

For future research, the proposed research model is applicable for analyzing similarities and differences among any firms. Researchers may select firms and countries for analysis based on their interests. If they are interested in the trans-Atlantic similarities and differences in corporate climate change strategies, they may focus on the North American and European firms. If they are interested in the firms in the other Annex-I Parties in the developed regions, they may include firms from Australia, Canada, Japan, New Zealand or the United States. If they are interested in the contrasts between the developing and developed regions of the Annex I Parties, they may include firms in Russia or Eastern European countries. The model is also applicable for analyzing any industrial sectors that are important in the context of climate change such as power generation, oil refineries, cement production, chemicals and pulp and paper. It is, however, suggested to focus on one industrial sector. The proposed model requires extensive elaborations into all three analytical dimensions. The collection of the information and data for empirical research is a challenging task.

Contributions of this research

This research brought together theoretical, empirical and policy contributions. The theoretical contribution is the demonstration of the research framework. This is one of the first attempts to address three different dimensions simultaneously. Financial economists examine acceptability of climate change policy instruments among firms from the economic perspective. Innovation economists demonstrate the roles of technological innovation in firm's responses to the policy instruments. Scholars who are looking at business management and practices investigate how firms receive and respond to influences from the external environment in formulating climate change strategies. While all of the research efforts equally aim at understanding corporate climate change strategies, each of them tends to place their focus on their individual focal dimension. The proposed research methodology is an attempt to identify the factors of importance from all three dimensions, simultaneously.

While the steel industry sector is one of the most energy-intensive and GHG emissions producing sectors, there has been little research to analyze corporate climate change strategies within it. Previous industrial sectors with research attention have been limited to the automobile and oil industry sectors. Therefore, this study is the first empirical case study that provides an in-depth analysis of corporate climate change strategies of the steel industry sector. It is also noted that previous regional research in this area was limited to the United States and Europe. This thesis research is, therefore, one of the first efforts to also include Japanese and Korean firms in the analysis.

The ultimate goal of this research was to ascertain if there is a common strategic platform among firms in the steel industry to cope with global climate change. This researcher also questions whether and to what extent strategic convergence can take place among steel industry firms towards the post Kyoto period. It is the author's hope that the results of this research provide valuable input for policymakers in the design of the post Kyoto concepts, tools and policies.

Findings of this study

As stated in previous paragraphs, a research framework was developed and applied in the analysis of the steel industry sector. The steel companies investigated were Nippon Steel, JFE, Corus Group, Arcelor, U.S. Steel and POSCO.[4] The analysis covered the steel companies in the four different countries (regions): Japan, the EU, the U.S. and South Korea. The steel-making process is highly energy-intensive. It produces a large volume of GHG emissions. The steel industry sector is responsible for approximately 3% of the global GHG emissions. The GHG emissions from the steel sector are among the largest in the whole industry sector. For example, the CO_2 emissions from the steel sector account for nearly 15% of total CO_2 emissions in Japan.

The thesis author conducted and presented the results of the empirical analysis in Chapters 5 – 9. He sought to answer the research questions in Chapter 10. Chapter 10 describes the details of a number of findings obtained through this research. This executive summary addresses a few of the findings.

Overall, the author found a high level of homogeneity in corporate climate change strategies between the Japanese and EU companies. There is a "coercive" force leading to isomorphism among them. The acceptance of the emissions reduction targets under the Kyoto Protocol is turning into a coercive force for the companies in the two different regions. On the other hand, the author came to recognize that "normative" pressures to cope with climate change are absent not only in the U.S. and South Korea but also in Japan and the EU. The social concerns towards climate change have not been strong enough for the steel companies to consider in the formulation of their climate change strategies. A mimetic pressure toward isomorphism was observed, in particular, with the Korean company. The Korean company is investigating how the European and Japanese steel companies are coping with the regulatory pressure to reduce GHG emissions.

[4] Nippon Steel and JFE are Japanese steel companies. The size of steel production was the 3rd and 4th in the ranking of steel production in 2004 respectively, Corus is a steel company based in the UK and the Netherlands (the 8th in the same ranking), Arcelor is a steel company based in Luxemburg and the largest steel company. The U.S. Steel is the largest steel company in the U.S. and ranked the 7th in the 2004 ranking. POSCO is the largest steel company in South Korea and the 5th in the ranking. In 2006, Arcelor received an offer from Mittal for merger, while Corus received an offer from Tata Steel for merger.

The author paid particular attention to the trends that may lead to convergence on corporate climate change strategy within the steel industry. One trend is economic globalization. Some scholars such as Porter argue that because the products and services are traded increasingly in the international market, the firm's management and structure are becoming more global. Indeed, this thesis author came to realize that this is the case within the steel industry sector. Steel products are increasingly traded in the international market. Raw materials including iron ore and coal are imported from multiple countries. In addition, there are many international, joint ventures in the steel industry. The other trend is the emergence of climate change as a "global issues arena". In response, there are now several international initiatives in the steel industry sector to cope with climate change. The most holistic initiative is the "CO2 Breakthrough Program," facilitated by the International Iron and Steel Institute (IISI) that includes all major steel companies in the world. This program, together with other multilateral, regional, and bilateral programs is likely to be another source of pressure for convergence on corporate climate change strategies.

Through this researcher's efforts, he observed not only convergent trends but also divergent trends. It was confirmed that the regulatory culture and schemes of each country are playing an important role in shaping corporate climate change strategies. Each country has different a regulatory culture and a different set of regulatory approaches. The country-specific culture and schemes are turning into as a strong divergent force among companies in the formulation of corporate climate change strategies. This thesis author found that the Kyoto Protocol is a source of strong pressures for divergence among the companies in the steel industry sector. He found a high level of convergence in corporate climate change strategies between the Japanese and EU steel companies. The Kyoto Protocol is providing a "coercive" force leading to isomorphism between them. In the absence of the commitment under the Kyoto Protocol, the strategy of the U.S. company (U.S. Steel); its climate change responses are diverting from the approaches being taken by the Japanese and EU companies in the steel industry sector.

Limitations of this study

There are several limitations in the empirical part of this study. The details of the limitations are illustrated in Section 3.11. Some of the important limitations are:

- This research only addressed Arcelor and Corus Group in the EU region. There are many differences among European steel companies as to their business strategies and management, business models, cost structures and quantity and quality of produced steel as well as their corporate strategies on climate change. In particular, there may be distinct differences between the northern and southern EU steel producers. It is noted that the analysis of the two steel producers headquartered in Northern Europe may not be applicable to the steel companies in Southern Europe. There are variances with respect to the degree of coercive and normative pressures among the EU member countries. Focusing on the two steel companies headquartered in the Northern region may not provide proper insight into possible differences and diversities among steel companies in the EU.
- There are significant differences in the level of sophistication of analysis among countries (or regions). This thesis author was able to conduct thorough analysis of European and Japanese steel companies since there was ample information and data on their corporate climate change strategies. However, he was not able to perform the same level of analysis for the U.S. and Korean steel companies. This was mainly due to the fact that availability of the information and data on this

subject in the U.S. and South Korea was extremely limited. In light of this, the author considers that the analysis of Japanese and European steel companies is the main part of the empirical study, while the analysis of U.S. and Korean steel companies is less in-depth.

- Most of the firm-specific issues were placed out of the research scope. The author recognizes, however, that some of the firm-specific issues can often play an important role in the formulation of corporate climate change strategies. For example, the differences in corporate history and culture can contribute to their divergent views on climate change issues among firms. The exclusion of individual company's history and culture from this analysis may lead to failure in capturing important factors that influence the formulation of their corporate climate change strategies.
- This author assumed that the firm's corporate climate change strategy is consistent within the firm and across the firm's operations. However, this assumption is not the case in reality. For example, the views among business operations such as finance, marketing and procurement may vary greatly within a firm. Their views may be different from the environmental department. In addition, firms with international operations tend to have diverse strategies depending upon the location of the business units. In the case of the Corus Group, for example, the company has different strategies between its UK and Dutch operations. Arcelor is another case where its strategies are different in its Belgium, French, Spanish operations. The strategy of each country may also be different from the headquarters in Luxemburg.

Samenvatting (Dutch translation of Executive Summary)

Er bestaat grote consensus over het opwarmen van onze planeet en dat de menselijke activiteiten na de industriële revolutie significant aan dit proces bijdragen. Wanneer de opwarming van de aarde in de huidige en geprojecteerde snelheid doorgaat zal het duidelijke schade veroorzaken aan het wereld ecosysteem waar mensen van afhankelijk zijn. Het recente rapport van het *Intergovernmental Panel on Climate Change* (IPPC) in 2007 roept de ontwikkelde landen op om hun CO2 emissies in 2050 met 60% te reduceren in vergelijking met het huidige niveau en de ontwikkelingslanden om hun emissies rond 2030 onder controle te gaan houden.

Dit proefschrift richt zich op de rollen en verantwoordelijkheden van de industrie met een speciale blik op de staalindustrie. De industrie-sector is verantwoordelijk voor een groot deel van de werelduitstoot antropogene GHG. De rol van de industrie is kritisch in het klimaatveranderingsregime. De sector kan in technische oplossingen voorzien om de GHG emissies te helpen reduceren. Aan de andere kant kan het ook interfereren met politieke initiatieven om emissies te reduceren. Sinds de klimaatonderhandelingen officieel begonnen in 1992, is de mate van betrokkenheid van de industrie in de onderhandelingen sterk uitgebreid.

Dit proefschrift is gebaseerd op een theoretische en empirische studie van de klimaatveranderingsstrategie van de staalindustrie. De auteur onderzoekt hoe ondernemingen in de energie-intensieve sectoren hun strategie en management formuleren in relatie tot hun verantwoordelijkheid voor de wereldwijde klimaatsverandering. De in de empirische studie geanalyseerde ondernemingen zijn staalbedrijven in Europa, Japan, de Verenigde Staten en Korea. Het proefschrift kent drie onderzoeksvragen: [1] Wat zijn de overeenkomsten en verschillen in ondernemingsstrategie en management met betrekking tot de reductie van broeikasgas emissies in de bedrijven? [2] Wat zijn de overeenkomsten en verschillen in hun antwoorden op de klimaatveranderings-beleidsinstrumenten tussen de bedrijven? [3] Wat zijn de voornaamste factoren die bijdragen aan zowel de klimaatveranderingsstrategie en management van de ondernemingen als ook hun antwoorden op de klimaatveranderings-beleidsinstrumenten? Zijn het economische, technologische of institutionele factoren of een combinatie van sommige factoren? Dit proefschrift gaat op deze vragen in met het oog op het vinden van een algemeen strategisch platform van bedrijven voor de post-Kyoto periode.

De auteur komt tot de conclusie dat de institutionele en technologische dimensies een belangrijke rol spelen in het creëren van klimaatveranderingsstrategieën op zowel het strategisch als beleidsspecifieke niveau van de onderzochte staalbedrijven. De invloed van de economische dimensies is op het beleidsspecifieke niveau wat minder waarneembaar. Dit onderzoek toont aan dat de internationale regulering (Kyoto Protocol) aan het veranderen is in een dwingende druk op de Europese en Japanse staalbedrijven die zich in de richting van isomorfisme bewegen. Het empirisch onderzoek geeft de indicatie dat er toenemende isomorfisme trends tussen de Europese en Japanse ondernemingen met betrekking tot klimaatveranderingsstrategieën zijn. Er is een hoge mate van overeenkomst op de gebieden van beleidsverklaringen, organisatiestructuur, informatie ontsluiting, accounting en geïntegreerde productketen/ levenscyclus analyses. De Europese en Japanse ondernemingen tonen sterke initiatieven in de eerste drie gebieden en wat minder initiatief in de laatste twee. De overeenkomsten zijn vooral opmerkelijk in vergelijking met de ondernemingsstrategie van de Amerikaanse en Koreaanse staalbedrijven met betrekking tot klimaatverandering. Het empirisch onderzoek demonstreert dat het Kyoto Protocol heeft bijgedragen aan strategische convergentie tussen de Europese en Japanse staalbedrijven. Het Kyoto Protocol is een dwingende kracht geworden die tot isomorfisme tussen hen leidt.

Terwijl de internationale regulering aan het veranderen is in een dwingende druk op de Europese en Japanse staalbedrijven die zich richt op isomorfisme te bewegen, is er een divergente druk op de Europees/Japanse en

Amerikaans/Koreaanse staalbedrijven inzake de formulering van een klimaatveranderingsstrategie. Uit empirisch onderzoek is duidelijk geworden dat het Kyoto Protocol heeft bijgedragen aan het scherpe verschil tussen de Europees/Japanse en Amerikaans/Koreaanse staalbedrijven. Er is een hoge mate van overeenkomst tussen de Amerikaanse en Koreaanse staalbedrijven met betrekking tot het ontbreken van initiatieven op de gebieden van beleidsverklaring, informatie ontsluiting, meting, accounting en geïntegreerde productketen/levenscyclus analyses. De Amerikaanse en Koreaanse staalbedrijven tonen geen initiatief in deze gebieden, terwijl de Europese en Japanse staalbedrijven enige of sterke initiatieven tonen.

Er is een andere factor die bijdraagt aan het genereren van divergentie tussen de geanalyseerde staalbedrijven in de Europese Unie, Japan, de Verenigde Staten en Korea. Dit onderzoek toont aan dat de verschillen in de lokale reguleringscultuur en schema's aan het veranderen zijn in een divergente druk (land van oorsprong effect) op de bedrijven in de formulering van een klimaatveranderingsstrategie. Het werd in het onderzoek duidelijk dat er zowel verschillende reguleringsschema's als achtergrondculturen zijn om de broeikasgas emissies te reduceren in de geanalyseerde landen. In Japan bestaat een gebrek aan initiatief op overheidsniveau om beleidsinstrumenten voor broeikasgas emissies te introduceren. De initiatieven worden alleen op vrijwillige en unilaterale basis door de industrie sector genomen. In de EU nemen zowel de Europese Commissie als de nationale overheden in de regio in toenemende mate initiatieven om klimaatveranderings-beleidsinstrumenten te installeren, terwijl er een grote variatie is in de mate van regulerings of dwingende druk tussen de EU lidstaten. In de Verenigde Staten is de reguleringsdruk op de industrie om broeikasgas emissies te reduceren extreem zwak of niet-bestaand geweest sinds de regering Bush het Kyoto Protocol verwierp. De conclusie was dat waar reguleringsdruk wordt gecreëerd in de unieke lokale reguleringscultuur, de druk verandert in een divergente druk op de bedrijven met betrekking tot het formuleren van klimaatveranderingstrategieën.

Deze studie toonde ook aan dat technologische dimensies belangrijke factoren bij het genereren van divergentie inzake een klimaatveranderingstrategie aan het worden zijn. Technologische factoren werden herkend als belangrijke dimensies in het genereren van zowel enige kern strategieverschillen tussen Europese en Japanse staalbedrijven als in hun positie tegenover de specifieke, aan klimaatverandering gerelateerde, beleidsinstrumenten. Het strategisch belang van Japanse bedrijven in samenwerking met ontwikkelingslanden door bijvoorbeeld CDM wordt aangedreven door hun sterke technologische vaardigheid. Het gebrek aan interesse in CDM bij de Europese staalbedrijven wordt geassocieerd met het feit dat zij geen belangrijke patenten voor staalproductie technologieën hebben. In het empirisch onderzoek werd ook opgemerkt dat technologische dimensies enige verschillen tussen de Japanse en Europese staalbedrijven inzake hun strategische blik op het post-Kyoto regime creëren.

Deze studie ontvouwde ook dat de economische dimensies bij bedrijfsmanagers centraal komen te staan bij besluitvormingsprocessen over een klimaatveranderingstrategie in het geval dat de kosten en baten van specifieke beleidsinstrumenten als hoog worden geschat. Managers van staalbedrijven bijvoorbeeld houden met zowel de economische structuur van de wereld-staalmarkt als de economische effecten van de Chinese markten rekening bij het formuleren van een klimaatveranderingstrategie. Aan de andere kant bestaat er grote onzekerheid over de vaststelling van de kosten en baten van beleidsinstrumenten. Onder onzekere omstandigheden gaat de institutionele factor een veel belangrijkere rol bij de percepties en besluitvorming door bedrijfsmanagers met betrekking tot klimaatverandering spelen.

Thesis structure

This thesis begins with background information on the research. The author reviews the scientific knowledge base about global warming (Chapter 1). He also presents an overview of the process of international negotiations on climate change under the United Nations Framework Convention on Climate Change (UNFCCC) and describes major policy instruments implemented under that Convention.

In Chapter 2, the author examines theoretical discussions about corporate strategies on climate change. This chapter provides a theoretical basis for building a research framework on corporate climate change strategy presented in Chapter 3. The author explores three dimensions of corporate climate change strategy: economic, technological and institutional. He reviews economics, social science and business management literature.

In Chapter 3, the author attempts to extract theoretical insights into firm's behaviors from Chapter 2 and formulates them as a research framework for the subsequent empirical study. It is argued that corporate decision-making mechanisms are mainly a function of the economic, technological and institutional factors to which the company is exposed. It is contended that all dimensions are important in gaining an understanding of how and why firms formulate their climate change strategies and how they perceive and respond to the climate change policy instruments. Chapters 2 and 3 present the theoretical context of the thesis.

Before the author presents the results of the empirical research within the steel industry sector in Chapters 6 – 9, he presents an overview of the steel industry sector (Chapter 4). This chapter describes 1) market trends, 2) international trade trends, 3) production process, 4) GHG emissions sources and 5) cost structure of the industry sector. A particular attention is provided to the economic and technological features of the industry sector.

In Chapter 5, the author examines the economic and technological dimensions of the sector. With respect to the economic dimensions, he reviews literatures that demonstrate the economic impacts of climate change policy instruments upon the sector. It is examined whether and to what extent economic impacts of climate change policy instruments may have upon the steel industry sector. With respect to the technological dimensions, the author reviewed literature that examines technological options to reduce GHG emissions in the steel industry sector.

In Chapters 6-9, the author examines the institutional dimensions of each country/region and corporate climate change strategy of the steel companies (Chapter 6: Japan, Chapter 7: the EU, Chapter 8: the U.S. and Chapter 9: South Korea). He pays particular attention to the "home country effects" and discusses how the societal concerns about climate change and regulatory cultures and schemes on climate change differ among the countries. In these chapters, he examines corporate climate change strategies at two different levels. As stated above, corporate strategy and management in climate change is the first level of analysis. At this level, the author examines firm's overall strategic and management responses. The second level of analysis addresses the firm's approaches on specific climate change policy instruments.

In Chapter 10, the author presents the findings and conclusions of this study. After the findings, he elaborates a question of whether strategic convergence among the steel companies is observable. The structure of this thesis is illustrated in the following diagram:

Figure 1: Structure of this thesis

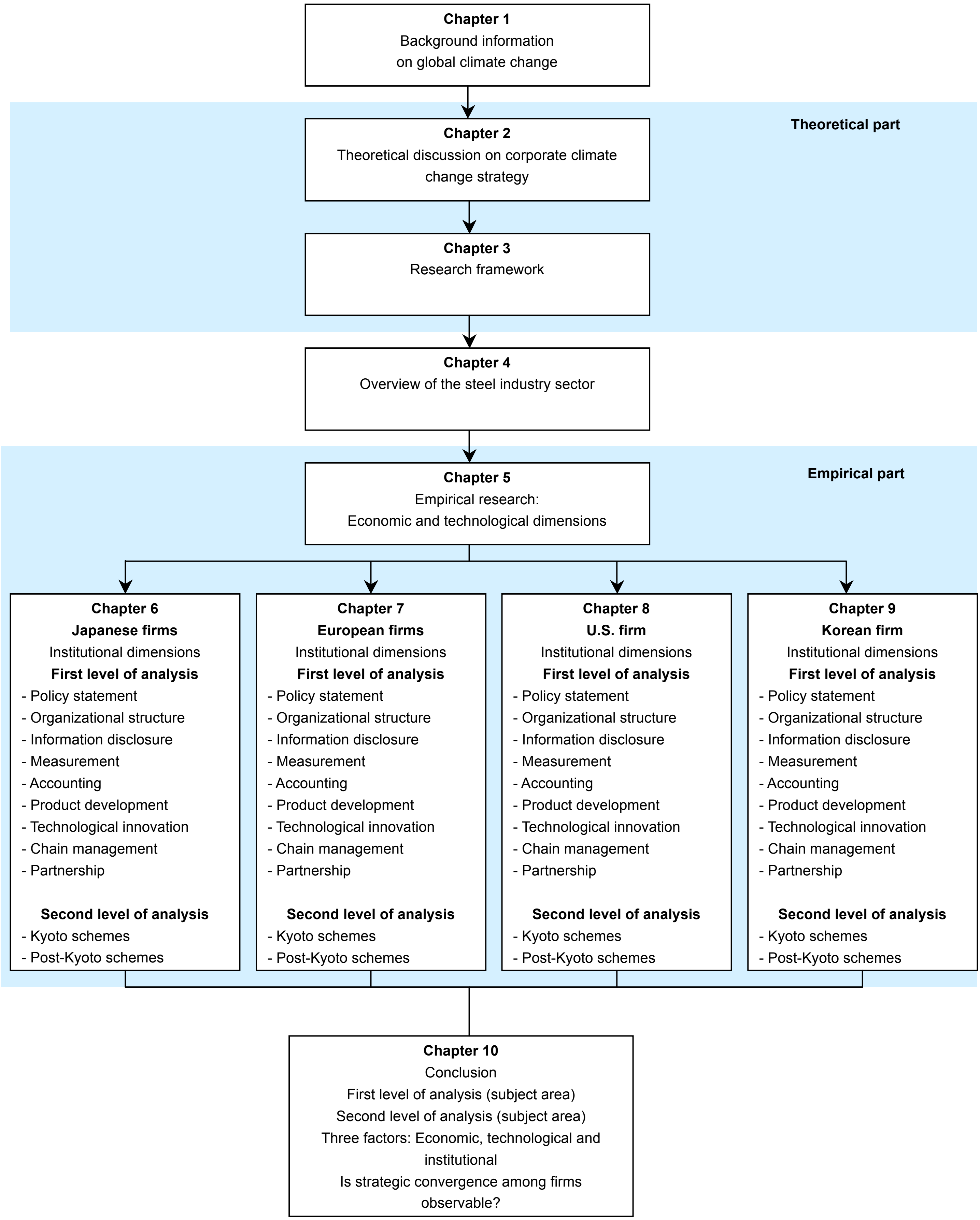


Table of contents

Acronyms and abbreviations

AAU: Assigned Amount Unit
ACM: Approved Consolidated Methodology
AISI: American Iron and Steel Institute
AR: Aforestation/Reforestation
ASEAN: Association of South East Asian Nations
BAT: Best Available Technologies
BOF: Basic Oxygen Furnace
BOS: Basic Oxygen Steel-making
BPT: Best Practicable Technology
BTM: Best Technical Means
CCF: Cyclone Converter Furnace
CCS: Carbon Capture and Storage
CDM: Clean Development Mechanism
CDQ: Coke Dry Quenching
CEF: Carbon Emission Factor
CER: Certified Emissions Reduction
CDP: Carbon Disclosure Project
CISA: China Iron and Steel Association
CSR: Corporate Social Responsibility
CERUPT: Certified Emission Reduction Unit Procurement Tender (The Netherlands)
CFC: Chlorofluorocarbon:
DBJ: Development Bank of Japan
DOE: Department of Energy
EDF: Environmental Defense Fund
EMA: Environmental Management Accounting
ENGO: Environmental Non-governmental Organization
ERUPT: Emission Reduction Unit Procurement Tender (The Netherlands)
FIELD: Foundation for International Environmental Law and Development
GCC: Global Climate Coalition
GRI: Global Reporting Initiative
OECD: Organization for Economic Corporation and Development
EAF: Electric Arc Furnace
EBRD: European Bank for Reconstruction and Development
EMAS: Eco-Management Audit Scheme
ERU: Emission Reduction Unit
ETS: Emissions Trading Scheme
EU: European Union
EUA: EU (emission) Allowance
GHG: Greenhouse Gas
HFC: Hydrofluorocarbon
IFC: International Finance Cooperation
IISI: International Iron and Steel Institute
ISO: International Standardization Organization

IPCC: Intergovernmental Panel on Climate Change
JGRF: Japan GHG Reduction Fund
JI: Joint Implementation
JISF: Japan Iron and Steel Federation
KFEM: Korean Federation for Environmental Movement
KVAP: Keidanren Voluntary Action Plan on the Environment (Japan)
LCA: Life Cycle Assessment
LCI: Life Cycle Inventory
LTA: Long-Term Agreement (The Netherlands)
METI: Ministry of Economy, Trade and Industry (Japan)
MOCIE: Ministry of Commerce, Industry and Energy (South Korea)
MoE: Ministry of the Environment
NAP: National Allocation Plan
NEA: Negotiated Environmental Agreement
NEDO: New Energy and Industrial Technology Development Organization (Japan)
NEPP: National Environmental Policy Plan
NOx: Nitrous Oxide
OAPEC: Organization of Arab Petroleum Exporting Countries
OECD: Organization for Economic and Development Cooperation
OHF: Open Hearth Furnace
PDD: Project Design Document
ppm: parts per million
PVEP: Public Voluntary Environmental Program
SO: Sulfur Oxide
TRT: Top Pressure Recovery Turbine
ULCOS: Ultra Low CO_2 Steelmaking
ULSAB: Ultra Light Steel Auto Body
UNEP: United Nations Environmental Program
UNFCCC: United Nations Framework Convention on Climate Change
UVEP: Unilateral voluntary Environmental Codes and Action Plans
VEA: Voluntary Environmental Agreement
VROM: Ministry of Housing, Spatial Planning and the Environment (The Netherlands)
WMO: World Meteorological Organization
WTO: World Trade Organization

List of tables and figures

Chapter 1: Development of the climate change regime

Introduction

There is a broad scientific consensus that the climate of our plant is warming, that human activities are importantly responsible for it and that if it continues at this pace, it will cause significant damages to the global eco-systems and to human existence. There is also a consensus that in order to limit the temperature rise to 2 degrees Celsius and to prevent risky anthropogenic interference with the climate system, it is critical to stabilize carbon dioxide (CO_2) concentration at no more than 550 pars per million (ppm). According to the Intergovernmental Panel on Climate Change (IPCC), this calls for the developed countries to reduce their CO_2 emissions 60% by 2050 relative to the present level and for the developing countries to control their emissions starting around 2030.

As the first tangible step to cope with the global problems of climate change, most countries of the world adopted the Kyoto Protocol in 1997 and in subsequent years. Under the Protocol, the European Union (EU) and Japan established targets to reduce greenhouse gas (GHG) emissions by 8% and 6% respectively, between 2008 and 2012 relative to 1990. The developing countries including China, Brazil and India ratified the Protocol without establishing specific emissions reduction targets. Two countries with the highest CO_2 emissions release per capita, the United States and Australia did not ratify the Protocol.[5] Intensive discussion is now underway about how to include these countries in the post Kyoto regime. The European Commission is suggesting reducing GHG emissions by 15-30% by 2020 and by 60-80% by 2050. There is a strong pressure on the United States to accept a GHG emissions reduction target in the post-Kyoto period. As we know, the Kyoto Protocol is only the starting point of the forthcoming marathon-alike multilateral negotiations.

In the first half of 2007, there were several events that have contributed to increases of the public interest in global climate change. The movie based on Al Gore's personal mission titled, "An Inconvenient Truth" has received extensive favorable attention. Al Gore won two academy awards for the film in 2007 and he was awarded a Nobel Prize together with the IPCC in the same year. President Bush of the U.S. acknowledged, for the first time in his "State of the Union" address, in 2007 that there is a linkage between human economic activities and global warming. Climate change was also a major issue at the 2007 World Economic Forum. The IPCC released three reports indicating serious consequences of climate change on our life in the near and long-term future. In December 2005, the Bali Road map was agreed at the COP 13 in Bali, Indonesia indicating the schedule for the discussion of the post Kyoto regime.

This chapter provides background information on this research. The first section reviews the scientific knowledge base about global warming. The second section demonstrates the concepts of climate change "mitigation" and "adaptation" to climate change. The third section provides an overview of the process of international negotiations on climate change under the United Nations Framework Convention on Climate Change (UNFCCC). The thesis author then reviews the major policy instruments implemented under the Convention.

1.1 The scientific knowledge base on climate change

The World Meteorological Organization (WMO) and the United Nations Environmental Program (UNEP) established the IPCC in 1988 to assess the risk of climate change caused by human activities. Since then, the IPCC has published peer reviewed scientific and technical literature on climate change. Since the IPCC published

---

[5] Australia ratified the Kyoto Protocol in December 2007.

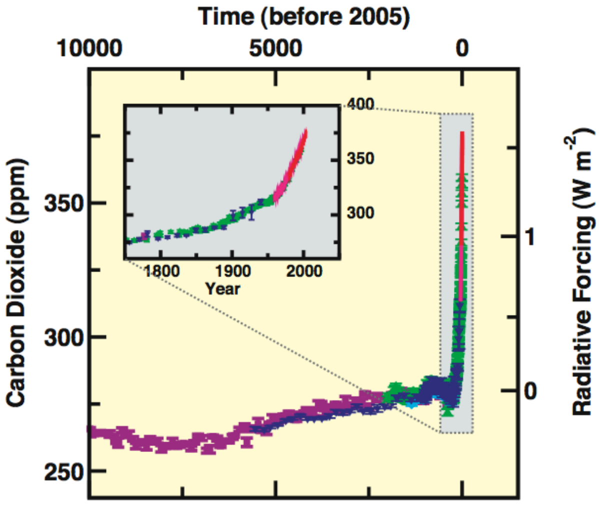
the First Assessment Report on climate change in 1990, its publications have gained an authoritative status in the scientific study of climate change and have often been used as a basis for political negotiations on climate change.

The study groups of the IPCC consist of three working groups. The Working Group I studies the physical science basis of climate change. The Working Group II studies impacts, adaptation and vulnerability. Working Group III studies mitigation of climate change. Each working group releases a main report and summary version of the report known as the "Summary for Policymakers". In February 2007, the Working Group I published a Summary for Policymakers for the Fourth Assessment Report addressing the outcomes of the latest research on physical science of climate change (Intergovernmental Panel on Climate Change, 2007).[6] The report concludes that with more than 90% probability, the global warming observed since the mid-20th century is caused by GHGs produced by human activities. The following summarizes some of the major scientific evidence presented in the report.

The first evidence is that the concentration of GHGs in the atmosphere is increasing. According to the report, the global atmospheric concentration of CO_2, the most important anthropogenic GHG, has increased dramatically over the last hundred years. It has increased from 280ppm to 379ppm (parts per million) from the beginning of the 20th century to 2007. The report concludes that the primary source of the increased atmospheric CO_2 concentration since the pre-industrial period is from fossil fuel use. It has increased from an average of 6.4GtC (23.5 $GtCO_2$) per year in the 1990s, to 7.2GtC (26.4 $GtCO_2$) per year in 2000–2005. Figure 2 illustrates the increasing trend of CO_2 emissions over the last 10,000 years:

[6] The data presented in Section 1.1.1 were cited from the latest IPCC report: Intergovernmental Panel on Climate Change (2007) Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

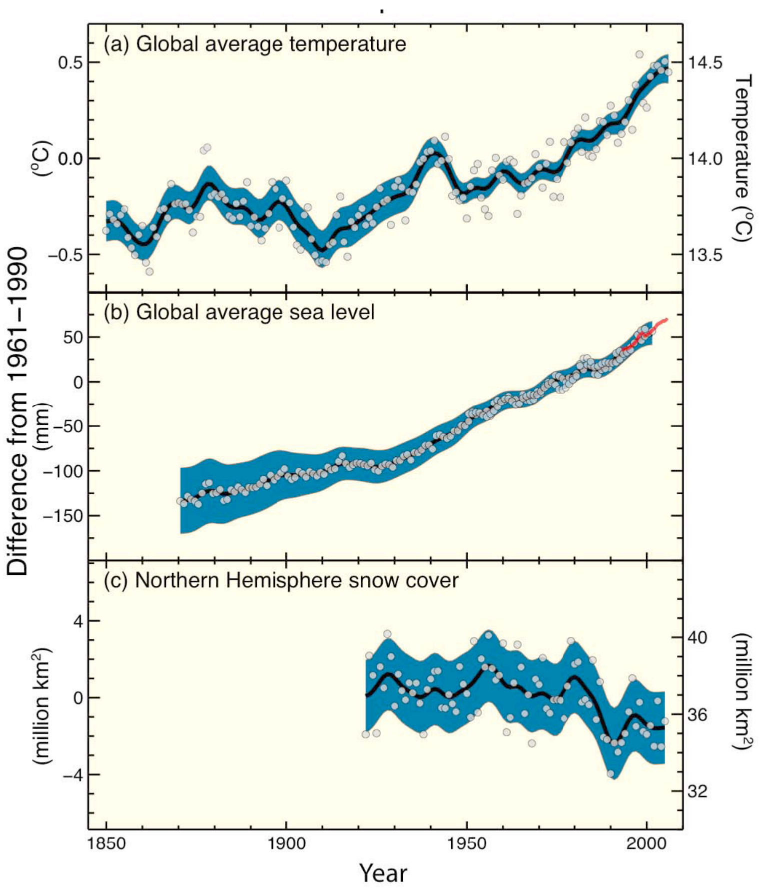
Figure 2: Increasing trend of CO_2 emissions



(Source: Intergovernmental Panel on Climate Change, 2007)

The second source of evidence is based upon documented changes in the biosphere environment. The report demonstrates that we will experience a warming of about 0.2°C per decade. The climate change modeling estimates that a global temperature increase of 1.8°C to 4.0°C and a sea level rise of 0.18-0.59 m by 2090-2099 relative to 1980-1999. Mountain glaciers and snow cover have declined on average in both hemispheres. Widespread decreases in glaciers and ice caps are contributing to sea level rise. Figure 3 illustrates the changes in temperature, sea level and northern hemisphere snow cover.

Figure 3: Changes in temperature, sea level and Northern Hemisphere snow cover



(Source: Intergovernmental Panel on Climate Change, 2007)

The report indicates other changes observed in the climate and related dimensions.

- Satellite data since 1978 show that the annual average Arctic sea ice extent has shrunk by 2.7% per decade, with larger decreases in summer of 7.4% per decade.
- Long-term trends from 1900 to 2005 have been observed in precipitation amounts over many large regions. Significantly increased precipitation has been observed in eastern parts of North and South America, northern Europe and northern and central Asia. Drying has been observed in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.
- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights, and heat waves have become more frequent.
- There is observational evidence for an increase of intense tropical cyclone activity in the North Atlantic since about 1970, correlated with increases of tropical sea surface temperatures.

While the outcomes of the IPCC study have been widely accepted as scientific evidence on climate change, there are still some criticisms about them. In January 2005, Dr. Landsea withdrew his participation in the Fourth Assessment report expressing his opinion that the IPCC had become “politicized”. Some scientists contend that the IPCC report underestimates positive feedbacks that could lead to a runaway greenhouse effect. On the other hand, the Bush Administration endorsed, for the first time, the scientific validity of the IPCC report. The Secretary of the Department of Energy confirmed “as the president has said, this report makes clear, human activity is contributing to changes in our earth's climate and that issue is no longer up for debate” (Duray, 2007).

1.2 Two measures to cope with climate change: mitigation and adaptation

It is widely recognized that in order to avoid “dangerous interference with the climate system”, two different measures are necessary to take: mitigation and adaptation. It is specified in Article 4.1 of the UNFCCC as “all Parties…shall…formulate, implement, publish and regularly update national and…regional programs containing measures to mitigate climate change…and measures to facilitate adequate adaptation to climate change.” Mitigation refers to an anthropogenic intervention to reduce the sources or to enhance the sinks of GHGs (Intergovernmental Panel on Climate Change, 2001a). This can be done through various actions such as improvement of energy efficiency, installation of renewable energy sources, storing of CO_2 in the underground and reforestation. On the other hand, adaptation refers to adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities (Intergovernmental Panel on Climate Change, 2001a). There are various types of actions including anticipatory and reactive adaptation, private or public adaptation and autonomous or planned adaptation. For detailed classification of adaptation activities, see (Smit et al., 2000).

It is important to note that the major part of the international efforts to cope with climate change presently focuses on mitigation measures. The GHG emissions reduction targets established under the Kyoto Protocol are part of the mitigation efforts. On the other hand, the developing countries, especially the ones vulnerable to the changes in the climate system, are calling for financial and technical assistance to implement adaptation measures. The IPCC report published in 2007 titled as “Impacts, Adaptation and Vulnerability” describes what changes may occur in the future in the climate system as well as the natural and human environments. In 2001, three funds were established to conduct adaptation measures including the Special Climate Change Fund (SCCF), Least Developed Country Fund (LDCF) and Adaptation Fund (AF). The Adaptation Fund is financed with a share of proceeds from the Clean Development Mechanism (CDM) amounting 2% of Certified Emission Reduction (CERs) issued for a CDM project activity.

The linkages between mitigation and adaptation measures have been explored by a number of scholars (Michaelowa, 2001, Kane and Shogren, 2000, Burton, 2000, Intergovernmental Panel on Climate Change, 2001a). Kane and Shogren address an organizing framework to link mitigation and adaptation in modeling climate risk (Kane and Shogren, 2000). According to them, integrated modelers have long argued that effective risk reduction strategies should address the optimal mix of adaptation and mitigation. In the policy-making arena, however, mitigation and adaptation are perceived to be “mutually exclusive at worst or parallel strategies at best” (Dang et al., 2003). Dang et al. contend as follows (Dang et al., 2003):

> …The structure of the UNFCCC reporting guidelines for national communications includes a separate section on adaptation, rather than requiring parties to report adaptation strategies under “policies and measures”. Even countries that, at first glance, would have a large stake in adaptation, such as the Netherlands, make just a passing reference to it even if this may not reflect the true state of awareness in the country.

Fankhauser provides his idea of a function to estimate the present cost to cope with climate change consisting of three elements: Mitigation Cost (MC), Adaptation Cost (AC) and residual damage cost (D) (Frankhauser, 1998).

According to Frankhauser, it is necessary to minimize the following costs in order to maximize the present social welfare (Here, (m) and (a) are mitigation and adaptation actions. D depends negatively on the magnitude of (m) and (a).):

Cost to cope with climate change = MC (m) + AC (a) + D (m, a)

According to this function, there is no relationship between investment in mitigation and investment in adaptation. In fact, it indicates that when one allocates resources in mitigation efforts, the resources are not likely to be available for adaptation efforts. In this situation, policymakers are under pressure to pursue one strategy that stakeholders could support (Dang et al., 2003).

On the other hand, several studies reflect the link between mitigation and adaptation as a "cause and effect" interaction (Dang et al., 2003). IPCC report states that the adaptation costs and challenges can be lessened by mitigating climate change (Intergovernmental Panel on Climate Change, 2001b). The Stern Report that attracted a great deal of attention among policymakers, when published in October 2006, addresses the following points (Stern, 2006, Osborne, 2006):

- The benefits of strong, early action considerably outweigh the costs.
- Unabated climate change could cost the world at least 5% of GDP each year. If more dramatic predictions come to pass, the cost could be more than 20% of GDP.
- The cost of reducing emissions could be limited to around 1% of global GDP. People could be charged more for carbon-intensive goods.
- Each ton of CO_2 we emit causes damages worth at least $85, but emissions can be cut by a cost of less than $25 a ton.
- What we do now can have only a limited effect on the climate over the next 40 or 50 years, but what we do in the next 10-20 years can have a profound effect on the climate in the second half of this century.

This thesis author's opinion is in line with Stern's discussion. The efforts on mitigation and adaptation are complimentary.

1.3 The process of international negotiations under the UNFCCC

1.3.1 UNFCCC negotiations

The UNFCCC was signed by 154 countries at the United Nations Conference on Environment and Development (UNCED) in 1992 (known as the Earth Summit). It entered into force in 1994. The objective of the Convention was "to achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2 of the UNFCCC). The Parties agreed to recognize "common but differentiated responsibilities" with greater responsibility for reducing GHG emissions on the part of the developed countries.

The Kyoto Protocol is the cornerstone of the UNFCCC negotiations. The Protocol was signed in Kyoto, Japan in 1997 and came into force in 2005 after ratification by Russia in 2004. The Protocol covers more than 160 countries and over 55% of global GHG emissions. The developed countries (including the EU member countries, Canada and Japan) and countries in economic transition (including Russia and Ukraine) have legally binding emissions reduction targets under the Protocol. These add up to a total GHG emissions reduction of 5% from the 1990 level during the commitment period of 2008 and 2012. Those countries are referred as the “Annex I” countries. When the Protocol was signed, the EU, the U.S. and Japan committed to reduce GHG emissions by 8%, 7% and 6% respectively over the period of 2008 and 2012 relative to the 1990 level. The developing countries that ratified the Protocol without the legally binding emissions reduction targets are referred as the “non-Annex I” countries. Table 1 illustrates the GHG emission reduction targets of the Annex I countries:

Table 1: GHG emission reduction targets of the Annex I countries

Country/region	Target
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
U.S.	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0%
Norway	+1%
Australia	+8%
Iceland	+10%

(Source: (Secretariat, 2002))

While the United States signed the Protocol, neither the Clinton nor Bush Administrations passed legislation to the Congress for ratification. President Bush officially declared in 2001 that the Administration does not intend to submit the Protocol for ratification. The president contended that the ratification of the Protocol would harm the U.S. economy because there are no commitments to the Protocol from the developing countries. He also questioned the scientific validity of the research conducted by the IPCC. Australia followed the United States and refused to ratify the Protocol.

Under the Protocol, three mechanisms were introduced with the goal of providing the Parties with flexible options to reduce GHG emissions in a cost effective fashion. They are known as the Kyoto mechanisms or flexible mechanisms including Clean Development Mechanism (CDM) defined in Article 12 of the Protocol, Joint Implementation (JI) in Article 6 and Emissions Trading (ET) in Article 17. Some details of these mechanisms are described in the following sub-sections.

As the end of the GHG emissions reduction commitment period (2008-2012) approaches, intensive discussions on the regulatory framework after 2012 (so-called, the “post-Kyoto” or the “post-Kyoto regime”) has been taking place. There are several main issues that have been discussed lately. The issue with a great deal of attention is the involvement of the United States after 2012. The United States is the largest GHG emissions producer, accounting for approximately one quarter of the global emissions. The country’s GHG emissions per capita are also the highest in the world. Another issue of attention is an involvement of the developing countries. Many scientists and policymakers contend that in order to prevent the consequences of climate change, some commitments of the developing countries are beginning to be necessary. There are also discussions as to whether we shall continue the Kyoto approach by establishing new, legally binding, emissions reduction targets among countries or shall we establish industry-specific legally-binding or voluntary targets among industry sectors.

1.3.2 Policy instruments to reduce GHG emissions

This section briefly describes the policy instruments to reduce GHG emissions. A special attention is paid to the flexible mechanisms introduced under the Kyoto Protocol. They are emissions trading, CDM and JI. In addition, each government implements other policy instruments to reduce GHG emissions that are not stipulated under the Protocol including carbon tax and voluntary measures. Since carbon tax has been implemented only in the EU, this thesis author described it in the later section on the EU (Chapter 7). On the other hand, voluntary measures are broadly implemented across the countries including the EU, Japan, U.S. and other countries. This section briefly discusses different types of voluntary measures based on a classification presented by OECD. This thesis author reviews the characteristics of the voluntary measures implemented in each country in later sections.

1.3.2.1 Emissions trading scheme

Emissions trading scheme (or emissions trading) is an approach to control pollution by providing economic incentives for achieving pollution reduction targets established by a national or international authority. The rationale behind it is to ensure that the pollution reductions take place where the cost of the reductions is the lowest thus; lowering the overall costs of the pollution reductions (See Section 2.1.2). This scheme was first introduced in the United States in 1990 to reduce SO_2 under the Acid Rain Program. In the negotiation leading to the Kyoto Protocol, the United States eagerly promoted emissions trading to be part of the agreements.

Since the United States withdrew from the Protocol, the EU has become a strong supporter of the scheme. In 2003, the EU decided to introduce it and adopted the EU Emissions Trading Directive (2003/87/EC). Subsequently, it adopted the “Linking Directive” to make it possible to trade credits generated through CDM and JI projects in the EU ETS (See Section 7.2.3.3). The Article 17 of the Kyoto Protocol defines the use of emissions trading as follows:

> The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

The article stipulates that any trading shall be “supplemental” to domestic actions to reduce GHG emissions. This is known as supplemental principle. It was included in the Kyoto Protocol by the request of the EU. There has been a remarkable change, however, in the EU approach to the principle since the signing of the Protocol. The present position of the EU is to utilize emissions trading and other Kyoto mechanisms fully in order to meet its emissions reduction target (See Section 7.2.3.4).

1.3.2.2 Clean Development Mechanism/Joint Implementation

CDM is a project-based mechanism where entities in Annex I Parties assist entities in non-Annex I Parties in implementing a project activity to reduce GHG emissions or to enhance the sinks of GHG emissions. The Article 12 of the Kyoto Protocol defines the objective of CDM as follows:

> The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

On the other hand, JI is a project-based mechanism where entities in Annex I Parties assist entities in another Annex I Parties in implementing a project activity to reduce GHG emissions or enhance the sinks of GHG emissions. Most commonly, a project activity takes place in the countries in economic transition such as Russia and Ukraine with assistance of European or Japanese entities. The Article 6 of the Kyoto Protocol defines the objective of JI as follows:

> For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party, emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy.

The emission credits generated through CDM and JI project activities are respectively known as Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs). The volume of the CERs generated through a CDM project has been dramatically increasing in recent years. According to the report published by the International Emissions Trading Association and the World Bank, in 2005 nearly four times as much volume of CERs was traded (346.15 million tCO_2e) than was transacted in 2004 (97.00 million tCO_2e) (International Emissions Trading Association and the World Bank, 2006). On the other hand, the volume of the ERUs remain relatively low constituting 4.8% of the total volumes of carbon credits generated through project-based activities reflecting the perception of regulatory and institutional risks of the countries such as Russia and Ukraine (International Emissions Trading Association and the World Bank, 2006).

The increasing number of CDM projects being implemented is partly due to the increasing number of approved methodologies available from the CDM Executive Board. There is a rigorous process for the approval and registration of a CDM project. In order for their project to be considered as a CDM activity, project participants must develop a document known as the Project Design Document (PDD) and obtain an approval from the CDM Executive Board for the methodologies that they use to estimate GHG emissions reduction. However, when there is an approved methodology that matches their project activity, project participants can use the methodology without an approval from the CDM Executive Board. The number of approved methodologies is increasing.

According to the report, HFC destruction projects occupy the largest share of the CERs generated from CDM project activities. HFC destruction projects amount to 58% of the volume transacted in 2005 compared with 36% in 2004 (International Emissions Trading Association and the World Bank, 2006). While HFCs have high global warming potential (GWP) and represent significant volumes of CO_2e, HFC destruction projects have relatively lower implementation risks and lower investment costs. Therefore, this type of project is extremely attractive to project participants and investors. Other popular projects as CDM include nitrous oxide (N_2O) reduction projects, landfill gas utilization projects and coal mine methane capturing projects. In 2005, landfill gas utilization projects occupied the second largest share of the CERs generated from CDM project activities (9%) (International Emissions Trading Association and the World Bank, 2006).

1.3.2.3 Voluntary measures

Voluntary measures in the environmental policy arena are typically referred as voluntary environmental agreements (VEAs). According to Jacob, the term “voluntary” can be defined as being “not forced by law nor persuaded by financial incentives” (Jacobs, 1991). Based on this definition, there are no legal or financial bases for firm’s commitments to achieve a goal. However, some voluntary measures contain legally binding features and/or links to a financial incentive scheme. It is acknowledged that there is a great degree of variety among VEAs. In 1999, OECD published a report titled “Voluntary Approaches for Environmental Policy: An Assessment” (Organisation for Economic Cooperation and Development, 1999). In this report, OECD presents a classification of three types of VEAs, which many scholars studying VEAs later began to refer to in their research. The three types of VEAs are the following:

- Type 1: Public voluntary environmental programs (PVEPs). They involve commitments devised by the environmental agency and in which individual firms are invited to participate. Since participation in the voluntary program is a choice left to individual companies, they can be seen as “optional regulations”. Examples are the U.S. program 33/50 or the Eco-Management and Auditing Scheme (EMAS) implemented in the European Union since 1993.
- Type 2: Negotiated environmental agreements (NEAs). They involve commitments for environmental protection developed through bargaining between a public authority and industry. They are frequently signed at the national level between an industry sector and a public authority, although agreements with individual firms are also possible.
- Type 3: Unilateral voluntary environmental codes and action plans (UVEPs). These commitments are set by the industry acting independently without any involvement of a public authority. The Responsible Care program is a well-known example of a unilateral commitment made by the chemical industries in many countries.

In the climate change area, many countries have implemented VEAs to reduce GHG emissions in the industry sectors. In the Netherlands, the new "second generation" Long Term Agreements on Energy Efficiency (LTA2) were established with medium-sized and small businesses in 2001. In addition, the Energy Efficiency Benchmarking Covenant was signed with the energy-intensive sectors. In Japan, the Nippon Keidanren Voluntary Action Plan was established in 1997. In the United States, 12 industry sectors announced their emissions reduction targets under the program called Climate VISION. Those voluntary initiatives are all considered VEAs. However, each voluntary agreement varies greatly in the design and implementation. This research highlights some of the key differences and presents them based on the above OECD classification from Chapter 6 to Chapter 9.

Summary of Chapter 1

Chapter 1 provided background information on this research. This thesis author reviewed the process of the international negotiations on climate change under the UNFCCC and discussed the issues that are likely to be central on the agenda in the forthcoming negotiations for the post-Kyoto period. In the UNFCCC negotiations, the roles of the industrial sectors have been increasingly important. In the beginning of the negotiation, the industry sectors emerged as a blocking force toward the Kyoto Protocol. Major oil and automobile companies formed the Global Climate Coalition (GCC) and objected to the Protocol. Subsequently, they have appeared as major players in the negotiations. In addition, they are the major actors in the above-mentioned policy instruments such as emissions trading and CDM. In the post-Kyoto regime, their roles will become more important, since they can provide technological solutions to reduce GHG emissions or interfere into a political initiative to control the emissions release.

Chapter 2 presents theoretical discussions on corporate climate change strategy. This thesis author presents the results of a literature review on corporate strategy. Literature exploring different factors in the formulation of corporate strategy is reviewed. The investigation into the literature was designed to build the basis to answer the third research question of this thesis: “What are the main factors that contribute to formulation of industrial responses to climate change policy instruments?” Furthermore, this chapter is part of the basis used for building the theoretical framework for the subsequent empirical research.

Chapter 2: Theoretical discussions about corporate climate change strategies

Introduction

This chapter examines theoretical discussions about corporate strategy on climate change. It provides a theoretical base for building a research framework on corporate climate change strategy. What factors are contributing or may contribute to the formulation of the firm's responses to the present and future climate change regulatory schemes or policy instruments?[7] To put it differently, what factors do firms consider important or decisive in the formation of their corporate climate change strategies? As noted above, this is one of the main questions that this research attempts to answer. The crux of this question is to identify similarities and differences in firm's responses to the present and future climate change regime. This research highlights similarities and differences in corporate strategies on GHG emissions reductions with a view to finding a common strategic platform among firms toward the post-Kyoto period. This chapter reviews economics, social science and business management literature and attempts to extract sound theoretical insights from firm's behaviors.

This thesis author began to explore the economic dimensions of corporate climate change strategy. It is not surprising that firms take into account, or pay attention to, the estimated financial and economic consequences of the present and future regulatory schemes for GHG emissions reduction. Economists and financial experts have conducted empirical studies about the positive and/or negative impacts the schemes may have upon the firms. This chapter reviews their theoretical framework. (In Chapter 5, this thesis author addressed the results of the empirical analysis and reflects upon how the firms in the steel industry sector perceive the results of the financial analysis.)

Section 2.2 examined the technological dimensions of corporate climate change strategies. Technological innovation is another essential issue that firms consider under the emerging pressure for GHG emissions reduction. When firms have cost-effective technological options to reduce GHG emissions, they may be willing to accept an introduction of a regulatory scheme. When firms have limited technological options to reduce GHG emissions, however, they are likely to be opposed to such policies. It is contended that firm's prospect for technological innovation plays an important role in the formation of their corporate climate change strategies. The author paid particular attention to the argument presented by the renowned economist, George Stigler, who argued that with certain market and technological conditions firms may support an introduction of GHG emissions reduction regulations. Based on Stigler's argument, the interface between technology and regulation is discussed in some detail.

The focus of attention is then changed in Section 2.1.5 to the institutional dimensions of corporate climate change strategy. A hypothesis is established that firm's strategies on climate change issues as well as their strategic responses to climate change policy instruments are not solely formulated based upon their economic and technological considerations. This thesis author contends that they are also influenced by the external "institutional environment" surrounding the firms. The factors in the institutional environment that influence firms are, for example, the regulatory culture, history of government-private partnership and social pressures. It is important to note that the characteristics of the institutional environment typically differ from one country to another. This thesis

[7] In this thesis, the term "regulatory scheme" is used with regard to policy instruments proposed by governments. According to the OECD, there are three types of policy instruments. Regulatory schemes are one type of policy instruments whereby public authorities mandate the environmental performance to be achieved, or the technologies to be used by firms. For more details and for the other types of policy instruments, see Section 1.3.2.3.

author argues that the country-specific (or regional-specific) natures of the institutional environments present divergent pressures on firm's strategies on climate change.

There is an increasing body of theoretical literature about the interface between the economic and institutional factors. An example is Oliver's literature that argues that the institutional influences are stronger under conditions of uncertainty, because managerial discretion is higher when the economic consequences of actions are unclear (Oliver, 1991). Levy and Rothenberg found this trend in their empirical study on the responses of the automobile industry to the climate change issues. They contend that given the high level of uncertainty concerning climate science, technological and market developments, and policy responses, automobile firms cannot easily make a rational, objective calculus of their economic interests and appropriate strategic responses, and would thus be more subject to institutional pressures (Levy and Rothenberg, 2002). Section 2.3 presents the results of a literature survey on the institutional study. This section identifies the institutional factors to consider in the subsequent empirical analysis of corporate climate change strategy.

It is noted that this research is strongly inspired by the theoretical observation that recognizes firms as an open system and therefore, they are subject to institutional pressures in the formulation of their strategies and management. As discussed in Section 2.1.4, economists are aware of the limits of the rational decision-making assumptions in economic analysis. Based on the theoretical reflection among the institutional literature, the main hypotheses of this research are formulated and presented in Section 3.1 (See Hypotheses 1 and 2 in Section 3.1).

It is also important to acknowledge that the economic and technological factors also play important roles in the formulation of corporate strategies and management. There are many significant interrelations among the economic, technological and institutional dimensions (See Section 3.2.1). In this thesis author's opinion, there is little theoretical exploration or empirical testing that has attempted to look into the three dimensions simultaneously from a more holistic perspective. In light of this, this researcher sought to develop and test a framework to examine the three dimensions of corporate climate change strategy (See Section 3.1 for the detail.)

2.1 Economic dimensions

When the government proposes a new climate change regulatory scheme or policy instrument, public and private research entities conduct an analysis to estimate possible negative and/or positive financial and economic impacts on the sectors. Occasionally, firms conduct analyses too in their in-house research units to examine the possible impacts on their business bottom-line. Firms use such analyses as a preliminary source of information to formulate their views and positions on the policy instruments. This section reviews theoretical discussions on the economic and financial impacts of the policy instruments. A particular attention is paid to the Kyoto mechanism among the policy instruments.

2.1.1 Economic impacts: negative or positive impacts?

An introduction of a climate change policy instrument is considered as additional costs among the industry sectors. Economists generally contend that there is a trade off between compliance with an environmental regulation and economic gain. They also argue that environmental regulations can even lead to adverse effects in some cases such as loss of international competitiveness and loss of innovation capacity.

On the other hand, there are some arguments that claim that this is not necessarily true. According to them, compliance with an environmental regulation can lead to economic gain. Porter and Vanderlinde demonstrate the most notable argument of its kind. They contend that appropriately designed environmental regulations can stimulate technological innovation and provide a basis for "first mover advantage" in the international market. They specifically argue that innovation offset "can not only lower the net cost of meeting environmental regulations, but can even lead to absolute advantages over firms in foreign countries not subject to similar regulations" (Porter and Vanderlinde, 1995b). While Porter and Vandelinde do not specifically discuss the implications of climate change related regulations, other scholars who are looking into the application of renewable energy technology in the automobile industry sector, for example, discuss their hypothesis in the climate change contexts.

While a number of empirical studies tested Porter and Vanderlinde's thesis, it is inconclusive whether environmental regulations lead to technological innovation or comparative advantage for firms. There is no empirical evidence to support Porter and Vanderlinde's hypothesis (See Section 2.3.1.1 for further detail on Porter and Vanderlinde's hypothesis). In the absence of convincing evidence, the industry sectors normally consider that introduction of climate change policy instruments bring or will bring negative impacts on their business operations.

2.1.2 Economic theory of the Kyoto mechanism

Many economists maintain that the Kyoto mechanism is an economically palatable solution to reduce GHG emissions. According to them, firms can minimize their cost to comply with their emissions reduction target through the utilization of that mechanism. This section illustrates this point based on Figure 4,[8] in which an emissions trading scheme is used as an example. (The economic rationality of the other policy instruments including the CDM and JI can be explained in the same fashion.) In this explanation, there are two important assumptions made: 1) all firms are price-takers in the market. They do not have monopolistic power to influence a price of emissions credits in the market and 2) all firms make a rational decision to maximize their profits in the market.

Firms attempt to minimize the total cost to comply with their emission reduction targets by making the marginal emission abatement cost equal to the price of an emission allowance. In other words, firms reduce emissions internally to the level so that their marginal abatement cost becomes equal to the price of an emission allowance. The levels of GHG emissions and marginal (emissions) abatement costs are indicated respectively on the vertical and horizontal lines in Figure 4.

The present level of firms' emissions is positioned at the BAU (Business as Usual). It is necessary for firms to reduce emissions or purchase emission allowances to the point of Ec. In other words, the government has allocated emission allowances (AAU: Assigned Amount Unit) and capped firms' emissions levels at the point of Ec.

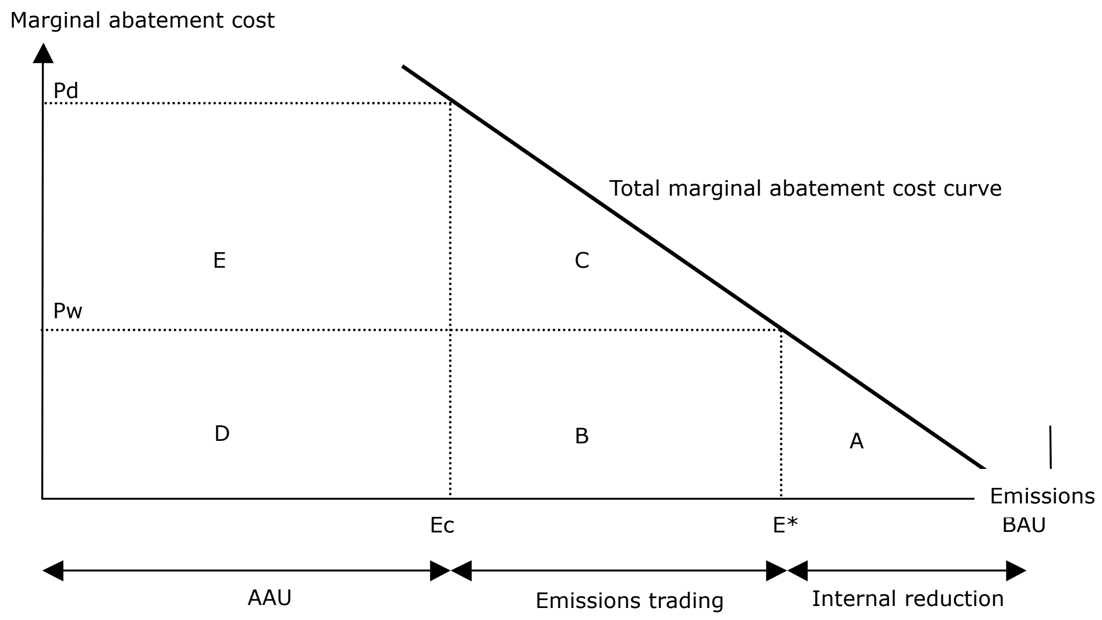
This figure also indicates the total marginal abatement cost curve. The shape of this curve is left-side upward because firms begin to utilize technologies available at lower cost to reduce GHG emissions. It is important to note that the marginal abatement cost (Pd) to meet the emission reduction target (Ec) is higher than the price of the emissions allowance (Pw).

In this situation, firms would reduce GHG emissions internally from BAU to E* where the marginal abatement cost equals the price of the emission allowance (Pw). Firms would bear the cost to reduce the emissions equivalent to the area A in the figure. Firms would purchase the emissions allowances until the level of their emission abatement reach from E* to Ec. Firms bear the costs to purchase the emission allowances equivalent to the area B. The total cost that firms bear to meet their emissions reduction target is, therefore, equivalent to the area of A and B. On the

[8] Some illustrations on the economic theory were drawn from the report by Akai, K., Okagawa, A., Kusakawa, T. & Saijo, T. (2004) Designing Domestic Institutions to Cope with Global Warming. Osaka, Graduate School of Economics, Osaka University.

other hand, firms save the cost equivalent to the area C that firms would have had to pay if they have not had bought the emissions allowances from the emissions trading market. It appears that firms can reduce the cost to meet emissions reduction target by participating in the emissions trading market.

Figure 4: Economic theory indicating that the Kyoto mechanism is an economically palatable solution



(Source: Akai et al., 2004)

The idea that the emissions trading scheme is an effective and economically palatable policy vehicle prevails in the U.S. The scheme has been utilized in some occasions. In 1990, the U.S. EPA (Environmental Project Agency) introduced a cap-and-trade scheme for trading SO_2 among the electricity generation companies under the framework of the Acid Rain Program. In 1997, the State of Illinois adopted a trading program for volatile organic compounds (VOCs) in Chicago, called the Emissions Reduction Market System. In 2003, the Northeast states of the U.S. committed to introducing the cap-and trade scheme to reduce GHG emissions. In the same year, companies began a voluntary GHG emissions trading through the Chicago Climate Exchange. Thus, while the emissions trading scheme has been utilized in several occasions in the U.S., the European Union Emissions Trading Scheme (EU ETS) is the largest of its kind under implementation.

2.1.3 Four areas of economic impacts

In 2003, the European Union adopted the EU Emissions Trading Directive (2003/87/EC). Member state governments allocated the emission allowances to each installation in the area for the pilot phase (2005-2007). Since the EU published the Directive, there have been intensive discussions about what impacts the emissions trading may bring to the firms covered under the emissions trading scheme. (For the detail of the EU ETS, see Section 7.2.2.3). This section looks into the EU ETS as an example of climate change policy instruments and discusses possible economic impacts of climate change policy instruments.

According to a report published by the International Energy Agency (IEA), there are four area of possible economic impacts including 1) costs to reduce GHG emissions internally and/or to purchase emission allowances, 2) increases in electricity prices, 3) demand reduction and 4) losses in competitiveness in the international market (Reinaud, 2005).[9]

With respect to the first area, in Section 2.1.2, this thesis author illustrated that when emissions trading scheme is introduced, firms attempt to reduce GHG emissions internally to the point where the internal marginal abatement cost equals to the price of the emission allowances in the market in theory. When the internal marginal abatement cost becomes higher than the price of emission allowances, firms begin to purchase emission allowances to the point where they comply with the capped emissions reduction target. (The costs associated with internal reduction of GHG emissions and purchasing emission allowances are considered as direct costs of the EU ETS.)

The electricity generation sector is covered under the EU ETS. Since the ETS was launched in 2004, the energy-intensive industry sectors consuming a large volume of electricity have continuously reported that the electricity generation sector is passing through the opportunity cost of the EU ETS to its customers including them. The price of electricity is becoming higher due to the passing through of the opportunity costs. If this is the case, the energy-intensive sectors such as aluminum have been suffering from the increase of electricity price. An increase of electricity price may become a substantial cost to the energy-intensive sectors. (The costs of the increase of electricity prices are considered as indirect costs of the EU ETS.)

When it becomes necessary for firms to reflect the costs of the EU ETS into the price of their products, there is a possibility of demand reduction. The demand reduction may result from a substitution of the products possibly available at lower price. A good example of product substitution would be fuel switching. When the price of oil becomes higher, consumers or customers begin to consider alternative fuels such as natural gas or renewable sources of energy. For the oil company which sells oil only, this situation leads to loss of revenue.

When firms increase the price of their products, there is also a possibility of losing against foreign competitors. Concerns about loss in international competitiveness occur when the foreign competitors do not share additional costs associated with the EU ETS. This is the case, for example, when the origin of the foreign competitors is a non-Annex I Party free from any climate change regulations. The loss in competitiveness may lead to loss in sales and relocation of industries and reductions in employment.

2.1.4 Limits of rational economic decision-making

Do firms make an *economically* rational decision based on the economic and financial analysis? The economic analyses described in Section 2.1.2 were conducted based on an assumption that firms make rational decisions to maximize their profits in the market. Besides this, firms are assumed to operate with perfect knowledge on the market conditions. Those assumptions are difficult to conceive of in reality.

Economists and other social scientists have been aware of the limits of the rational decision-making assumptions in economic analysis. There have been different perspectives as to why firms cannot reach economically rational choices. Scholars who recognize firms as a group of individual members presented their perspective on this matter. They focus on the firms' organizational nature to fail in collective rational decision-making. They maintain that there is a limit of making a collective rational choice. For them, discovering conditions under which decisions made collectively can approximate Vifredo Pareto's optimality is a classical problem (Koza and Thoenig, 2003).

[9] This report analyzes economic impacts of the EU ETS in five energy-intensive industry sectors including the steel (BOF), steel (EAF), cement, pulp and paper and the aluminum sectors. The results of the study are reviewed in Chapter 5.

Herbert Simon provided his perspective to demonstrate that organizational decision-making does not conform to the neo-classical rational decision-making model. One of Simon's central themes was to observe the behavior of individuals and groups that he termed as "bounded rationality" that has later emerged as a central theme of behavioral economics. Simon wrote several articles (including a compilation of the articles titled "Models of Bounded Rationality" published in 1982) over the course of his life focusing on the concept of bounded rationality (Simon, 1982). The term is used to designate rational choice that takes into account the cognitive limitations of both knowledge and cognitive capacity. According to Simon, the informational and cognitive limits of rational analysis leads to a decision-making of "satisfying", rather than optimizing in organizations (Koza and Thoenig, 2003). In reality, corporate managers have limited capabilities and resources to translate the results of the economic analyses into their business operations. In fact, many corporate managers are expressing their concern that the pace of the policy development in climate change is too fast for them to keep up with. Corporate managers tend to fail in generating a cognitive map to make economically rational decisions.

Simon also argued that it is impossible to have perfect and complete information to make a decision at any given time. He was among the first scholars to discuss uncertainty in the context of organizational decision-making. In many cases, economic study treats uncertainty as assumptions or exogenous variables. However, the degree of the uncertainty is often too great for economic study to be realistic, in the real world. In climate change, the assumptions made to gauge possible economic impacts of an economic policy instrument are often too difficult to handle as inputs for realistic estimations and sound decisions. Admittedly, there is a great scale of uncertainty associated with the future path of the climate change regime. For example, the regulatory procedures for the implementation of the Kyoto Protocol, are uncertain at the national and international levels.

2.1.5 From the economic dimensions to the institutional dimensions

Institutional theory challenges the rational decision-making theorem of organization. It argues that organizational decision-makings are formulated not only by their perceived costs and benefits but also by the pressures from (or through the linkages with) the external environment. The theory demonstrates "skepticism toward atomistic accounts of social processes and a common conviction that institutional arrangements and social processes matter" (DiMaggio and Powell, 1991). It recognizes "the importance of the wider social and cultural environment as the ground in which organizations are rooted" (Scott and Christensen, 1995).

According to Céline Louche, who reviewed the origin and stream of institutional theory in her Ph.D. thesis, the roots of institutional theory go back to the 19th century and are associated with Veblen, Commons, Marx and Durkheim (Louche, 2004). Louche states that "the theory has been marked by a succession of developments within different disciplines, and approaches to institutions are very diverse" (Louche, 2004). However, around this time, each scholar has begun to question atomistic accounts of organizational behaviors and they contend that corporate behaviors cannot be analyzed without considering the social contexts in which organizations are situated.

Louche's study on the theoretical development of institutional theory indicates that in the 20th century, several schools of social scientists become interested in studying the influence of the external environment on the decision-making within organization. The results of their studies made contributions to the theoretical foundation of institutional theory. According to Scott, there were mainly three schools that contributed to the development of the theoretical stream. The first one is the *Columbia School*. A leading researcher of this school is Philip Selznick (Louche, 2004). Selznick distinguished between organizations as "the structural expression of rational actions" –

as a mechanistic instrument designed to achieve specified goals – and organizations viewed as an adaptive organic system affected by the social characteristics of their participants and environments (Scott, 1995). The second school is the *Harvard School*. A prevailing researcher in this school is Talcott Parsons. Parsons was interested in the ways in which the value system of an organization are legitimated by the connections to the main institutional patterns in different functional contexts (Scott, 1995). He differentiated between three levels within organizations: the technical, concerned with production; the managerial, concerned with control and coordination activities; and the institutional, concerned with relating the organization to the norms and conventions of the community and society (Louche, 2004) The last school is the *Carnegie School*. Herbert Simon is the leading scholar in this school. As discussed earlier, Simon illustrated the cognitive constraint of an individual and a group of individuals (organizations) in rational decision-making (Simon, 1982).

According to Louche, a new stream of institutional theory has emerged since the 1970s including the works of Williamson (1975). Hannah and Freeman (1977), Pfeffer and Slancik (1978), Meyer and Rowan (1977), Scott (1991), Zucker (1977) and DiMaggio and Powell (1983) (Louche, 2004). The most prominent work among all is presented by DiMaggio and Powell in 1983 titled as "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields". DiMaggio and Powell provided strong theoretical arguments in this thesis. They affected many social scientists studying public and private organizations. They argued that structural change in organizations is less and less driven by competition and the need for efficiency. Instead, organizational change occurs as the result of processes that make organizations more similar without necessarily making them more efficient" (DiMaggio and Powell, 1983). According to them, there are three different forces in the external environment that affect organizational behaviors - coercive, mimetic and normative (For the details of their study, see Section 2.3.2.1). DiMaggio and Powell introduced a concept of "isomorphism". They argued that the behaviors among organizations begin to resemble one another because if these organizations share the same "organizational field", they tend to be equally affected by the external forces.[10] Since DiMaggio and Powell published the thesis, their theoretical model has been employed in many theoretical and empirical studies of social science.

A number of studies employ DiMaggio and Powell's theoretical model to analyze corporate decision-making mechanism in the environmental area. Andrew Hoffman used it to examine an evolutional process of corporate environmentalism in the U.S. (Hoffman, 2001). Based on their model, Frank Boon et. al. analyzed institutionalization of environmental agenda into the five aspects of business operations in the Dutch industry including internal processes, labor relations, products, technology and capital (Boons et al., 2000). Some scholars used their model to analyze a specific environmental issue. Bouma, for example, used their model to analyze adoption and effectiveness of environmental management accounting (Bouma and Correljé, 2003, Bouma and Veen, 2002). Louche's thesis mentioned above examines institutionalization of the concept and practice of "ethical investment " in the Netherlands based on their model (Louche, 2004). Several scholars, including Ans Kolk and Jonathan Pinkse refer to the model in the analysis of corporate strategy on climate change (Kolk, 2005, Pinkse, 2006).

As the social scientists in the old schools attempted to look beyond the "atomistic accounts of social pressures", scholars studying the corporate environmental arena are increasingly attracted to analyzing the influence of the

---

[10] DiMaggio and Powell define the "organizational field" as the arena where competitors, regulators, suppliers, and consumers (or any other concerned parties) collectively "constitute a recognized area of organizational life" (DiMaggio and Power, 1983). Scott considers it as "a set of diverse organizations attempting to carry on a common enterprise" (Scott, 1995). Based on their arguments, regardless of differences in the business operations, products and target clients, firms tend to receive the external pressures equally, as long as they share a common organizational field.

external environment on the decision-making mechanism within firm. According to Jennings and Zandbergen, the new institutionalism is useful in “understanding how consensus is built around the meaning of ‘sustainability’ and then understanding the ways in which concepts or practices associated with sustainability are developed and diffused among organizations” (Jennings and Zandbergen, 1995, Boons et al., 2000).

Scholars examine different factors in the institutional environment that seem to influence upon corporate strategy. The examples of the factors are regulatory culture, regulatory arrangements between the government and firms and normative pressures from the society to the firms. Some scholars such as Hoffman emphasize an influence of the external stakeholders on firms’ decision-making. It seems that attention to those external factors is inevitable for corporate managers in formulating their corporate managers, especially when the economic and financial consequences of their actions are unclear, as argued by Oliver mentioned above.

This thesis author particularly pays attention to the argument presented by these scholars. Section 2.3 elaborates further the theoretical discussion on the institutional environment in detail.

2.2 Technological dimensions

It is not deniable that technology plays an important role in the formulation of corporate climate change strategies. When firms have a good prospect for technological development to reduce GHG emissions, they may be willing to accept an introduction of regulatory schemes to control GHG emissions. When firms have limited prospect, however, they are likely to oppose to it. This thesis author addressed a question about the roles of technology in the formulation of firm’s response to climate change policy instruments.

It appears, however, that this question has received little research attention. In fact, scholar’s attention is geared in the direction of the interface between technology and government policy. Some scholars have addressed questions about the impacts of government regulations on technological development such as how government regulations can stimulate technological development and whether government regulations are an importance source of pressures to stimulate technological development (Klaus and Ziegler, 2006, Thomas and Rennings, 1999). These questions are of particular interest in the study of innovation management study and economics.

There are scholars examining the technology-government regulation interface and in order to ascertain how firms’ technological prospects can change in response to government policies and regulations. George Stigler has presented a theoretical argument about a role of technological development in corporate responses to environmental regulations (Stigler, 1971). Stigler contends that under certain economic and technological conditions, firms may respond to regulations in a favorable fashion. Mikoto Usui, Kenneth Oye and James Maxwell elaborate Stigler’s argument and apply Stigler’s model to observe firm’s responses to environmental regulations at the local and international levels (Usui, 1999, Oye and Maxwell, 1995). The following section reviews Stigler’s theory as well as Usui’s elaboration on his theory.

Before the discussion on the Stiglerian situation, however, this thesis author reviewed the concept of technological innovation. It seems that technological innovation is one form of technological change that has some variations. There are minor and major technological changes, for example, and minor changes cannot be called technological innovations. This thesis author reviewed the theoretical landscape provided by innovation management theorists about technological changes and discussed how technological innovation can be considered in this landscape.

2.2.1 Technological changes and innovations

The degrees of technological change differ greatly from company to company. The impacts of the technological changes on business operations also vary greatly. The technological changes that have greater impacts may be recognized as "technological innovations". From the socio-economic perspective, Geels and Kemp contend that technological changes can be classified in three ways (Geels and Kemp, 2006):

- "Reproduction". It refers to incremental change along existing trajectories.
- "Transformation". It refers to a change in the *direction* of trajectories, relating to a change in rules that guide innovative action.
- "Transition". It refers to a discontinuous shift to a new system and trajectory.

Geels and Kemp illustrate the "reproduction" process as an incremental and cumulative change along trajectories. In this process, the main components of the socio-economic system such as orientation of dominant actors, key technologies and knowledge base do not change fundamentally.[11] The "transformation" process is dynamically accompanied with changes in visions, goals, guiding principles, relative costs and incentive structures, regulations and perceptions of opportunities. While the process induces a birth of a new system through cumulative adjustments, it remains as a re-orientation of an existing trajectory. The "transition" process is a shift to a new trajectory. It involves changes in the main components of the socio-technical system such as knowledge base, infrastructure, regulations, user practices and cultural preference. As an example, Geels and Kemp illustrate the transition from a transport system based on horse-drawn carriages to a transport system based on automobiles (Geels and Kemp, 2006).

There are ample examples of the transition process in our society and economy. Anderson and Tushman provide sixteen examples of the transition processes in the industry sectors accompanied with the technological discontinuities as well as drastic changes in the socio-economic system. They recognize the technological discontinuities as a cyclical model. They state that "an evolutionary model of technological change is proposed in which a technological breakthrough, or discontinuity, culminating in a single dominant design. This era of ferment is followed by a period of incremental technical progress, which may be broken by a subsequent technological discontinuity" (Anderson and Tushman, 1990).

The system innovation concepts such as "evolutional change" and "paradigm shift" indicate radical changes in the society. In climate change, the concepts such as "technological breakthrough" suggest technologies that lead to not only drastic GHG emissions reduction but also changes in the socio-economic system. All these concepts seeking radical changes in the technological as well as in the socio-economic contexts are part of the transition process described by Geels and Kemp.[12] The subsequent empirical research, in this thesis, explores whether

---

[11] There are several concepts that indicate environmental technologies possible along the line with the reproduction process. Boons et al. classify the concepts as: 1) Best Practicable Technology (BPT), 2) Best Available Technologies or Techniques (BAT) and 3) Best Technical Means (BTM). According to them, the Best Practicable Technology (BPT) refers to proven technical measures that are economically feasible. Best Available Technologies or Techniques (BAT) indicates the latest stage of development (state-of-the-art) of processes, facilities, or methods of operations. In principle, it does not take into account economic considerations. Best Technical Means (BTM) can be regarded as an equivalent for BAT, in which "means" may cover more than strict technical measures (Boons et al., 2000).

[12] In the study of environmental management, there are several terminologies indicating the radical changes in socio-economic and technological contexts. According to Boons et al., for example, "clean" or "cleaner" technology can mean radical process innovations for producing the same product with less resource use and reduced waste production. In the 1990s, the cleaner production or pollution prevention approach integrated the use of technology to achieve a zero emission goal. (Boons et al.,

such a transitional change may occur in the steel industry sector.

2.2.2 Technological innovation in corporate strategy and management

Section 2.2.1 reviewed a theoretical landscape provided by innovation management theorists. What is needed to reduce GHG emissions is the “transition” process of technology addressed by them. In what circumstances, does a firm respond to climate change regulation in a favorable fashion? According to George Stigler, technological innovation is playing an important role in it. Stigler contends that under the certain economic and technological conditions, firms may respond to regulations in a favorable fashion. To put it into the climate change context, with the certain market and technological conditions, some firms may, in fact, support an introduction of GHG emissions reduction regulations.

The Stiglerian situation can be discussed in contrast to the “Olsonian” situation. Mancur Olson points out that when benefits from a public good are distributed over many firms and each of whose contribution is small relative to the total cost of provision, the good will not be supplied in optimal quantity, unless institutional arrangements exist that induce incentives to provide it (Olson, 1965). The Olsonian situation is such that the benefits of a regulation are diffused over many firms while its costs are concentrated on a smaller number of firms. In this situation, firms would collectively resist new regulations.

On the reverse side of this argument, there is the Stiglerian situation, in which benefits are concentrated on a few while costs are diffused over many firms. In such a situation, public goods may be supplied even in the absence of institutional incentives to provide them (Stigler, 1971). Mikoto elaborates this point as “when a new environmental regulation promises quasi-monopoly rents for a handful of firms that are in possession of relevant new environmental technologies these firms will opt to coalesce with environmentalists to press for the regulation jointly” (Usui, 1999).[13]

According to Usui, Oye and Maxwell, the adoption of the Montreal Protocol just two years after the Vienna Framework Convention, stands a classical example of the Stiglerian situation (Usui, 1999, Oye and Maxwell, 1995). The leading producer of CFCs, DuPont, came to recognize incentives to support the Montreal Protocol for the protection of the ozone layer by the time when the framework convention was signed in Vienna in 1985. During the decade prior to that, their research on CFC substitutes, initiated in the mid-1970s, had been discontinued, one time on account of the lack of a market and they had opted to impede the agreement-making process. Dupont eventually began to see a technological prospect for a rapid commercialization of CFC substitutes. By 1988, ICI announced its intention to join DuPont in the production of CFC substitutes, prompting the UK and EC commitment to the eventual phase-out of CFCs. Usui lists several examples of the Stiglerian situation in the environmental arena include (Usui, 1999):

- Banning the use of leaded gasoline (which promised higher profits for producers of unleaded gasoline).
- Restricting the sale of DDT (supported by the leading chemical companies capable of producing safer, more sophisticated pesticides).

2000).

[13] In this respect, the Stiglerian situation is akin to Porter’s hypothesis that was addressed in Section 2.1.1. According to Porter’s hypothesis, appropriately designed environmental regulations can stimulate technological innovation and provide a basis for “first mover advantage” in the international market. The difference is that Stigler discusses firm’s responses to regulations, while Porter addresses regulatory impacts on firm’s competitiveness.

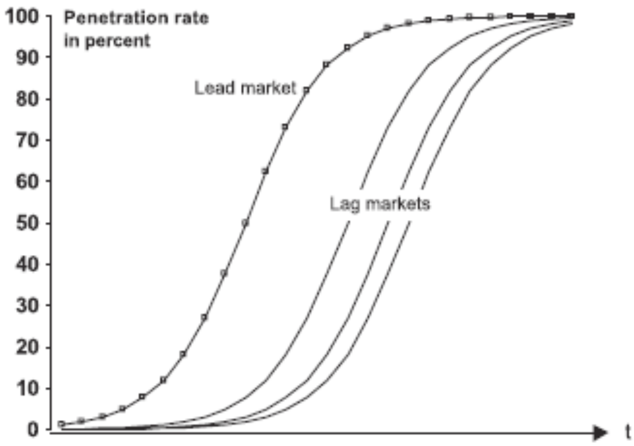
- Acts for recycling of packaging materials and automotive parts (once even suspected of serving as a new barrier to foreign firms' entry into the German market).
- Requiring special procedures and techniques for the handling and disposal of medical wastes (in favor of large waste-disposal firms equipped with special technologies).
- Barring the sale of "immature" lobsters in the U.S. market (motivated to raise a barrier to entry of Canadian lobsters which attain sexual maturity at a smaller size in cold waters).
- The adoption (as early as in 1978) of a stringent NOx regulation (0.25 ppm comparable to the frustrated American Muskie standard) by the Japanese automobile industry (which saw the new standard as an opportunity for enhancing its international competitiveness).

If there is a Stiglerian situation in the technological frontier of GHG emissions reduction, is a drastic change in corporate climate change strategy observable? Clearly, it depends upon the level of the technological change. If the technological change is great enough to induce the "transitional" process discussed in the previous section, a significant change in corporate climate change strategy may be observable. With a good prospect for technological innovation, a firm may support ambitious emissions reduction targets such as the recent proposal submitted by the EU Council of Ministers to reduce GHG emissions by 15-30% and 60-80% reductions by 2020 and 2050 (For the details of the proposal, see Section 7.2.2.5).

2.2.3 Diffusion of technological innovation

According to George Stigler, when some firms successfully generate technological breakthroughs, they will enjoy the benefits of innovations in the beginning (Stigler, 1971). However, other firms begin to adopt the same technology. A diffusion of the technology eventually takes place in the local and international markets. Beise and Rennings illustrate a diffusion pattern of technological innovation. The pattern is represented by the S-shaped curve over time as presented in Figure 5 (Beise and Rennings, 2005):

Figure 5: Diffusion pattern of technological innovation



(Source: Beise and Rennings, 2005)

In Figure 5, the countries that are first in adopting technological innovations are referred as the lead market and the countries following the lead market as the lag markets. According to Beise and Rennings, the rate of penetration tends to be higher in the leading country for a considerable period of time. This provides the firms that innovated technologies with long-term user feedback and market knowledge enabling them to improve the innovation and to retain their lead (Beise and Rennings, 2005). Eventually, however, the lagging countries begin to catch up. Their penetration rate reaches the same level as in the leading countries. (Beise and Rennings conducted two case studies in the environmental field to examine how this pattern of technological innovation can be observed in this field.) Now, with respect to the technological developments in the GHG emission mitigation, the increasing rate of penetration will contribute more to mitigation of climate change.

The insight into the pattern of technological diffusion leads to another question. When firms adopt technological innovations of another firm, do they also adopt the corporate climate change strategy of another firm? Do the convergent trends at the technological level have a spillover effect on the level of corporate management? If this is the case, corporate climate change strategies of diverse firms may begin to resemble one another.

2.3 Institutional dimensions

Before embarking upon a theoretical discussion, this author takes the case of CDM as an example to illustrate different responses to the climate change policy instruments among firms. In reality, firm's motivations to conduct a CDM project vary greatly. There is a great variety of motivations among companies in the different industry sectors. Some firms are keen to obtain carbon credits in the form of CERs to count the credits toward their voluntary and/or compulsory emissions reduction target under the Kyoto Protocol. Some firms view the CDM as a new business channel to sell their renewable energy or energy efficiency improvement technologies. Some firms are interested in conducting their projects in line with their Corporate Social Responsibility (CSR) initiatives. They are eager to conduct a project that will bring social benefits to the local communities such as re-forestation projects and mini-hydro projects. On the other hand, some firms take a stance of 'wait and see.' They wait until the level of the regulatory and other uncertainties relating to the implementation of the project activities is improved. This illustrates diverse responses in making use of the CDM policy instrument under the Kyoto Protocol.

What are the factors that contribute to the formulation of a firm's strategy? To put this question in the above episode, why does one firm decide to conduct a CDM project activity, while another firm decides not to do so? If their decisions were not based on the economic or financial ground, on what grounds do they use to decide to do so?

2.3.1 Institutional theory: External pressures

As illustrated in Section 2.1.6, scholars of the institutional theory provide a conceptual framework for investigating such questions. The institutional theorists recognize firms as an open system whereby the pressures from the external environment affect a decision-making within the system. Andrew Hoffman articulates this point with the following examples:

> Firms are not free to define environmental risk management practices alone; they are bound by the norms and values of the insurance company. Firms are not free to develop their own property in a fashion they deem consistent with their own economic objectives; the community determines the validity of development projects through zoning requirements and political protests. Firms are not free to obtain capital based on their own interpretation of the validity of a proposed project. Instead, financial institutions establish the standard evaluation procedures and norms. Each of these examples emphasizes the institutional aspects of the open system in defining individual corporate action (Hoffman, 2001).

It is understood that the actors such as financial institutions and local communities can become the sources of the external pressures. A question arises in one's mind. What types of pressures can the financial institutions and local community place on the firms? If there are differences among the pressures, how are they classified? A classification presented by Scott in his book titled "Institutions and Organizations" is a famous one. Other institutional scholars eventually began to use this classification as a basis for their theoretical discussion and empirical research (Scott, 1995). Scott classifies the external pressures into three "institutional pillars" and explains characteristics of each pillar as follows:

Table 2: Characteristics of three institutional pillars: Regulative, Normative and Cognitive

	Regulative	**Normative**	**Cognitive**
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanisms	Coercive	Normative	Mimetic
Indicators	Rules, laws Sanctions	Certification accreditation	Prevalence isomorphism
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, Conceptually correct
Cultural carriers	Rules, laws	Values, expectations	Categories

(Source: Scott, 1995)

These levels provide a hierarchy moving from the conscious to the unconscious and from the legally enforced to the taken for granted (Hoffman, 2001). Let us think about some examples of the institutions in each pillar in the environmental context. An example of a "regulative" institution is the Kyoto Protocol. Once a country ratifies the Protocol as Annex-I Party, it is obliged to follow the coercive or legally binding GHG emissions reduction targets established under the Protocol. The concept and practice of CSR is a "normative" institution. Society pressures firms to conduct their business operations in an environmentally and/or socially responsible fashion. Firms sometimes respond to such pressures by attempting to increase its accountability through independent certifications such as EMAS (Eco-Management Audit Scheme) and ISO 14001. Switching off lights to save electricity is a "cognitive" practice or institution that firms or individuals may follow. It is a practice embedded in the society that individuals may follow almost unconsciously.

This thesis author now poses the following question: Who are placing such pressures on firms? In Hoffman's examples, they are the financial institutions and the local community. In the case of the regulative pillar, it is apparent that the most important actor is the government. The government provides a pressure on firms to meet an environmental standard or emission reduction target by hinting or imposing an introduction of regulatory standards. It should be noted that the regulatory pressures take a variety of forms such as command-and-control regulations, market-based mechanisms and voluntary schemes. An announcement of government policy or strategy can also present a different form of pressure. For example, when the government publishes a "national environmental policy" or a "national energy strategy", firms are bound to consider it in establishing their own environmental or energy strategy. It is also important to point out that firm's strategies are always formulated within a regulatory history and culture. The history and culture are likely to differ significantly among countries. The differences provide a unique pressure on firms. This point is further elaborated in Section 2.3.3.

It is difficult to determine a main actor in the normative pillar. In general, there are multiple actors influencing firms in the normative frontier such as non-governmental organizations, the media, stockholders, employees, financial institutions, NGOs, the supply chain members, customers and general public opinion. The local community also sets normative codes for firm's operations in the community. Those groups can be classified as "stakeholders". In fact, stakeholders can include any group in the society as long as "they have an interest, claim or stake in an organization, in what it does, and in how well it performs" (Jones, 1995). The types of actors influencing firms are case-specific. It depends upon which firm, which industry and which subject to cope with.

There are other actors that provide external pressures on firms. For example, shareholders or financial institutions provide remarkable pressures when firm's stock is open to the public. According to the scholars studying the influence of shareholders, the executives of firms recognize shareholders' current stock value as their key concern. And they make a decision to maximize the current value of the future cash flow of the firm (Brewer and Egenhofer, 2005). Grant argues that the purpose of firms' strategy is to increase the long-term profitability of the corporation by maximizing the present value of the firm (Grant, 1991). Based on his argument, the shareholders provide the single important pressure to firms.

2.3.1.1 Government regulations

Governmental regulations are identified as a key institutional driver of corporate environmental management. The relationship between government regulations and corporate responses to the environmental regulations are extensively researched by institutional scholars (Kolk, 2000, Pinkse, 2006). Several empirical studies indicate that most firms spend between one and two percent of their revenues as a response to environmental concerns (Medhurst, 1993). Henriques and Sadorsky conducted an empirical study to test their hypothesis that environmental regulation represents a main determinant of managerial action to deal with environmental concerns among Canadian firms (Henriques and Sadorsky, 1996). They found that governmental regulations are the most significant source of pressure on firms in the development of environmental strategy, while other sources of pressures such as consumer pressure, community pressure and shareholder pressure also have an important role in the strategic formulation.

What impacts that the regulatory pressures place upon firms and how firms respond to the pressures are other important facets that need attention. As shown in the previous section, economists contend that there is a trade off between compliance with a stringent environmental regulation and economic gain. According to their argument, environmental regulations lead to adverse effects such as loss of international competitiveness and employment. Porter and Vanderlinde disagree with this view. They contend that appropriately designed environmental regulations can stimulate technological innovation and provide a basis for "first mover advantage" in the international market (Porter, 1990, Porter, 1991, Porter and Vanderlinde, 1995a, Porter and Vanderlinde, 1995b). According to Porter and Vaderlinde's argument, early adoption of strict environmental standards may lead to "innovation offsets" that lower costs or improve quality and ultimately lead to net benefits for firms.

Porter and Vanderlinde's thesis has been examined through a number of empirical studies. It is inconclusive, however, whether environmental regulations lead to technological innovation or comparative advantage for firms in the international competition. Rugman and Verbeke conducted an extensive literature review on the empirical studies testing Porter and Vanderlinde's thesis. They concluded that environmental regulations have a wide variety of impacts and it is often unclear *ex ante* whether industrial and environmental performance is complimentary or conflicting (Rugman and Verbeke, 1998). In short, they did not find any empirical evidence to support Porter and Vanderlinde's hypothesis.

It is important to recognize that government regulations are the products formulated in the unique regulatory culture and history of the country. Regulatory culture and history are typically country or regional specific. To examine a linkage between regulatory pressures to firms and firm's responses to such pressures, it is also necessary to look into the historical and cultural contexts behind the regulatory pressures on the country or regional basis. Diversity in regulatory culture can be found, for example, in the choice between command-and-control regulations and voluntary initiatives. Some countries such as the U.S. have a tradition to control environmental emissions through command-and-control approach, while others such as the Western European countries and Japan have a tradition to control them through industry-led voluntary initiatives. In the latter case, as long as the governments can monitor and validate the progress of such initiatives, it may be unnecessary to consider command-and-control regulations. Mikoto Usui articulates this point as follows (Usui, 2003):

> Different countries have different institutional cultures, especially with respect to industry-government relationships, making it difficult to transfer the specific design of a national scheme to other countries. National institutional culture influences the way the hard and soft contents of law are interlaced. Thus, the way people envision the issue of “compliance” varies from country to country, although much depends on the nature of the problem at issue. Differences in regulatory culture loom large between European countries, Japan and the USA, particularly in regard to the issue of compliance with the Kyoto Protocol – an agreement geared toward precaution and not quite a tangible threat of catastrophe (as yet).

There is extensive literature that examines variations among countries as to the interaction between the government and firms. For example, Murtha and Lenway investigate the degrees of authoritative coordination on business practices and property rights allocations to the private sector in several countries. They classified the types of the government-firm interactions into four categories: transitional, command-and-control, pluralist and corporatist. Based on their findings, the countries were classified as follows: countries in the Eastern and Central Europe as transnational, China and Cuba as command-and-control, The U.S., the UK, India and Canada as pluralist and Japan, the Netherlands and Germany as corporatist. They contend that the degrees and scopes of the government capabilities to affect firm’s international strategies vary among countries (Murtha and Lenway, 1994).

2.3.1.2 Stakeholders

Stakeholder influence on corporate environmental strategy is lately receiving a particular research interest among institutional scholars. Sharma and Henriques describe, as a common view of the institutional scholars, that “stakeholders who are important, primary, or considered salient by managers in terms of their power, legitimacy, and urgency influence organizational strategies” (Sharma and Henriques, 2005). There is an empirical sign that firms attach importance to other stakeholders than government regulators in formulating their environmental strategy (Buysse and Verbeke, 2003, Neu et al., 1998, Fineman and Clarke, 1996, Christmann, 2004). The above-mentioned empirical study by Henriques and Sadorsky, for example, demonstrates that in addition to governmental regulations, pressures from different stakeholder groups are playing important roles in the formation of environmental strategy among the Canadian firms that they analyzed.

It is important to note that the theoretical base of the study examining the stakeholder influences is different from the study for governmental regulations. Pinkse articulates the point that the study of stakeholder influence draws on the theories such as agency theory and resource dependency theory, while the study to look at governmental influence is rooted in industrial economics (Pinkse, 2006).

As noted above, stakeholders can be any groups in the society insofar that “they have an interest, claim or stake in an organization, in what it does, and in how well it performs”. Scholars examine stakeholder influence by focusing on salient groups at stake inside and outside of the firms. It is also important to bear in mind that stakeholder influence is not static. Mitchell, Agle, and Wood point out in their literature that the importance of stakeholders is relative and issue-based and can change over time (Mitchell et al., 1997).

There are multiple classifications of stakeholders provided from different perspectives. Buysse and Verbeke classify stakeholders as primary or secondary based on the type of relationships they entertain with firms. The primary stakeholders refer to employees, suppliers, customers, shareholders and public agencies which are engaged in formal relationships with the organization. The secondary stakeholder groups include actors such as the media and special interest groups which are not engaged in formal transactions with the organization (Buysse and Verbeke, 2003).

Frooman presents another interesting classification. Frooman categorizes stakeholder influence by “usage” and “withholding” as well as “direct” and “indirect” (Frooman, 1999). He demonstrates four scenarios of resource interdependence based on the classification. Sharma and Henriques explain about Frooman’s scenarios as follows (Sharma and Henriques, 2005).

> The first scenario is where the focal firm and its stakeholders have high resource interdependence on each other. Frooman argues that under such a scenario, the stakeholders are likely to use a direct strategy to influence the firm’s usage of the resources so that their objectives are accommodated. Under the second scenario, stakeholder power, stakeholders control critical resources, but are not in turn resource dependent on the firm. In such a scenario, Frooman argues that stakeholders are more likely to use a direct strategy to withhold resources from the local firm unless it adopts certain practices. In the third scenario, when the focal firm and the stakeholders have no resource interdependence on each other, the stakeholders are likely to exercise indirect strategies via other stakeholders to either influence usage of resources that the other stakeholders hold or influence the other stakeholders to withhold the resources from the firm altogether.
>
> The type of strategy adopted depends on whether the stakeholders exercise influence via stakeholders who, in turn, are resource interdependent with the focal firm or via those that hold stakeholder power. In the fourth scenario, the stakeholder group is resource dependent on the firm but the firm has no resource dependence on the stakeholder group. In such a situation, the firm’s sustainability practices are unlikely to be influenced by stakeholder pressures.

Sharma and Henriques identify each stakeholder group in the four scenarios as follows:

Table 3: Four scenarios of stakeholder groups

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Is the stakeholder dependent on the firm?</td></tr>
<tr><td>No</td><td>Yes</td></tr>
<tr><td rowspan="2">Is the firm dependent on the stakeholder?</td><td>No</td><td>Low dependence
Environmental NGOs
Social NGOs
Special interest groups/activists
Aboriginal groups
International regimes
(UNEP, Kyoto Protocol)</td><td>Firm power
Suppliers
Employees</td></tr>
<tr><td>Yes</td><td>Stakeholder power
Regulators/government agencies
End consumers
Media
Local communities
Activist shareholders</td><td>High interdependence
Customers
Investors/shareholders
Financial institutions
Insurers
Trade associations
Local communities
Suppliers
Managers</td></tr>
</table>

(Source: Sharma and Henriques, 1996)

This classification presents conceptual linkages between the stakeholder pressures and firms' responses to the pressures based on the resource-interdependence perspective. As Sharma and Henriques indicates in their study, however, that stakeholder influence on firms is issue-specific in reality. The approach (direct or indirect) and degree (strong or weak) of the influence can vary greatly among the issues at stake.

This thesis research was not designed to examine the causal linkages between the stakeholder pressures and firm's response. This thesis author recognizes, however, that firms tend to perceive that stakeholder pressures and stakeholder influence is not negligible in the formulation of corporate strategy on climate change. The empirical study of this thesis, considers the stakeholder influence as one of the major external pressures to firms and attempt to identify the sources and degrees of the influences in the countries of analysis.

2.3.2 Convergent trends

How do firms respond to the pressures from the external environment? When their governments ratified the Kyoto Protocol, how did firms react to the event? Did they consider making their climate change position explicit by publishing a policy statement? Did they consider hiring a climate change expert who may be able to explain what climate change means to their top management? Did they consider monitoring their GHG emissions production to prepare for future regulations?

2.3.2.1 Isomorphism

Institutional theorists have their view on such situations. They expect that the firms in the same "organizational field " or industry sector begin to adopt similar structures and strategies, yielding to common pressures for change (Hoffman, 2001). As discussed earlier, this is so-called "isomorphism". The concept of isomorphism was introduced in 1983 in the DiMaggio and Powell paper. (DiMaggio and Powell, 1983). DiMaggio and Powell contend that there are three mechanisms leading to isomorphism among organizations: coercive, mimetic and normative. **Coercive** isomorphism stems from political pressures exerted on organizations by other organizations upon which they are dependent and by cultural expectations in the society within which organizations function. **Mimetic** isomorphism results from standard responses of organizations to model themselves on other organizations to cope with technological and other future uncertainties. **Normative** isomorphism is a consequence of "professionalization" in which organizations collectively attempt to define the conditions and methods of their work and establish a cognitive base and legitimation for their occupational autonomy. Institutional scholars are conducting empirical research to test three models of isomorphism among organizations.

According to DiMaggio and Powell, these three types of isomorphism can be together called "institutional isomorphism" (DiMaggio and Powell, 1983). The contrast is "competitive isomorphism". Competitive isomorphism is the process where market competition matters a great deal. According to DiMaggio and Powell, competitive isomorphism presents a limited picture of organization. It needs to be complemented by institutional views on isomorphism involving organizational competition for political and institutional legitimacy as well as market position (Louche, 2004).

The tendency for "institutional isomorphism" among organizations has been a subject of research interests in a different domain of study. Scholars examining the greater degree of economic globalization have begun to look at a homogeneous trend in corporate management among the multinational firms in the 1980s. According to them, the operations of multinational firms such as material procurement, production, supply chain and sales are increasingly becoming borderless or "stateless". The globalization process is playing an important role in weakening domestic or home country roots of the multinational firms (Hu, 1992, Reich, 1991) They contend that the management strategy and organizational structure among the multinational firms has seemingly begun to resemble each other under the influence of similar patters of industrialization, mass media, financial markets and mobile capital (Kolk, 2005).

2.3.2.2 Analysis of convergence in the corporate environmental arena

The analysis of convergent trends among organizational strategies and structures is subsequently expanded to the corporate environmental arena. An example of such analysis is Kolk's research to examine the environmental reporting by multinational firms among the United States, Europe and Japan. It investigates whether any convergence in environmental report is observed in the triad region. She concludes that considering Europe as a whole, there is a convergence between Europe and Japan, while the differences between the United States and Europe and within Europe have increased (Kolk, 2005). Kolk's research also indicates that the existence and degree of convergence hinge upon a subject area in the corporate environmental strategy.

By intuition, however, there seems to be some convergence among firms in the environmental arena. The number of the multinational firms publishing a sustainability or environmental report has dramatically increased over the last several years. The number of the firms establishing an environmental department has also grown especially in the OECD countries. The emergence of convergence is noteworthy considering the fact that many firms managed the environmental issues only in the compliance contexts at the compliance department, until recently.

There are industry-specific researches to examine whether or not there is convergence among the corporate responses to climate change. The industry sectors with a particular research focus are oil and automotive industry sectors. Kolk, Levy and Rothenberg conducted a series of research to highlight strategic similarities and differences between the U.S. and European firms in the sectors (Kolk and Levy, 2004, Levy and Rothenberg, 1999, Levy and Kolk, 2002, Levy and Rothenberg, 2002). In the case of the oil industry, Kolk and Levy found that while there are remarkable differences between the U.S. and European firms in the initial corporate reactions to the climate change issues, convergent pressures predominates the issues mature (Kolk and Levy, 2004, Levy and Kolk, 2002).

The literature also addresses what explanatory factors that lie behind the convergent trends among firms' climate change strategies. Kolk and Levy point out two factors that lead to convergence as follows: "MNEs (multinational enterprises) competing in global industries participate in a common industry-level field, creating some tendencies toward convergence for companies in the same industry. The emergence of climate change as a 'global issues arena' constitutes a second convergent influence." (Kolk and Levy, 2004)

The first point relates to the above discussion on the relationship between economic globalization and stateless firms. As explained above, as the products and services are traded increasingly in the international market, firm's management and structure become increasingly global. The second point is connected to the fact that climate change is a threat to global community and the regulatory schemes to cope with the issues are established in the global negotiations. The discussions and forum on the climate change issues among firms also take place in the global arena. The corporate managers responsible for the climate change strategy attend the same events on climate change such as UNFCCC's subsidiary body meetings and industry expert workshops. They also subscribe to the same discussion papers and journals such as Point Carbon's newsletters. Based on the shared information and data among them, they develop their own strategy by following the framework and guidance of the industry association groups. It is not difficult to assume that firm's strategies for climate change begin to resemble each other.

2.3.2.3 Definition of convergence in the political science literature

The institutional literature hardly describes the definition of "convergence", however. The literature does not elaborate on the degree, direction and time period of convergent forces or pressures. Convergence is usually treated as a synonym for similarity or uniformity among countries in the literatures. At this point, it is relevant to pay special attention to a theoretical discussion on convergence in the political science literature. There is a burgeoning volume of literature in political science that is based upon studies of how and to what extent policy convergence takes place among the member states of the European Union (Knill, 2005, Holzinger and Knill, 2005, Albrecht and Arts, 2005, Heichel et al., 2005). This literature attempts to develop and understanding of the dynamics of convergence. For example, Bennett elaborates the term in his literature titled "What Is Policy Convergence and What Causes It?" as follows (Bennett, 1991):

> Policy convergence probably means one of five things. First, it can signify a convergence of *policy goals*, a coming together of intent to deal with common policy problems. Secondly, it can refer to *policy content*, defined as the more formal manifestations of government policy – statutes, administrative rules, regulations, court decisions and so on. Thirdly, there may be a convergence on *policy instruments*, i.e. the institutional tools available to administer policy, whether regulatory, administrative or judicial. Fourthly, convergence may occur on *policy outcomes*, impacts or consequences – the results (positive or negative, effective or ineffective) of implementation. Finally, there may be a convergence of *policy style*, a more diffuse notion signifying the process by which policy responses are formulated (consensual or conflictual, incremental or rational, anticipatory or reactive, corporatist or pluralist, etc.).

Knill presents a classification about the degree and direction of convergent forces that are typically discussed among the convergence studies as follows (Knill, 2005):

> The most common convergence type…refers to α-convergence. [α-convergence] occurs if there is a decrease in variation of policies among the countries under consideration…β-convergence occurs when laggard countries catch up with leader countries over time, implying, for instance, that the former strengthen their regulatory standards more quickly and fundamentally than the latter…γ-convergence is measured by changes of country rankings with respect to a certain policy. Finally, we speak of δ-convergence, when similar change is operationalized by comparing countries' distance changes to an exemplary model.

The organizational units of the research interests differ between political science scientists and management scholars who are focusing on the institutional aspects of the firms. Political scientists and management scholars are interested in countries and firms respectively. However, this definition and classification of "convergence" is applicable to the study of firm management. It is used to define the term of convergence in the management study performed in by this thesis author.

2.3.2.4 Policy implications of the convergence study

The institutional studies examining firm's strategic and technological convergence can be a great contribution to the public policy discussions. Mapping and highlighting of the similarities and differences in their strategic decisions as well as in their perceptions on certain public policies can become a starting point to understand what policies are likely or unlikely to be supported among firms. With this respect, public policy on climate change is not an exception. Understanding the similarities and differences in corporate climate change strategy will be a great input for policymakers to discuss the possible regulatory schemes in the post-Kyoto period. Considering the fact that the firms in the energy-intensive industry sectors are responsible for nearly 40% of the global anthropogenic GHG emissions release, it is important for policymakers to understand what strategic convergence towards GHG emissions reduction possibly occurs in the energy-intensive industry sectors.

Surprisingly, however, the institutional literature on corporate climate change strategies does not elaborate on the policy implications of their research. On the other hand, the engineering studies take the role in exploring the policy implications of technological convergence among countries. They analyze technological convergence among firm's renewable energy and energy efficiency initiatives and discuss possible policy options for technological convergence among firms. Groenenberg's thesis titled "Development and Convergence: A Bottom-up Analysis for the Differentiation of Future Commitments under the Climate Convention" is an example (Groenenberg, 2002). Groenenberg derives a possible future path to achieve technological convergence in energy efficiency improvement in 2030 and 2050 from the present differences in the energy efficiency levels among the countries. Groenenberg presents policy options to realize such a convergent path. The thesis author stresses an importance of such policy-minded research. This research was designed to bring policy recommendations through an empirical study.

2.3.3 Divergent trends

Albeit with the convergent pressures, there are many differences in corporate climate change strategy among firms. What are the sources of the heterogeneity? Indeed, the existence of the heterogeneity is normal, as every firm has different corporate history, culture and philosophy as well as business operations and marketing positioning. According to the institutional theorists, firms are also subject to divergent pressures from the external environment.

The following illustrates theoretical discussions about the external pressures that contribute to heterogeneity in corporate climate change strategies.

2.3.3.1 Home country factors

Section 2.3.1.1 discussed that the regulatory pressures tend to be created in the unique local regulatory culture and history. The characteristics of the regulatory pressures and the way firms respond to such pressures are often country-specific (or region-specific). The fashions that stakeholders influence firms also seemingly vary from one country to another. The natures of the roles and powers that stakeholders exercise are closely connected to the social and cultural contexts of the country.

Sethi and Elango label the home country factors as “country of origin effects” (Sethi and Elango, 1999). According to Sethi and Elango, the home country factors consist of 1) economic and physical resources and industrial capabilities, 2) cultural values and institutional norms; and 3) national government’s economic and industrial policies. Sethi and Elango contend that those home country factors provide a powerful influence on firm’s capabilities and strategies and create divergent pressures on firms in the formation of their corporate strategy.

The home country factors are discussed in a different context in the management literature. Porter is eager to discuss the attributes in the context of “competitive advantage” of the firms. According to Porter, the success of firms in the international market is a function of four home country attributes: demand patterns, factors of production, the competitive environment, and a network of related industries (Porter, 1990). A combination of those factors determines the level and area of firm’s competitive advantage. According to Levy and Kolk, if these country-based attributes shape corporate capabilities, the resource-based view of strategy suggests that they also influence strategic choices of markets and technologies (Levy and Kolk, 2002).

Some scholars such as Rugman, Brain and Hu challenge the notion of “globalization” and contend that firm’s operations and strategies are attributable to the local environment. They dismiss the idea that economic globalization is contributing to an emergence of “stateless” firms. They maintain that few multinational firms are truly global and most of the firms are regionally-oriented, and therefore strategic management of the firms should be regional-focused (Rugman and Brain, 2003). In the publication titled “Global or Stateless Corporations Are National Firms with International Operations”, Hu examines the level of internationalization among the U.S., European and Japanese firms in terms of their ownership and control, nationalities of the executive managers and legal nationality (Hu, 1992). He concludes that with a few exceptions, all firms that he analyzed are regarded as “national firms with international operations”. According to Hu, corporate strategies and operations are deeply rooted in the home country environment.

Baron and others contend that the business environment is composed of market and non-market components. According to Baron, the non-market components include interactions intermediated by the public, stakeholders, government, the media and public institutions. Baron argues that the non-market environment is, to an important degree, nation-specific and it depends on the institutions and cultures of individual countries as well as on the organization of interests in the countries (Baron, 1995, Baron, 1997). The non-market components that Baron discusses seem to be pointing out the second and third home country factors that Sethi and Elango demonstrated: cultural values and institutional norms and national government’s economic and industrial policies. The differences between the U.S. and European institutional norms are examples of the former. The Japanese METI’s (Ministry of Economy, Trade and Industry) industrial policy is an example of the latter.

This thesis author did not elaborate on the first factor that Sethi and Elango presented (economic and physical resources and industrial capabilities). It is important, however, to recognize that there are many examples relating to this factor. For example, the geographical advantages of the United States are associated with the characteristics of business operations of American firms. On the other hand, the spatial limitation of the Netherlands and the resource limitation of Japan are also relating to their business models. It is conceivable that these differences lead to strategic divergence among firms.

These arguments suggest that there are remarkable local pressures that lead to heterogeneity among corporate strategies. Kolk and Levy examined the home country factors in the formation of corporate climate change strategy (Kolk and Levy, 2004). They analyzed the significance of the factors in the automobile and oil industry sectors in the United States and Europe. The home country factors that they identified are the following:

- Societal concerns about climate change;
- Societal views on corporate responsibilities;
- Regulatory culture (litigious or consensus-oriented);
- Ability of firms to influence regulation;
- National environmental policies;
- National industrial promotion strategies.

The following empirical study pays particular attention to those home country factors. It investigates whether or not and how these home country factors are playing a role in the formulation of corporate climate change strategy (See Section 3.1.2).

2.3.3.2 Firm-specific issues

As stated earlier, every firm has a different corporate history and culture as well as different business operations. While this thesis research was not designed to elaborate the firm-specific issues, it is recognized that these differences in corporate history and culture also contribute to their divergent views and strategies on climate change. Kolk and Levy articulate this point as follows (Kolk and Levy, 2002):

> Companies that experienced a history of losses associated with alternative energy sources are likely to institutionalize a negative view toward the future prospects of such technologies. While some companies still believe that environmental regulations are a burdensome imposition, others are embracing the notion that proactive environmental management practices can offer “win-win” strategic opportunities.

An example of the first part of Kolk’s explanation is the renewable energy subsidy program under the Carter Administration in the United States. While some U.S. oil companies were heavily involved in the program, the budget for the program was discontinued under the Reagan Administration. The U.S. oil companies have a painful history where they lost money through their renewable energy initiatives. As this example indicates, the firm’s individual backgrounds (historical and cultural as well as economic and financial) are associated with their corporate climate change strategy. This study does not, however, elaborate such firm-specific issues.

Summary of Chapter 2

This chapter examined theoretical discussions about corporate strategy on climate change. It focused on three factors that influence on the formulation of corporate strategy: economic, technological and institutional factors. This thesis author conducted a literature survey and reviewed the relevant theories in the three dimensions with a special focus on the institutional dimensions. He contends that there are both convergent and divergent forces in the external environment in the shaping of corporate climate change strategies. Based on the theories presented in this chapter, Chapter 3 formulated a research framework. The framework is then used as the foundation for the empirical research of this thesis.

Chapter 3: Research framework for the analysis of corporate climate change strategy

Introduction

This chapter extracts theoretical insights about firm's behaviors from the previous chapter and formulates them as a research framework for the empirical research of this thesis. Chapter 2 reviewed economics, business management and other social science research as well as the climate change-specific research on corporate strategy. Both their theoretical discussions and empirical findings were examined. In addition, the three different dimensions of corporate climate change strategy were investigated: economic, technological and institutional. This thesis author maintains that the corporate decision-making mechanism is mainly a function of the economic, technological and institutional factors. Therefore, none of the dimensions is negligible for understanding how and why firms formulate their climate change strategies and how they perceive the climate change policy instruments.

With respect to the economic dimensions, Chapter 2 took an example of the emissions trading scheme and described four economic impacts that firms may receive through an introduction of a climate change policy instrument. The impacts are 1) cost to reduce GHG emissions internally and/or purchase emission allowances, 2) increase in electricity prices, 3) demand reduction and 4) loss in competitiveness in the international market. Firm's responses to the climate change policy instruments largely depend on a perceived scale of the economic impacts upon business operations.[14]

This thesis author then contended that when firms have a good prospect for technological change, they may consider a drastic change in their corporate climate change strategy. When a technological change is great enough to induce the "transitional" process in the socio-economic system or the "Stiglerian" situation, firms may support regulatory schemes or policy instruments to control GHG emissions release. In fact, this may also be the case to some degree when firms have existing technological capability to reduce GHG emissions, in the short term. Therefore, this thesis author proposed to examine whether or not there is a possibility of an occurrence of the Stiglerian situation and technological capability in the steel industry sector.

It was discussed in Chapter 2 that the institutional factors also contribute to the formulation of corporate climate change policy and strategy. This thesis author contended that the home-country factor is the essential factor to provide divergent pressures on firms. However, there are also convergent pressures among firms. The increasing trend for globalization among industry sectors and the global nature of the climate change issue provide convergent pressures on corporate managers to develop similar policies and strategies on climate change. This thesis author studied both divergent and convergent factors in the external environment in his research.

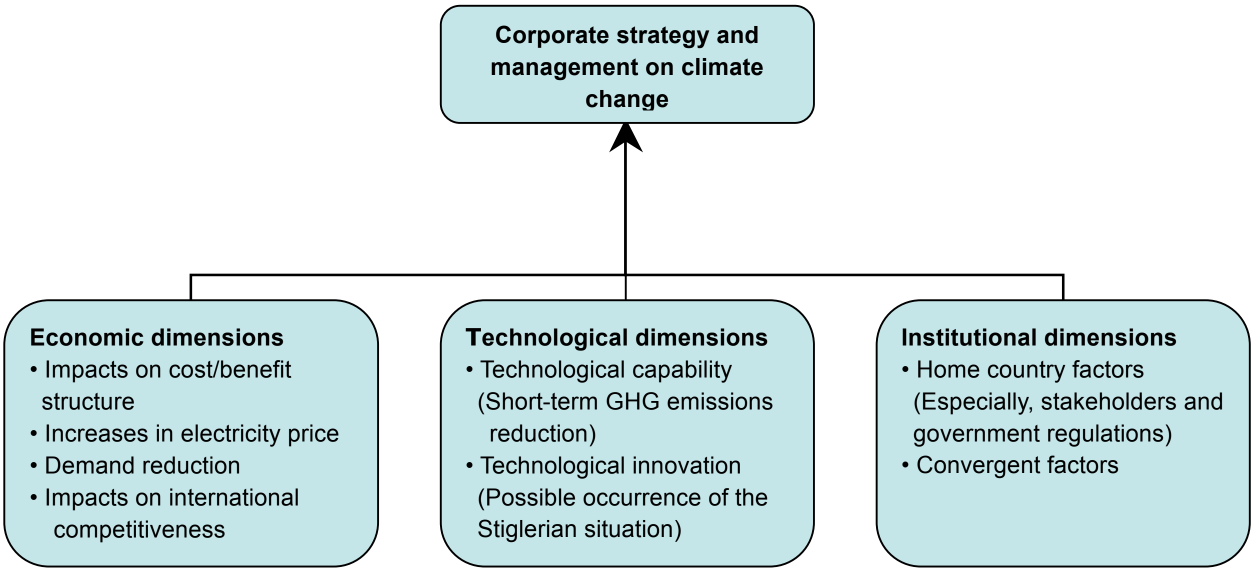
3.1 Research framework

3.1.1 Research framework

The research framework of this thesis is presented in Figure 6. As discussed in previous paragraphs, the main argument is that corporate strategies and management approaches on climate change are formulated in response to three factors: economic, technological and institutional.

[14] Since there is a great degree of variance in business operations as well as in market conditions among the industry sectors, the scale of the economic impacts vary among them. In order to understand firms' responses to the policy instruments, therefore, it is necessary to conduct research on a sectoral basis.

Figure 6: Research framework for the empirical research



It is important to understand which factor(s) firms take into account is subject-specific. For example, the case of an emissions trading scheme can be different from the case of a voluntary emissions reduction scheme. Firms may stress the economic dimensions of an emissions trading scheme, while they may focus on the technological dimensions of a voluntary emissions reduction scheme. It is also country- or region- specific. For example, the factors that European firms consider important toward an emissions trading scheme may be different from those considered by managers of Japanese firms. While European firms may only consider economic factors, Japanese firms may consider both economic and technological factors.

This research is one of the first attempts to develop and test a framework to examine simultaneously the three dimensions of corporate climate change strategy. This thesis author took an interdisciplinary approach. Special attention is paid to different arguments presented by economists, social sciences and engineers about corporate climate change strategy. The thesis author attempted not to overlook issues that are significant in the formulation of corporate climate change strategy.

In fact, there are many research initiatives to analyze corporate climate change strategy in each individual dimensions. Financial economists have examined whether or not the policy instruments are acceptable to the industry sectors only from the economic perspective. Innovation economists have discussed the roles of technological innovation in the firm’s response to environmental regulations. The scholars who are looking at business management and practices have investigated how firms receive influence from the external environment in formulating climate change strategy. While all of the research efforts equally aim at understanding of corporate climate change strategy, each of them tends to remain the focus on the individual dimensions. There were few attempts, thus far, to look into the different dimensions. The research methodology proposed here made it possible to consider the three dimensions and to identify the factors of utmost importance from the wider dimensions.

3.1.2 Focus on home country factors

As indicated in Section 2.3.3.1, this empirical study pays particular attention to the home country factors. It examines whether or not and how these home country factors are playing a role in the formulation of corporate climate change strategy. First, this thesis author looked at societal concerns about climate change. In order to have a brief picture of the differences in the level of the concerns among the countries, a result of a public opinion survey is examined. There are many surveys conducted at the national level. It appears, however, that there are only a few surveys at the international level that applies a consistent methodology among the countries. A research firm based in the North America, GlobeScan, conducted one of the surveys. The results of the surveys are referred as the starting point. Then, this thesis author attempted to grasp further the level of societal concerns about climate change as well as social expectations to firms to cope with the global issue through a literature survey. This thesis author observed the roles of different actors in raising the concerns and expectations towards firms and identified the leading actors playing an effective role in raising the awareness in each country. Then this thesis author attempted to picture how the climate change issue has received societal attentions over years. In the case of the EU, the focus is placed on the Netherlands.

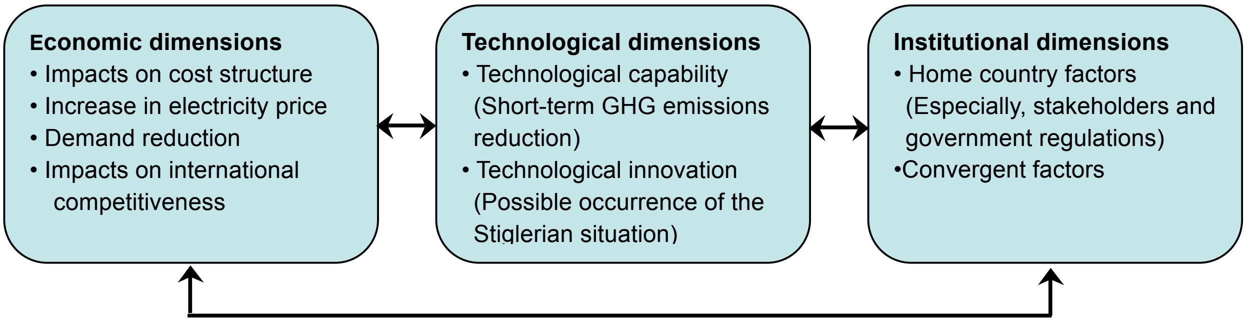
Second, this thesis author looked at regulatory culture and schemes on climate change. It is planned to review the characteristics of the regulatory schemes among countries including both mandatory and voluntary policy schemes. Among all, a particular attention is heeded to voluntary schemes. Voluntary schemes are exercised among many countries to achieve a policy goal. In some countries, they are widely implemented in the public policy arena with a positive recognition as an alternative approach to the command and control approach. In some countries, they are implemented based on a consensus between the industry sectors and national government. If voluntary schemes are introduced in these fashions in the area of climate change, it is expected that there are significant differences in regulatory culture among countries.

3.2 Theoretical elaborations on the research framework

3.2.1 The linkages among the three dimensions

It is noted that the three dimensions are not completely separated or independent. They are interrelated and influence one another as illustrated in Figure 7. This section elaborates upon the linkages among the three dimensions.

Figure 7: Interrelations among the economic, technological and institutional dimensions



3.2.1.1 The linkage between the economic and technological dimensions

To begin with, there is a strong linkage between the economic and technological dimensions. It is a long lasting theoretical and empirical question for economists whether or not an introduction of economic measures induces technological innovation. In the area of climate change, this discussion is presently centering on the technological implication of the emissions trading scheme being introduced in the EU (EU ETS). As described above, the pilot phase of the EU ETS started in 2005. After two years of experience, there are discussions to ask whether the trading of the emissions is leading to the reduction of the emissions. There are some studies investigating the impact of the emissions trading on the management decision of the electricity generation sector switching fuel from coal to natural gas. However, most of the studies are presently under way and the results of the studies are inconclusive or incomplete at this time.

In the nexus of the economic and the technological dimensions, another point of attention goes to “pollution haven hypothesis”. The hypothesis indicates that the firms with international operations lower their environmental standards by operating their business in the developing countries or relocating pollution-intensive operations to these countries to take advantage of lax environmental regulations (Pinkse, 2006, Zarsky, 1999). The hypothesis assumes that cross-country differences in the economic burden of environmental regulation are an important driver for firms to relocate operations abroad (Pinkse, 2006). In the area of climate change, this hypothesis is translated as “carbon leakage”. The problem of carbon leakage occurs when firms move their operations from an Annex I country to non-Annex I country where there are no-caps on the GHG emissions under the Kyoto Protocol. This point is further elaborated in Section 6.4.2.2.

3.2.1.2 The linkage between the economic and institutional dimensions

The linkage between the economic and institutional dimensions was discussed in Section 2.1.6. The institutional theory was demonstrated as a social science approach that challenges rational decision-making theorem of organization.

3.2.1.3 The linkage between the technological and institutional dimensions

Section 2.2 explored theoretical discussions about the roles of technological development in the formulation of corporate strategy. It demonstrated possible impacts of technological “innovation” on the corporate responses to government regulation as well as possible impacts of technological “diffusion” on the mitigation of climate change. In this respect, Boons et. al. provide a conceptual model to discuss “innovation” and “diffusion” in the context of institutional theory (Boons et al., 2000). They describe mechanisms that are responsible for organizational change within an organizational field that they call “innovation and diffusion of new organizational routines”. They divide the mechanisms into two categories. The first category contains mechanisms in which one or more actors have an intention of inventing or diffusing a new organizational routine. The second category consists of mechanisms that result in innovation or diffusion without actors striving for that goal. Table 4 illustrates the mechanisms in two categories:

Table 4: Conceptual model indicating "innovation" and "diffusion" in the context of the institutional theory

	Innovation	**Diffusion**
Intentional	- Individual problem solving - Think-tank - Policy development - Model developed by trade associations - Researchers	- Coercive isomorphism - Normative isomorphism
Emergent	- Individual goal-oriented action	- Competitive isomorphism - Mimetic isomorphism

(Source: Boons et.al.)

It becomes clear from Table 4 that the concept of technological innovation discussed in the context of technological impacts of government regulations (Section 2.2.2: Stiglerian situation) and the impacts of technological impacts on climate change mitigation (Section 2.2.1 and 2.2.3: Innovation management study and economics) fits in the lower right corner. It resembles the concepts of competitive isomorphism and mimetic isomorphism with an idea that technological diffusion emerges without efforts among organizations (firms, governments and other actors sharing the same organizational field) striving for that goal. It is based on the optimistic view that technological spillover will eventually take place from the technological innovators or forerunners to the laggards.

On the other hand, the conceptual model presented by Boons et al. captures a broader scope of technological diffusion. It elaborates the mechanisms - coercive isomorphism and normative isomorphism where technological innovation is a consequence of efforts among organizations. In these mechanisms, the regulatory pressures from the government and normative pressures from the stakeholders typically play an important role. In this mechanism, firms are encouraged to induce technological diffusion by the external pressures.[15]

It is important to stress again that the characteristics and consequences of the external pressures also tend to be country-specific (or region-specific). Therefore, some of the issues in the nexus of the technological and institutional dimensions tend to be country-specific. For example, there are significant differences between the U.S. and European government programs for research and development. Some characteristics of Japanese government program are also attributable to the cultural contexts of the country.

[15] It is recognized that some scholars have a negative view on the optimistic model of technological diffusion. Most notably, evolutional economists present a negative argument by addressing a path dependent model of technological change. According to them, a future success of technological changes depends on the past events dominated by "chance elements rather than by systematic forces". David argues, for example, that technological changes tend to be "local" and learning occurs primarily around the technologies in use. Therefore, more advanced economies will learn more about advanced technologies and stay at the cutting edge of process. See David, P. A. (1975) *Technical Choice, Innovation and Economic Growth: Essays on American and British Experience in the Nineteenth Century,* Cambridge, Cambridge University Press, David, P. A. (2001) Path dependency, its critics, and the quest for "hostorical economics". IN GARROUSTE, P. & IOANNIDES, S. (Eds.) *Evolution and Path Dependency in Economic Ideas: Past and Present.* Cheltenham, Edward Elgar.

3.2.2 Corporate responses to the institutional pressures

The pressures from the external environment (such as the pressures from stakeholders and government regulations) encourage firm to formulate their strategy for or against them. It is important to note, however, that each firm may respond to such pressures differently even though the pressures that they receive may be equal. With this respect, the institutional theory does not provide a theoretical explanation as to why there are different responses among them. In general, institutional theory has assumed a rather passive attitude of firms in response to institutional pressures (Hoffman, 2001). In fact, institutional theory has been criticized for emphasizing too much, corporate passive compliance to institutional pressures while ignoring the capability of organizations to resist these pressures (Oliver, 1991).

This thesis author's view agrees with such a criticism. As discussed in Section 2.3.3.2, each firm has a different corporate history and culture as well as different business operations. Their responses to the pressures from the external environment are likely to vary one another. It is also important to point out that while the external pressures affect firms, firm's responses to the pressures also affect the formulation of the external environment. For example, firm's aggregate responses to the government often affect the government decisions. The communications between stakeholders and firms are not always unilateral – firms address their key strategic issues to their stakeholders as a response to their pressures.

Recently, institutional scholars explore how firms respond differently to institutional pressures. In the corporate environmental area, several scholars have presented a typology as to how firms respond differently to the external pressures. Their typologies are typically based on a spectrum ranging from passive to proactive or progressive responses. For example, Oliver developed a typology of five possible strategic options including 1) acquiescence, 2) compromise, 3) avoidance, 4) defiance and 5) manipulate (Oliver, 1991). Roome addresses another typology classifying the following five strategic options: 1) non-compliance, 2) compliance, 3) compliance-plus, 4) commercial and environmental excellence and 5) leading edge (Roome, 1992). According to Rondinelli and Vastag, the corporate attitudes toward the environmental issues can be classified as 1) crisis preventive, 2) reactive, 3) proactive and 4) strategic (Rondinelli and Vastag, 1996). Kolk focuses on the climate change corporate strategy addressing a typology of the following six strategic options among firms (Kolk and Pinkse, 2005):

1) Cautious planners: Their posture can be characterized as preparing for action, with not much activity in the different area. On average, they mention measures to reduce GHG emissions only as a possibility in the future without giving any specific details.
2) Emergent planners: They have set a process in motion to develop a more comprehensive climate strategy in coming years. So far, their initial step has been to set a target for the reduction of energy consumption and/or GHG emissions, but they are only in an early stage with regard to implementing organizational change to realize this objective.
3) Internal Explorers: This group of firms has a strong internal focus, which involves a combination of targets and improvements in the production process. For most Internal Explorers, the "low-hanging fruit" has consisted of improvements in the production process in terms of energy efficiency with the intention of reducing CO_2 emissions.
4) Vertical Explorers: They are characterized by a strong focus on measures within the supply chain. Although these firms are also in the process of getting insight into the GHG emissions resulting from their own activities, they clearly see opportunities for developing more energy-efficient products and for engaging in a dialogue with their suppliers to reduce GHG emissions.
5) Horizontal Explorers: They focus on the exploration of opportunities in markets outside of their

current business scope, sometimes in cooperation with partners.

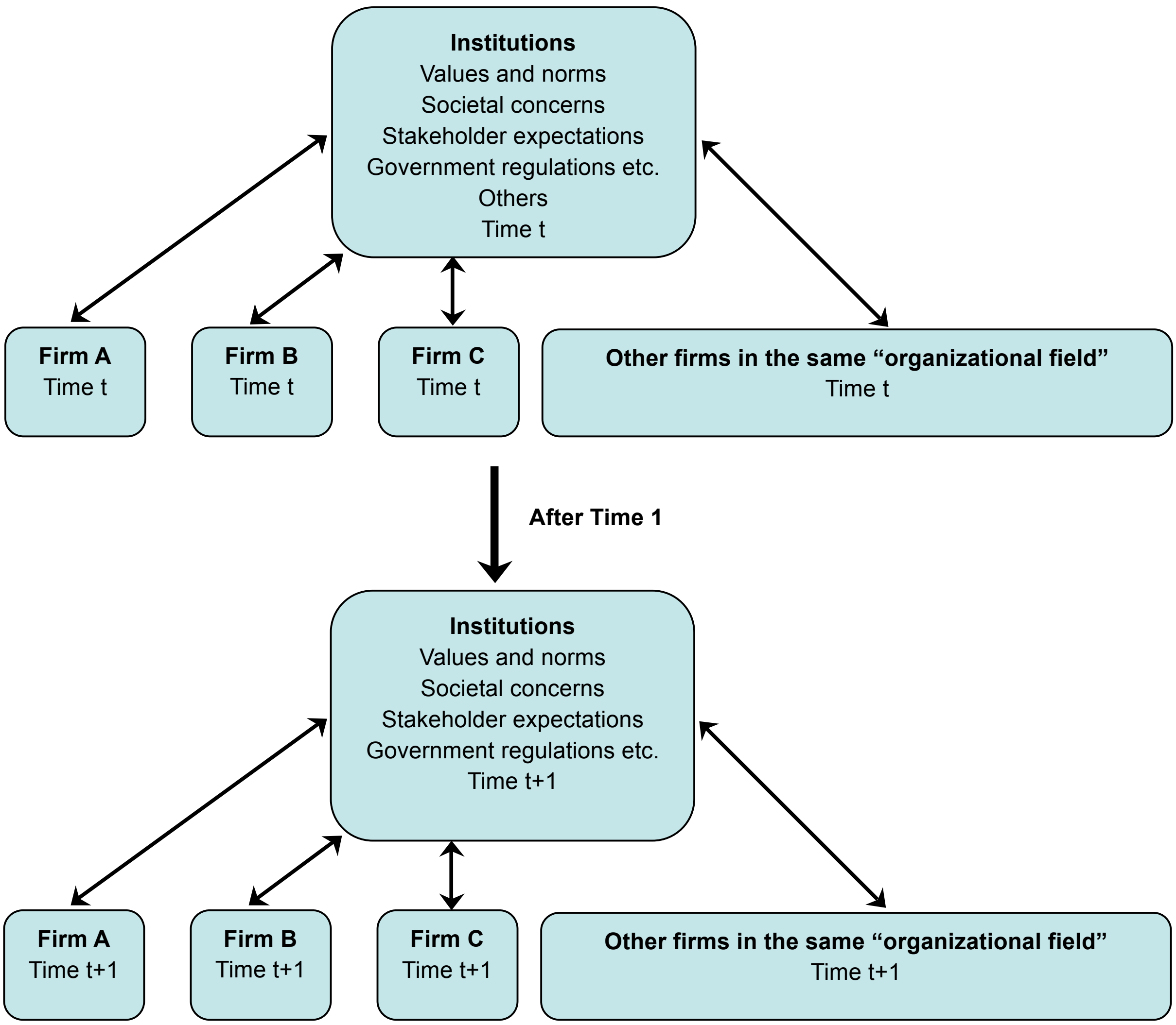
6) Emissions Traders: Emissions They directly focus on the opportunities of emissions trading and combine this option with an internal reduction target that has a global reach and with a favorable position towards new products and markets. Instead of offering products that facilitate emissions trading, they trade certified emission reductions themselves or act as an intermediary for other firms.

As stated in Section 2.3.3.2, this research is not designed to investigate the differences in strategic options among firms. As stated above, it recognizes, however, that each firm responds differently to the external pressures and the responses often become an important input into the formation of the external environment. Section 3.2.3 elaborates further the linkage between the external pressures and corporate responses.

3.2.3 The meso-level dynamics: The interaction between the aggregated corporate responses and the institutional dimensions

Figure 8 illustrates the linkages between “institutions” and firms as well as the interactions between external pressures and corporate responses to the pressures over time:

Figure 8: Linkages between institutions and firms as well as the interactions between external pressures and corporate responses to the pressures over time



It is important to note, as discussed in Chapter 2, that the "institutions" can be values and norms, societal concerns, stakeholder expectations and government regulations. According to Scott, the institutions consist of "cognitive, normative, and regulative structures and activities that provide stability and meaning to social behavior. Institutions are transported by various carriers – cultures, structures and routines – and they operate at multiple levels of jurisdiction" (Scott, 1995).[16] In fact, institutions can operate at any levels in our society "from the world system to localized interpersonal relationships" (Scott, 1995).[17] As for the firms, the institutions can influence their values and principles, board-level decision-making, manager-level decision-making and decision-making in their

[16] It is noteworthy that the concept of "institutions" is very similar to the concept of "regime" introduced by scholars studying international relations such as Krasner. The terms of institutions and regimes are broadly used in political science in the similar context. Krasner defines regime or institution as "as a set of explicit or implicit "principles, norms, rules, and decision making procedures around which actor expectations converge in a given issue-area". See Krasner, S. D. (1983) *International Regimes,* Ithaca and London, Cornell University Press..

[17] Based on Scott's argument, a firm itself is an institution itself. A firm is a form of cognitive, normative, and regulative structures and activities.

plant-level operations. They can also influence a very specific corporate decision-making matter such as their strategy on a proposed economic policy instrument. (Scholars generally focus on specific levels or area of corporate strategy and indicate them in their research. The focus of this research is specified in Section 3.4.)

Figure 8 indicates that institutions change over a period of time. The regulatory scene changes over time, for example, with an introduction of new regulations and abolition of old regulations. The societal values and norms also change over a long time period. Accordingly, firms make an adjustment (sometimes make a drastic change) in their responses to the institutions. It is important to note that the relationship between institutions and firms is mutually dependent. It can be also described as a feedback loop through which the flows of the influences reach each other. Since there are exchanges of pressures between institutions and firms, they influence each other.

It is also important to note that the formulation process of institutions does not necessarily follow a straight line or linear curve. The institutionalization process can be marginal, transitional, evolutional or a combination of these. It is possible, however, to present a conceptual model of the formulation process. Louche discusses in her Ph.D. thesis a three-stage model addressed by Tolbert and Zucker (Louche, 2004, Tolbert and Zucker, 1996). The model consists of 1) habitualization or pre-institutionalization stage, 2) objectivation or semi-institutionalization stage and 3) sedimentation or full institutionalization stage. The following statements provide a brief description of the three stages (Louche, 2004):

1) Habitualization or pre-institutionalization stage: Habitualization involves the generation of new structural arrangements in response to a specific organization problem or set of problems. It marks the transition to action in that certain organizations will move from discussion to action.
2) Objectivation or semi-institutionalization stage: Objectivation involves wider dissemination and a greater degree of consensus on the content and value of an idea. Organizations gather evidence from various sources to assess the risk parameters of adopting a new structure. Other organizations have already pre—tested the structure, and decision-makers' perception of the relative costs and benefits of adoption will be influenced by observation of other organizations' behavior.
3) Sedimentation or full institutionalization stage: The sedimentation phase is characterized by complete dissemination to organizations in field and by significant continuity in time and space.

3.2.4 The macro-level dynamics: The interaction between corporate climate change strategy and the physical environment

It is important to note that there are linkages between corporate climate change strategy and the physical environment. The evolutionary changes in the interactions between firms and the institutions become inputs in the physical environment. The aggregated interactions at the meso-level eventually reach the macro-level dynamics. Changes in corporate climate change strategy toward GHG emissions reduction will become part of the mitigation efforts to global climate change.

In Section 1.2, it was indicated that the mitigation efforts might lessen the adaptation costs and challenges in the future. Changes in corporate climate change strategy may have an impact on the efforts to adapt to the changing climate.

3.3 Research method used for this thesis research

This research was designed to collect necessary raw and primary information and data including the documents published by the national governments and international organizations, documents published by steel companies, and other disclosed documents. The following is the list of documents and publications to access to:

Table 5: Researched documents and publications in this study

1. Official documents published by the national governments and by international organizations	
1.1	UNFCCC (United Nations Framework Convention on Climate Change) documents
1.2	Regional governmental regulations and legislations (including the European Union Directives)
1.3	National governmental regulations and legislations
1.4	Documents published by regional and national governments concerning climate change and energy
2. Documents published by steel companies	
2.1	Annual reports
2.2	Corporate environmental and sustainability reports
2.3	Position papers on climate change policy instruments
2.4	Technical reports written and announced at workshops and conferences
2.5	Newsletters
3. Other documents	
3.1	Answers to the questionnaires collected by the Carbon Disclosure Project from 2003 to 2006
3.2	Publications and position papers published by industrial organization groups (In the case of the steel industry sector, they are IISI (International Institute on Steel and Iron), Eurofer, JISF (Japan Iron and Steel Federation) and AISI (American Iron and Steel Institute))
3.3	Publications, articles and position papers published by the non-governmental organizations (NGOs)
3.4	Publications and articles published by research institutes and consulting firms
3.5	Newspaper and media articles in the last 5 years

This thesis author referred to the research method applied in the above-mentioned study conducted by Boons et al. on the institutionalization of the environmental issues in the Dutch industry. It is noted that primary information for the analysis including 3.1, 3.3, 3.4 and 3.5 is used for this research. According to Boons et al., the primary information can be either raw data collected by another researcher or published reports in which the data are presented and analyzed by the original researcher (Boons et al., 2000). This thesis author took advantage of the information collected by previous researchers and analyzed their data from a new analytical perspective. Particularly noteworthy is the information collected by the Carbon Disclosure Project (CDP) (3.1). The CDP collects annually, the information through a questionnaire about corporate climate change strategies and programs from the firms listed on the FT 500. Its coverage includes the steel companies in the world. The information collected through the project is extremely valuable, because it is a challenging task to collect the climate change specific information from the steel companies.

In addition, this thesis author conducted company interviews with corporate mangers responsible for climate change issues among steel companies as well as officials working for industrial organization groups identified in

Table 5, and industry experts in the international organizations. Among all, companies the results of the interviews are highlighted as the information source of utmost importance. Louche categorizes three types of interviews as follows (Louche, 2004):

1) Open-ended nature, focused, or formal survey;
2) Structured, unstructured or semi-structured interviews;
3) Individual or group interviews.

According to Louche, respondents are asked, in open-ended interviews, about the facts of a matter as well as their opinions about events. In some situations, respondents may be asked about their own insights into certain occurrences. In a formal interview, the respondent is interviewed for a short period of time. It may remain open-ended, but it is more likely that the interviewer follows a set of questions derived from the case study protocol (semi-structured type). And the formal survey is a more structured type of interview (structures questions) (Louche, 2004).

This research is based upon use of the open-ended and semi-structured interview approach. While a list of questions was prepared to ask of respondents, this thesis author kept the opportunity open for the respondents to elaborate questions and provide their insights or information that are not necessarily directly relating to the questions. Initially, this thesis author considered conducting formal and structured interview. It appeared, however, after a few trials of the questionnaire that the information that can be obtained through this approach was extremely limited. It was concluded that the open-ended and semi-structure interview is the most effective approach in collecting the information that was needed for this research.

3.4 Subject area for analysis

The primary goal of this research was to find similarities and differences about corporate climate change strategy and management. In the course of research, this thesis author also investigated simultaneously, what factors in the economic, technological, and institutional dimensions contribute to formulation of the firm's responses to the climate change policy instruments.

There are two levels of subject area for analysis. Corporate strategy and management in climate change is the first level of the area for analysis. This thesis author investigated 1) how and to what extent the climate change issues were integrated into overall business strategies and management and 2) whether there are similarities and differences in the integration of the climate change issues across the regions. The following areas were examined: 1) Policy statement, 2) Organizational structure, 3) Information disclosure, 4) Measurement, 5) Accounting, 6) Product development, 7) Technological innovation, 8) Integrated chain management/life cycle assessment and 9) Partnership/membership. Before selecting the subject areas, a question was posed: what constitutes a corporate strategy and management of climate change? Section 3.5 illustrates the reasons for the selection of the subject areas.

The second level for analysis was the corporate view on specific climate change policy instruments. This thesis author attempted to highlight similarities and differences in corporate views on the Kyoto and post-Kyoto schemes. He also investigated, at this level, how the factors in the economic, technological, and institutional dimensions affected the formation of their views on the policy instruments. The policy instruments for analysis included emissions trading schemes, CDM/JI and others.

3.5 The first subject level area for analysis: climate change strategy and management

In order to determine the subject area for analysis, it is necessary to consider what constitute strategy and management of climate change. However, there is no single, standard model of strategy and management on climate change. Scholars and corporate managers have different ideas about the elements of climate change strategy and management. On the other hand, since the concept was introduced in the 1980s, there are many discussions about what constitute environmental management system (EMS). Looking into the elements of EMS is helpful for considering and determining the elements of focus in this analysis.

Boons et. al. describe how the conception of EMS was introduced in the Netherlands. According to them, the Dutch government (the Ministry of the Environment) together with VNO/NCW (The Confederation of Netherlands Industry and Employers) suggested in 1989 the following eight elements as main parts of EMS. The model including those eight elements quickly became *the* EMS to be implemented by firms in the Netherlands (Boons et al., 2000):

1) Environmental policy statement;
2) Environmental program;
3) Integration of environmental management into business activities;
4) Measurement and registration of environmental data;
5) Education and training;
6) Internal check;
7) Internal and external reporting;
8) Auditing of the EMS.

It was noticed that those are the important elements that are typically covered in corporate environmental reports. However, the categorization of some elements is too broad for this analysis. For example, there are many issues (or subject areas) under the third element titled as “integration of environmental management into business activities”. The issues such as environmental accounting, LCA and environmentally superior project development can all be included in this element. It is not very clear either where those specific issues fall into this element. They can be placed into another element. For example, LCA can be part of the fourth element titled “measurement and registration of environmental data.” It was noticed that it is important for this analysis to be more specific about the subject area to select.

This thesis author also evaluated several rating criteria that the environmental rating agencies use to investigate corporate environmental performance. Many rating agencies disclose their criteria or subject area that they use in their assessment. Although, this research is not intended to assess the firm’s performance, looking into their list of criteria can be useful for considering and choosing the subject area for this analysis. Innovest Strategic Value Advisors, for example, presents, in Table 6, the list of subject area that the company examines for the rating of company’s environmental performance (Some of the sub-areas are deleted for simplification):

Table 6: Innovest's rating model for the evaluation of company's environmental performance

1. Management Scores	
1.1	**Environmental strategy** • Policies • Integration with Core Business • Profitability Linkages • Consistency - All Operations/ International • Culture
1.2	**Corporate governance** • Board Structure • Senior Environmental Officer Level • Environmental Factor in Compensation
1.3	**Environmental management system** • Number and Qualifications of Environmental staff • ISO 14000 or other certified EMS • Environmental Performance Indicators
1.4	**Audit**
1.5	**Environmental reporting** • Environmental Reporting • Environmental Accounting
1.6	**Environmental training and development**
1.7	**Certification** • CERES • Other outside code • Voluntary EPA programs
1.8	**Products/materials** • Life cycle analysis • Suppliers - environmental screen • Eco-labels
2. Risk and improvement scores	
2.1	**Historic liabilities**
2.2	**Operating risk** • Spills and Releases • Regulatory Compliance • Toxic Emissions • Hazardous Waste • Other Operating Risk
2.3	**Sustainability risk** • Resource Use Efficiency/Recycling • Energy Efficiency • Market Risk - Including environmental sensitivities of customers • Regulatory/Legal Risk
2.4	**Industry specific factors**
3. Profit opportunity scores	
3.1	**Strategic competence** • Resource Use Efficiency/Recycling • Energy Efficiency • Market Risk - Including environmental sensitivities of customers • Regulatory/Legal Risk • Other Emissions Risk • Other Sustainability Risk – Operations
3.2	**Environmental opportunity** • Environmental Sensitivity of Geographic Regions Served • Environmental Sensitivity of Demographic Groups Served • Phase-out Risk of Products and Services • Environmental Improvement Potential • Environmental Positioning Within Sector
3.3	**Performance** • Current Environmental Businesses • Environmental Businesses Under Development

(Source, Innovest Strategic Value Advisors)

The elements identified in this list are far more broad and specific than the eight elements that constitute the EMS. For example, the list elaborates the environmental issues in corporate governance such as the Broad structure in response to the environmental issues, the level of a senior environmental officers and incorporation of environmental factor in employee compensation. In addition, Innovest's approach considers environmental risk explicitly as one of the three main areas of corporate environmental management.

In climate change, there are two studies that elaborate the elements of corporate climate change strategy and management. The CDP is one of them. The CDP collects annually the information through a questionnaire about corporate climate change strategies and programs from the firms listed on the FT 500. In 2006, using a questionnaire, the project conducted a survey to collect information from 2,180 firms worldwide.[18] The questionnaire had questions on management, measurement, product development and supply chain.

The other study is an information disclosure guideline published by the CERES on corporate climate change strategy and management titled, "Global Framework for Climate Risk Disclosure: A Statement of Investor Expectations for Comprehensive Corporate Disclosure" (CERES, 2006). While there are several other initiatives such as the Global Reporting Initiative (GRI) that established guidelines on overall corporate sustainability issues, the CERES guideline was the first attempt to establish a framework for information disclosure specifically on climate change.[19]

1) Climate Change Statement: A statement of the firm's current position on climate change, its responsibility to address climate change, and its engagement with governments and advocacy organizations to affect climate change policy.
2) Emissions Management: Explanation of all significant actions the firm is taking to minimize its climate risk and to identify opportunities. Specifically, this should include the actions the firm is taking to reduce, offset, or limit greenhouse gas emissions. Actions could include establishment of emissions reduction targets, participation in emissions trading schemes, investment in clean energy technologies, and development and design of new products. Descriptions of greenhouse gas reduction activities and mitigation projects should include estimated emission reductions and timelines.
3) Corporate Governance of Climate Change: A description of the company's corporate governance actions, including whether the Board has been engaged on climate change and the executives in charge of addressing climate risk. In addition, firms should disclose whether executive compensation is tied to meeting corporate climate objectives, and if so, a description of how they are linked.

Based on this guideline, the CERES conducted a study to evaluate firm's climate change strategies based on a checklist. The checklist contains questions about policy statement, organizational structure, information disclosure (including accounting) and measurement (Cogan, 2006, Cogan, 2003).

What constitute strategy and management of climate change? While scholars and corporate managers have different ideas about the elements of climate change strategy and management, it became clear, through the consideration of the subject area covered by the Dutch EMS model, Innovest's assessment model, CDP's

[18] The Carbon Disclosure Project publishes several reports the details of the survey. The reports are available at http://www.cdproject.net/.

[19] There is a reporting guideline on GHG emissions published by the World Business Council for Sustainable Development. The report titled "GHG Corporate Accounting and Reporting Standard" is available at http://www.ghgprotocol.org/.

questionnaire and CERE's guideline, that there are three main area in corporate environmental strategy and management. The three areas are 1) management area, 2) risk area and 3) profit opportunity and new business development area. The three areas are illustrated in Table 7.

Table 7: The three main area in corporate environmental management and strategy including management, profit opportunity/new business development

Management
• Policy statement • Organizational structure • Information disclosure • Measurement and registration • Accounting • Education and training • Auditing • Certification

Risk	Profit opportunity/new business development
• Historic liability (spills and releases) • Emissions risk • Operating risk • Regulatory/legal risk • Market risk (including environmental sensitivity of customers)	• Product development (integration of environmental factors into new product development) • Technological innovation (technological development for the improvement of environmental performance) • Integrated chain management/life cycle assessment

This thesis author placed research focus upon the management area and the profit opportunity/new business development areas. There are two reasons for this decision. The first is that the risk area is not relevant to the issue of climate change. GHG emissions are different from hazardous or toxic emissions that are directly linked to human health or immediate environmental disaster. There are no historical liability issues in climate change. More importantly, the second reason is associated with the fact that this research pays attention to a possible Stiglerian situation demonstrated in Section 2.2.2. One of this thesis author's focus was upon the technological dimensions in which the possible impacts of technological innovation on the corporate response to climate change regulations were explored. This thesis author therefore, placed a special focus on the profit opportunity and upon the new business development area. As discussed in Section 2.1.1, the investigation in this area was inspired by Porter's hypothesis which is akin to the thesis demonstrated by George Stigler for the analyzed intersection between technological innovation and environmental regulations.

From the management area, this thesis author selected the following five subject areas for analysis:

- Policy statement;
- Organizational structure;
- Information disclosure;
- Measurement;

- Accounting.

From the profit opportunity/business development area, this thesis author selected the following three subject area for analysis:

- Product development;
- Technological innovation;
- Integrated chain management/life cycle assessment.

The issues in the core management area in the list are policy statement, organizational structure, information disclosure, measurement and accounting. The issues relating to the degree of the integration of climate change issue into business activities including product development, technological innovation and integrated chain management/life cycle assessment are also examined in this research. In addition, the issue of partnership/membership is included in the list to investigate a convergent trend discussed in Section 2.3.2.2. It was contended in the section that if corporate managers share the same information among steel companies, their strategy and management might begin to resemble each other. This thesis author examined whether there is cooperation taking place to cope with climate change in the steel industry sector. The following sections describe each subject area.

3.5.1 Policy statement

According to Boons et al., the management literature recognize that in order for a firm to reach an organizational goal, corporate management shall consist of a clear policy, planning system, organizational structure, employees and control system (Boons et al., 2000). Establishing a clear policy statement is an important component in achieving an organizational goal. The CERES study as well as the CDP survey described in Section 3.5 examined numerous policy statements published by firms. The CERES study examined whether there is a statement at the chairman/CEO level about climate change. The CDP survey questioned firms about its general position on climate change as the first question in the questionnaire.

Policy statement has both internal (within the firm) and external (outside of the firm) implications in corporate strategy and management. Policy statement can internally serve as an important guiding principle for managers and employees to follow in business management and operations. Policy statement can externally serve as an expression or declaration of company's position on a specific management issue for the stakeholders surrounding a firm. The above-mentioned CERES guideline stresses the importance of policy statement for the purpose of external communications by defining it as "a statement of the firm's current position on climate change, its responsibility to address climate change, and its engagement with governments and advocacy organizations to affect climate change policy."

Policy statement is thus a good indication to see whether a firm recognizes climate change as an important management issue to handle internally and externally. If a firm has an explicit policy statement on climate change, it may be concluded that the firm recognizes climate change as an important management issue. To begin with, therefore, this thesis author examined the existence of a policy statement(s) on climate change. If a firm recognizes climate change as an important management issue to handle, it has an explicit policy statement(s) on the issue in its report. Firms typically address a policy statement in their 1) annual report, 2) corporate environmental and sustainability report and/or 3) position papers. (Their reports are identified as sources of information in 2.1, 2.2, and 2.3 in Section 3.3: Research Methodology). Investigations on the existence of a policy statement were conducted in the three categories of reports. On the other hand, technical reports (2.4) and newsletters (2.5) were excluded from the targets of the investigation, since these reports can not be considered as an official site for provision of a policy statement.

When a policy statement was found for one of the companies being studied, this author then evaluated the contents of a policy statement in the empirical study. This thesis author then attempted to extract the key message from the statements. The statements can be recognized as an expression of the firm's policy or strategy on climate change. After the empirical study, the policy statements published by the Japanese, European, the U.S. and Korean firms were addressed in a comparative fashion by evaluating their similarities and differences. Based on this comparison, this thesis author further explored whether the institutional factors are playing an important role in shaping the policy statement. In particular, the possible influence of regulatory pressure (both local and international) on the firms in forming their policy statement was investigated. As stated earlier, the author assumed that the Japanese and European firms are subject to strong regulatory pressure under the Kyoto Protocol, while the U.S. and Korean firms are free from it since both of them do not have a binding GHG emissions reduction target under the Protocol. If a sharp difference in policy statements between the Japanese/EU firms and the U.S./Korean firms is observed, it can be concluded that a regulatory pressure is playing a role in shaping the difference.

3.5.2 Organizational structure

It was observed in the management literature that establishing an organizational structure to handle a certain management issue is another important facet for a firm's process of achieving an organizational goal (Boons et al., 2000). Depending upon the established structure, one can observe how and to what degree climate change is integrated into firm's management and business operations. The results of the CERES study as well as the outcomes of the CDP survey indicate that the firms with comprehensive climate change strategy and management tend to have an executive officer(s) in place to monitor company-wide climate change initiative. There is also a tendency among such firms that their management board has direct oversight for climate change issues. With this respect, the CERES guideline requests firms to disclose information on "corporate governance actions, including whether the Board has been engaged in climate change and the executives in charge of addressing climate risk."

In the subsequent empirical study, this author investigated whether an executive officer(s) is involved among the firms analyzed. In particular, analysis was done to determine whether or not there is direct guidance or supervision from a CEO on the management of the climate change issue. When there is direct involvement, it can be concluded that the firm is likely to have a high level of awareness and commitment to the management of climate change at the highest management level. This thesis author also examined which department/committee handle climate change within the firm. When an existence of a specific department/committee coping with the issue is observable, it can be concluded that a firm has an organizational procedure to translate a management vision or strategy into operations.

In addition, this thesis author investigated whether an institutional factor is playing a role in shaping the organizational structure. As was the case with policy statement, this thesis author presumed that a regulatory pressure is placed upon the formulation of an organizational structure among the analyzed firms. The firms operating business in the Annex I countries (the countries with the GHG emissions reduction target under the Kyoto Protocol) are under the strong pressure to handle policy instruments such as emissions trading and CDM. It was presumed that a certain level of organizational structure and communications between management and business operations must be present in order for a firm to be able to handle the economic instruments. A possible existence of the regulatory pressure upon the firms in the Annex I countries lead to another presumption. There may be a clear difference in organizational structure between the Japanese/EU firms and the U.S./Korean firms. This thesis author presents the results of the comparative analysis in Chapter 10.

The main information sources for the investigation on corporate organizational structure were 1) annual report, 2) corporate environmental and sustainability report as well as the firm's answers to the questionnaires collected by the Carbon Disclosure Project from 2003 to 2006 identified as 3.1 in Section 3.3.

3.5.3 Information disclosure

Information disclosure is an important element of environmental management. As discussed in Section 3.5, the importance of information disclosure is emphasized in the Dutch EMS model, for example. It is recognized that the major pressures upon firms to disclose environmental information derive from two different sources (Gozali et al., 2002). The first source of the pressure comes from the government. From the 1980s to the 1990s, several important legislations were passed in the United States, Europe and Japan to make it mandatory for firms to disclose information on certain industrial toxic or hazardous emissions to human health. The turning point was the Bhopal accident in 1984, which took place at a local affiliate of a U.S. chemical firm, Union Carbide, in Bhopal, India that killed more than 2,400 people.(Sand, 2002). In response to this incident, the Toxic Release Inventory (TRI) was established in the United States in 1986 based on the Federal Emergency Planning and Community Right-to-Know Act requiring mandatory reporting of toxic industrial emissions. In 1996, the OECD published a guideline on the Pollution Release and Transfer Registers (PRTR) which prompted Japan to pass legislation on the disclosure of certain toxic emissions (Organization for Economic Cooperation and Development, 1996). In 2000, the European Union similarly established a mandatory European Pollutant Emission Register (EPER) on top of national inventories in several member countries (European Commission, 2000). At present, firms are required to disclose information on toxic industrial emissions in most of the developed countries.

The second source of the pressure comes from the financial community. The financial community is requesting more information from the companies on their environmental management. As early as 1992, Mastrandonas and Strife found that investors and other stakeholders are demanding more disclosure of firm's environmental information because of their concerns about the magnitude of costs and liabilities associated with the environmental issues (Gozali et al., 2002, Mastrandonas and P.T. Strife, 1992). In the United States, there is an increasing number of requests from the Securities and Exchange Commission (SEC) to the firms to disclose the existing and potential environmental liabilities (Gozali et al., 2002). Information disclosure on the environmental issues has then begun to receive stronger attention in shareholder activism. According to O'Rourke, shareholder activities are moving the rhetoric of their activism out of the realm of "ethics" or good versus bad behavior, and into that of traditional issues of profitability and shareholder value (O'Rourke, 2002).

In the area of climate change, the insurance and reinsurance companies are particularly active in requesting firms to disclose information on climate change, since they are confronted with the potential liabilities from the rising weather-related claims due to climate change. Munich Re, for example, estimates that climate change could cost $300 billion annually by 2050, through weather damage and impacts on industry and agriculture (Cortese, 2002). The objectives of the aforementioned two projects, the CDP and the CERES go along this line. They request the firms to provide the investors and shareholders with information on climate change risks and opportunities for the firms. It is important to stress, however, that the answers to the requests are not mandatory. There are no mandatory schemes for information disclosure on climate change thus far.

Under the circumstances, this thesis author investigated how and to what extent firms are voluntarily disclosing the information in the subsequent empirical study. The studies examined 1) whether a firm describes climate change initiatives in their annual report, 2) whether a firm publishes corporate environmental or sustainability reports and/or position papers on climate change and 3) whether a firm publishes technical reports on climate change. In addition, assessments were performed to determine whether the firm voluntarily discloses the information based on the request from the CDP.

When there is a higher level of information disclosure, it can be concluded that there is a certain level of willingness at the firm to communicate with internal and external stakeholders. In the case of the information disclosure to the CDP, the stakeholders are the investors and shareholders. Another group of stakeholders is the government. As presumed earlier, the Japanese and European firms may be receiving an increased regulatory pressure from the government than the U.S. and Korean firms to disclosure information on climate change. This thesis author investigated whether there is a sharp difference between these two groups of firms. Chapter 10 presents the results of the comparative analysis.

3.5.4 Measurement

As the Dutch EMS model discussed in Section 3.5 indicates, the measurement of environmental data is an important component of environmental management. It is important for firms to grasp the present status of the GHG emissions release to consider how to manage or how to reduce the emissions. Ultimately, the measurement of the emissions release becomes necessary to establish a baseline emissions and future emission reduction targets.

As stated in Section 3.5.3, it is mandatory for a firm in many countries to measure and to report toxic or hazardous emissions released through the industrial process. It is a requirement under the aforementioned programs (the TRI in the United States, the PRTR in Japan and the EPER in the EU) to measure and report the volume of the specific toxic emissions. It is also a requirement in those countries to measure and monitor a volume of air pollution emissions such as sulfur dioxide (SO_2), nitrogen oxides (NO_2) and particulates that are produced through the industrial process. At present, there is a discussion whether GHG emissions are considered to be air pollution emissions. Some contend that GHG emissions cannot be defined as air pollution emissions since they do not have direct impacts on the local environmental or human health. In most countries, therefore, it is not mandatory under the present circumstances for firms to measure the volume of GHG emissions production. In the case of the EU, however, the firms in several energy-intensive industry sectors are required to measure and monitor the volume of CO_2 emissions produced under the EU ETS.

In the absence of a mandatory emission measurement scheme, there is no standardized measurement guidance on GHG emissions. On the other hand, the World Business Council for Sustainable Development published a report titled “GHG Corporate Accounting and Reporting Standard” (World Business Council for Sustainable Development, 2005). The CERES encourages firms to measure their GHG emissions based on the guidelines that the CERES provides in the report. The CDP requests firms to report their emissions based on the guideline.

In the subsequent empirical study, this thesis author investigated how and to what extent firms are voluntarily (involuntarily, in the case of the EU) measuring the GHG emissions production. This thesis author examined 1) whether firm measures the GHG emissions produced, 2) whether the firm discloses or reports a volume of the GHG emissions production, and 3) whether firm obtains verification from a third party organization with respect to the approach and the results of the measurement. When a firm measures the volume of GHG emissions production, it can be concluded that the firm recognizes climate change as an important management issue. As is the case with the firms in the EU, this thesis author presumed that a regulatory pressure is playing an important role in encouraging a firm to measure its volume of the GHG emissions produced.

The main information sources for the investigation on the measurement of GHG emissions production were 1) annual reports, 2) corporate environmental and sustainability reports and 3) position papers on climate change policy instruments as well as the firm's answers to the questionnaires collected by the Carbon Disclosure Project from 2003 to 2006 identified as 3.1 in Section 3.3. In addition, this thesis author also looked into the technical reports presented at various workshops and conferences (2.4) as well as newsletters published by the firms (2.5).

3.5.5 Accounting

Environmental accounting has been developed since the 1980s through numerous applications of theoretical concepts to actual business practices. There were two types of information used in environmental accounting. One was physical information on the uses of energy, water and other necessary inputs to develop products. The other was monetary information such as costs and earnings realized through business operations with environmental aspects (Jasch, 2006). In environmental management, there are also two approaches that have different objectives (Jasch, 2006). Environmental management accounting (EMA) is one of them. Environmental management accounting is typically used for internal decision-making only. The other is environmental financial accounting that is commonly used as part of financial reports for external stakeholders or shareholders. While environmental financial accounting tends to contain only financial accounts, environmental management accounting tends to include non-financial accounts. Bouma et al., demonstrate that the annual accounts have an internal purpose and a primarily financial context, whereas environmental management accounting explicitly focuses on non-financial issues (such as environmental impacts) and has an internal purpose (Bouma et al., 2005).

It is noted that since the concept of EMA was introduced in the 1980s, contextual or institutional changes have influenced the design of accounting systems and the development of new techniques (Bouma and Correljé, 2003). According to Bouma and Correljé, the external pressures on firms such as societal pressures to reduce environmental impacts have induced them to develop the concept of EMA (Bouma and Correljé, 2003). Since the United Nations Conference on Environment and Development (UNCED) was held in 1992, there have been remarkable institutional pressures on firms to incorporate costs and benefits of pollution prevention into firm's business operations. The pressures are coming from both regulatory and social or societal arenas. Bouma and Correljé contend that new systems and methods of accounting systems have to be developed in order to fulfill the information demands from the introduction of new legislation (Bouma and Correljé, 2003).

This thesis author presumed that this is also the case with climate change. Since the Kyoto Protocol was ratified, there has been a growing pressure for firms to integrate climate change related costs and benefits into their accounting. There may be some differences among the firms analyzed, since the degree of the institutional pressures differs greatly among countries to which they belong. There are stronger institutional pressures in the EU and Japan since they have an emissions reduction target under the Kyoto Protocol.

In the subsequent empirical study, this thesis author first investigated whether environmental management accounting is internally utilized to calculate climate change related costs and benefits. This thesis author presumed, in the case of the EU, for example, that there would be a regulatory pressure upon the firms to introduce EMA within the firms. The increasing costs associated with the EU ETS may have been the reason for the firms to utilize

EMA. If a difference between the firms in the EU and the firms in the other regions is observed, it can be concluded that a regulatory pressure is playing an important role in the firm's decision to utilize EMA. This thesis author then examined whether environmental financial accounting is introduced as part of the financial reports being presented to external stakeholders or shareholders. The pressures from stakeholders such as the information request through the Carbon Disclosure Project (CDP) may influence upon the analyzed firms to introduce the accounting system for the external purposes. The investigation on accounting was conducted based on the same information sources identified in Section 3.5.4.

3.5.6 Product development

Integration of environmental considerations into product development is an important element of environmental management. The concept of 'sustainable product' has been developed over the last 10 years through a number of actual cases in different industry sectors. In the building sector, Green building initiatives are being taken to design and construct buildings in a more sustainable fashion. In the forestry sector, initiatives for sustainable forestry management and production are being facilitated by the Forest Stewardship Council (FSC) with a certification scheme. A common characteristic of these initiatives is the use of life cycle analysis (Boons et al., 2000, Hart, 1995). According to Boons et al., "sustainable product" can be defined as "searching for the reduction of ecological effects of economic activities with the life cycle of a product as the starting point" (Boons et al., 2000).

It is noteworthy that the development of sustainable products is often discussed as a way to increase new product sales and to develop a new market for the products. Boons et al. contend that "when a 'green' alternative is introduced by a major producer, the 'invisible hand' provides a mechanism that can force other producers to follow in the same direction" (Boons et al., 2000). Hart demonstrates BMW's strategy in automobile recycling which was eventually followed by other automobile firms at substantially higher costs (Boons et al., 2000, Hart, 1995). Another example would be the strategy taken by Toyota to develop hybrid vehicles by accepting significant market risks, in response to increasing consumer demands for higher fuel efficiency and improved environmental standards. It is concluded that these lines of argument are regarded as the "Stiglerian situation" discussed in Section 2.2.2. In the empirical study, this thesis author examined the extent to which the development of sustainable products designed to reduce GHG emissions was considered by the different firms studied for this thesis research.

3.5.7 Technological innovation

As illustrated in Section 2.2 and 3.1, this research recognizes technological innovation as one of the three independent valuables that determine strategy and management among firms. When firms have a good prospect for technological innovation, they may be willing to accept an introduction of regulatory schemes or policy instruments. When firms have limited prospect, however, they are likely to oppose to it. In Chapter 5, this thesis author investigated whether or not there are technological solutions (both short-term and long-term) to reduce GHG emissions in the steel industry sector.

On the other hand, it was presumed that there are differences among firms as to what technologies they invest in and to what extent they are active in their own technological innovation. It may appear that the differences in the focus of technological innovation are an important part of a firm's strategy and management. It is contended in Chapter 2 that technological innovation is an important element of environmental management. It is admitted, however, that technological innovation is not considered to be part of environmental management models and guidelines discussed above. It was not identified either in the Dutch EMS model or Innovest rating model. The CERES guideline only seeks anecdotal information on the investment in clean energy technologies. The CDP information request does not make it clear either whether or not/to what extent technological innovation is part of their evaluation. The focus of these models and guidelines is placed on how to manage and structure the ways to reduce GHG emissions rather than how to actually reduce their GHG emissions. In the empirical study, this thesis author presented results of assessments of similarities and differences on the technological choices among firms to reduce GHG emissions.

3.5.8 Integrated chain management/life cycle assessment

Integrated chain management is a concept in environmental management to reduce environmental impacts through supply product chain. According to Boons et al., the objective of the concept is to close the material cycles and it has attracted the interest of the chemical industry sector (Boons et al., 2000). Another concept in environmental management is life cycle assessment. The objective of the concept is to provide a tool to assess and possibly compare the ecological impact of different products. Both Integrated chain management and life cycle assessment are key concepts in the integration of environmental management into business activities of the EMS (Boons et al., 2000).

In climate change related efforts, integrated chain management and life cycle assessment are becoming part of corporate climate change strategies and management. The CERES guidelines suggest that corporations should engage in information disclosure on the issue. Kolk and Pinkse's study indicates that a majority of firms in the automobile, chemicals, metals, mining and electronics industrial sectors are taking initiatives to reduce GHG emissions through improved energy efficiency in the design of their products. Kolk and Pinkse state that this is being done based upon life cycle analyses of their major products (Kolk and Pinkse, 2004). The empirical study for this thesis examined similarities and differences among firms on their product improvement initiatives.

3.5.9 Partnership/membership

Many firms participate in business associations, they form partnerships and establish joint ventures with other firms to cope with climate change. They often establish a common strategy with other firms and implement joint measures to reduce GHG emissions. This is especially relevant since climate change is a "global common issue", the discussions and forum on the issue among firms take place in the global arena. In Section 2.3.2.2, this thesis author argued that if steel company managers share the same information among all steel companies, their strategies and management approaches would probably begin to resemble each other. This is likely to occur since the corporate managers from different firms attend the same climate change meetings and workshops and share the same information and data. This may cause a convergent trend on the corporate climate change strategies of the steel companies. The empirical study examined the similarities and differences in partnerships and other corporate organizational memberships among the firms.

3.6 The second subject level area for analysis: climate change policy instruments

The second level for analysis was to investigate corporate views on climate change policy instruments.[20] This

[20] This thesis author used the term "policy instrument" in the very broad context established by the OECD. According to the OECD, environmental policy instruments can be categorized in the following three types: The first type are regulatory instruments (e.g., emission standards, product bans), whereby public authorities mandate the environmental performance to be achieved, or the technologies to be used by firms. The second type are economic instruments (e.g., taxes, tradable permits, refund systems), whereby firms or consumers are given financial incentives to reduce environmental damage. And, the third type are voluntary instruments, (e.g., voluntary codes, eco-labeling schemes) whereby, firms make commitments to improve their environmental performance beyond what the law demands (Organization for Economic Cooperation and Development, 1999).

thesis author examined both the Kyoto and post-Kyoto policy instruments. By highlighting the similarities and differences among firms on their views on them, this thesis author attempted to provide policymakers in the UNFCCC negotiation with a basis for understanding of what schemes are likely or unlikely to be acceptable among firms. The following Kyoto policy instruments were analyzed in this study:

- Carbon tax;
- National or regional emissions trading schemes;
- Clean Development Mechanism (CDM);
- Joint Implementation (JI).

A carbon tax is a domestic policy measure and it is not directly related to the Kyoto Protocol, while the other three are explicitly mentioned and defined under the Kyoto Protocol (Some details of those measures under the Kyoto Protocol are described in Section 1.3.2). However, carbon tax has been implemented in the EU countries. As stated in Section 3.4, this research investigates this policy option and includes it in the analytical set.

With respect to the post Kyoto schemes, several different schemes were proposed in the UNFCCC negotiations, workshops and side events. The following post-Kyoto policy instruments were analyzed in this study:

- Continuation of the Kyoto scheme;
- Capping scheme based on industry-specific targets;
- Voluntary scheme based on industry-specific targets;
- Technology-specific scheme;
- Scheme to involve the non-Annex I Parties.

3.7 Selection of country coverage

The research framework is appropriate for analyzing similarities and differences among corporate climate change strategy across the world. Researchers may select firms and countries of analysis based on their interests. If they are interested in the trans-Atlantic similarities and differences in corporate climate change strategy, they can focus on the North American and European firms. If they are interested in the firms in the other Annex-I Parties in the developed regions, they may include firms in Australia, Canada, Japan, New Zealand and the United States. If they are interested in a contrast between the developing and developed regions of the Annex I Parties, they may include firms in Russia and the Eastern European countries. It is also possible to examine the firms in the non-Annex I Parties such as China and Brazil under this research framework.

For this research, this thesis author selected firms from the following countries (and a region): the EU (The Netherlands), Japan, the United States and South Korea. The following briefly describes the reasons for the selection.

3.7.1 EU firms

The member states of the EU ratified the UNFCCC between 1992 and 1995. They all ratified the Kyoto Protocol in 2002. The EU, as a whole (EU 25 countries), is responsible for 15.8% of the world's CO_2 emissions release in 2000. It is committed to reducing GHG emissions by 8% between 2008 and 2012 relative to 1990. The EU is actively involved in the climate change negotiation and is considered to be the most proactive and progressive region in conducting climate change initiatives. It introduced the cap-based emissions trading scheme (EU-ETS) in 2005 including the major energy-intensive industry sectors. At present, the national governments in the region are taking the lead in negotiation of the post-Kyoto regime.

Many EU firms are forerunners in the integration of the climate change issues into their business management and strategy. There is a mixed feeling, however, among the EU firms about the present and future GHG emissions reduction regime. While some firms are reducing GHG emissions, they are simultaneously expressing their concerns about a possible loss of their international competitiveness. They maintain that the costs associated with the EU ETS are too high. Some firms claim that an involvement of the firms in the Non-Annex I regions in the post-Kyoto period is essential to assure their continuous commitments to GHG emissions reduction.

It was found that there are sharp differences within the EU itself about the level of the integrating of the climate change issues into business management and strategy. The differences are a reflection of the economic, political, and social diversity in the region. This research pays particular attention to the economic, political and social circumstances in the Netherlands.

The investigation of EU firms addresses a case of the leading corporate climate change strategy and management in the world. Considering the level of their participation in the post-Kyoto discussion, their views on the proposed climate change policy instrument are worth observing. In addition, their present experience in the policy instruments (such as the emissions trading scheme) can be a valuable lesson for firms in the other regions.

3.7.2 Japanese firms

Japan ratified the UNFCCC in 1993. The country ratified the Kyoto Protocol in 2002. It is responsible for 5.2% of the world CO_2 emissions released in 2000. It is committed to reducing GHG emissions by 6% during the period 2008-2012 relative to 1990. Japan is another leading country in the climate change negotiations. Many Japanese firms have strong GHG emissions reduction initiatives. At present, however, Japan is lagging far behind in achieving its 6% GHG emissions reduction target under the Kyoto Protocol.

The Japanese government has not introduced any regulations hitherto to reduce GHG emissions reduction in the industry sector. The government's attempts to introduce policy instruments such as carbon tax and emissions trading scheme have been confronted with strong opposition from the industry sector. As some European firms, some Japanese firms are explicitly expressing serious considerations about possible negative impacts of the policy instruments. There are strong interests and initiatives among Japanese industry sectors to promote the project-based Kyoto mechanisms namely CDM and JI. On the other hand, there is a long-lasting tradition to cope with the environmental issues on a voluntary basis in Japan. The Japan Business Federation, namely *Nippon Keidanren*, comprising major industry sectors in the country, has established a voluntary-based GHG emissions reduction target among its member sectors.

The investigation of Japanese firms addressed another case of leading corporate climate change strategy and management. To some degree, there seems to be a convergence between European and Japanese firms with respect to climate change strategy and management. However, Japanese firms are also receiving divergent pressures from their unique local environment. As discussed in Chapter 6, for example, there are unique regulatory culture and schemes in Japan. The voluntary approach that Keidanren proposes differs greatly from the European approach.

3.7.3 U.S. firms

The U.S. ratified the UNFCCC in 1993. While it also signed the Kyoto Protocol in 1998 under the Clinton Administration, it did not ratify it under the Bush Administration. At present, it does not have any nation-wide, mandatory GHG emissions reduction targets committed under the Protocol. Considering the fact that the U.S. is the largest CO_2 emissions producer in the world, being responsible for approximately a quarter of the world CO_2 emissions release (24.4%) in 2000, its involvement in the climate change negotiations and actions to reduce their emissions are essential.

The investigation of U.S. firms has two important implications in this research. Firstly, it helped this thesis author to understand the U.S. company perspectives on the post-Kyoto policy instruments. It is essential for the policymakers in the UNFCCC negotiation to comprehend what policy instruments are likely and unlikely to be accepted among U.S. firms. Secondly, it helped this thesis author to develop empirical data to support the increasing argument that U.S. firms are lagging behind in the development of corporate climate change strategies and management. Many scholars contend that in the absence of the U.S. commitment to the Kyoto Protocol, their firms have been permitted to remain unresponsive to climate change issues and consequently they are falling behind in the development and implementation of GHG reduction strategies and technologies.

3.7.4 Korean firms

South Korea ratified the UNFCCC in 1993. The country ratified the Kyoto Protocol in 2002. It is a non-Annex I Party under the Protocol and does not have a binding obligation to reduce GHG emissions. It is expected however, that as the discussion on the post-Kyoto regime progresses, there will be increasing international and perhaps local pressures within and upon the country as well as to the firms in South Korea to accept a regulatory binding scheme of GHG emissions. After experiencing drastic economic growth, South Korea became a member of the OECD in 1996. It is becoming harder to conceive of South Korea as a developing country any longer. The perceptions and initiatives for the GHG emissions among South Korean firms are the subject of interest in considering their further commitments to future international GHG agreements.

3.7.5 Firms in the other countries

While this research focuses on the above three countries and within the EU region, there are other important countries in the climate change negotiation. Canada is an example. It ratified the Kyoto Protocol in 2002 and is committed to reduce GHG emissions by 6% between 2008 and 2012. The major concern for Canadian firms is the fact that the U.S. did not ratify the Kyoto Protocol. The Canadian firms are expressing their concern about a loss of international competitiveness against the U.S. firms (to some degree, against Mexican firms too) that are free from the commitment of the Kyoto Protocol. Considering this geo-economic uniqueness of the country, analysis of Canadian firms may present an interesting case.

Another interesting example is China which is responsible for 12.1% of the global GHG emissions. China does not have a binding emissions reduction target under the Kyoto Protocol. Examination of the perceptions and strategies of Chinese firms on climate change provides the policymakers in the UFCCC negotiation with an insight into the possible involvement of the firms in the post-Kyoto period. This thesis author was, however, concerned that the information and data of the firms from China would be too limited for detailed analyses for this thesis research. Firms in the developing countries are generally still at the early stage of the formulation of climate change strategies and management.

3.8 Selection of industry coverage

This research framework is appropriate for analyzing any industry sectors. Since this framework incorporates industry-specific issues, it does not allow the researcher to conduct cross-sectoral analyses. In addition, the methodology proposed under the framework requires extensive elaborations in three dimensions: economic, technological and institutional. The collection of information and data for empirical research in all three dimensions is a challenging task. It is therefore decided to focus on one industrial sector in this empirical analysis.

Section 3.11 illustrated that there is an ample amount of research data on the formulation of corporate climate change strategies in the oil and automotive sectors. There are also a few research initiatives in the cement and electricity generation sectors. Beside these sectors, however, no other industry sectors have received research attention. This is surprising considering the fact that other energy-intensive industry sectors such as the iron and steel, oil refineries, aluminum, chemicals and pulp and paper produce a large or larger volume of the GHG emissions. Research on the climate change strategies and management in these industry sectors would be highly valuable both for academic scholars and policymakers to better understand the possible strategic convergence among firms toward the post-Kyoto period.

3.9 Research questions

As indicated in the above sections, this research addresses the following questions:

1. What are the similarities and differences in corporate strategies and management on GHG emissions reduction among firms?

2. What are the similarities and differences in corporate perceptions and stances among firms on the climate change policy instruments including both Kyoto and post-Kyoto policy instruments?[21]

3. What are the main factors that contribute to the firm's formulation of their responses to the climate change policy instruments? Are they economic, technological or institutional factors or a combination of some of these factors?

The first two questions are policy relevant questions. This thesis author addressed these questions with to find a common strategic platform among firms towards the post-Kyoto period. The answers to these questions may provide valuable insight about whether and to what extent convergence is occurring among the steel industrial sector firms of this study with respect to their corporate climate change strategies.

This thesis author suggested in Chapter 2 that it is necessary to make a clear understanding of the meaning of the term "convergence" as used in the literature and in this thesis research. This research attempted to investigate two areas of convergence: *policy goals* and *policy styles*. Convergence of corporate strategic goals as well as management styles among firms to cope with climate change was investigated. In terms of the degree and direction of convergent forces, this thesis author examined a decrease in variation among corporate climate change strategy. This is equivalent to α-convergence, which was discussed in Section 2.3.2.3.

[21] In this thesis, this thesis author uses the word "firm" and "company" inter-changeably. However, the word "firm" is used in the theoretical context in most of the cases.

In contrast to the first two questions (that are policy-relevant), the third question is the theoretical side of research. By posing this question, this thesis author challenged the existing theoretical discussion on corporate climate change strategies. It was underscored earlier in Chapter 3 that none of the dimensions is negligible to understand how and why firms formulate their climate change strategies. Among others, this research looks into the institutional influences on the formulation of corporate climate change strategies. The case is based on Oliver's thesis presented in Chapter 2 that "the institutional influences are stronger under conditions of uncertainty, because managerial discretion is higher when the economic consequences of actions are unclear". Based on Scott's classification presented in Chapter 2, the nature of the institutional or external pressures to the firms were investigated to determine if the pressures are regulatory, normative or mimetic. This investigation led this thesis author to further consider, based on DiMaggio and Powell's thesis, - whether coercive, mimetic, or normative isomorphism is taking place and in which subject area for the anticipated corporate responses to the post Kyoto period.

Table 8 provides an overview of the subject area in this analysis:

Table 8: Subject area of analysis in this research

		EU	Japan	U.S.	South Korea
Climate change strategy/management					
	Policy statement				
	Organizational structure				
	Information disclosure				
	Measurement				
	Accounting				
	Technological innovation				
	Product development				
	Integrated chain management/life cycle assessment				
	Partnership/membership				
Kyoto policy instruments					
	Carbon tax				
	National or regional emissions trading scheme				
	Clean Development Mechanism (CDM)				
	Joint Implementation (JI)				
Post-Kyoto policy instruments					
	Continuation of the Kyoto scheme				
	Capping scheme based on industry-specific targets				
	Voluntary scheme based on industry-specific targets				
	Technology-specific scheme				
	Involvement of the non-Annex I Parties				

3.10 Research hypotheses

Section 3.9 indicated that there are three research questions in this study. The first two questions relate to the similarities and differences in corporate strategy and management and corporate perceptions towards the climate change policy instruments. The third question was designed to explore the main factors (economic, technological or institutional) that contribute to corporate formulation of their strategic responses to the climate change policy instruments. This thesis author posed the third question to examine whether the results of the empirical research match the theoretical arguments on corporate climate change strategies reviewed in Chapter 2. Through the literature review presented in Chapter 2, the research hypotheses were developed as follows:

Hypothesis 1: Firms are open systems. The pressures from the external environment influence the formulation of their corporate climate change strategies. (See Section 2.3.1).

Hypothesis 2: The local regulatory pressures and societal pressures on the firms are a divergent driver (so-called "home country effect") in shaping corporate climate change strategies (See Section 2.3.3).

Hypothesis 3: In the external environment, there are also drivers for the firms to converge their corporate climate change strategies. There can be three mechanisms leading to isomorphism including coercive, mimetic and normative (See Section 2.3.2.1).

Hypothesis 4: Economic factors are also significant in the formulation of corporate climate change strategy. When the costs of climate change policy to reduce GHG emissions are high, firms tend to oppose introduction of a policy (See Section 2.1).

Hypothesis 5: Technological factors are also significant in the formulation of corporate climate change strategy. When firms see an opportunity for the Stiglerian situation, they are willing to accept an introduction of a policy to control GHG emissions (See Section 2.2).

Hypothesis 6: Based on hypotheses 3, 4 and 5, corporate climate change strategies are formulated based upon economic, technological and institutional factors.

3.11 Other research initiatives on corporate climate change strategies

In Chapter 2, this thesis author stated that there are several climate change-focused research initiatives on corporate strategy and management. This section reviews them.

To begin with, there are several surveys among firms about their climate change initiatives and programs. The CDP is the most renowned survey among them. The project began in 2003 to collect annually the information through a questionnaire about corporate climate change strategies and programs from the firms listed on the FT 500. The company coverage has expanded since then. In 2006, the CDP sent information request to 2,180 firms worldwide. The questions were addressed in very general terms. There is no integration of industry sector specific matters in the questionnaire.

The U.S.-based non-profit organization, the CERES also conducted several studies to investigate financial risks associated with climate change in several industry sectors (Anderson and Gardiner, 2006, Cogan, 2006, Cogan, 2003). The studies highlighted some industry-specific risks and opportunities relating to climate change.

In Japan, the Development Bank of Japan (DBJ) conducted a study about climate change initiatives among Japanese firms. The study was exercised based on the data collected by the Japanese Ministry of the Environment from 2,644 firms listed in the major stock exchanges in Japan as well as 3,716 unlisted firms (Development Bank of Japan, 2003). It contains the largest survey sample of its kind. While the result of the study provides an overview of climate change strategies among Japanese firms, it fails to indicate any industry-specific issues.

There are also research initiatives to use survey results as raw data to analyze strategic similarities and differences among firms. Kolk and Pinkse used the data collected through the CDP to examine the FT 500 multinational firms (Kolk and Pinkse, 2004). Based on the data, they conducted a cluster analysis to examine the levels of an integration of climate change initiatives. They classified firm's climate change strategy into six different groups including cautious planner, emergent planner, internal explorer, vertical explorer, horizontal explorer and emissions trader (Kolk and Pinkse, 2005).

As illustrated earlier, there are several industry-specific research initiatives on corporate climate change strategy. The industry sectors with a particular research focus are oil and automobile industry sectors. Kolk, Levy and Rothenberg published several studies to highlight strategic similarities and differences between the U.S. and European firms in the sectors. Egan, Le Menestrel and Mayer also analyzed these two industry sectors. (Le Menestrel et al., 2002, Levy and Egan, 2003, Mayer, 2000). Why did the scholars pay a particular attention to those sectors? The major reason is possibly associated with the fact that both the oil and automobile firms in the U.S. had the highest political and economic stakes in climate change when the U.S. signed the Kyoto Protocol (before it decided not to ratify the Protocol). The firms in those two industrial sectors were politically active in lobbying in Washington and in formulating a coalition such as the 'Global Climate Coalition' (GCC) to protest against the Protocol. There was also a sharp trans-Atlantic contrast between the U.S. and European firms in those industry sectors about their responses to the Protocol. Since the U.S. government decision to withdraw from the Protocol, however, the level of the political activity of these industry sectors against climate change has been low in Washington. Besides the oil and automotive industry sectors, there are a few industry sectors that have become research targets in the institutional study. Nordqvist at University of Lund analyzed the cement sector (Nordqvist et al., 2002, Nordqvist, 2006). The electricity generation sector has attached some research attention but no through analysis is presented on this sector.

In Chapter 2, this thesis author stated that the industry-specific approach in climate change study was adopted in economic analysis. This is because the economic impacts of the climate change policy instruments such as the EU ETS differ greatly from one industry sector to another. As indicated, the research focus among economists is geared toward energy-intensive industry sectors including electricity generation, steel, oil refinery, pulp and paper, aluminum and others. Those are the industry sectors affected by introduction of the climate change policy instruments. In the EU, firms in those industry sectors are actively lobbying through their business association groups both in Brussels and their national capitals. They are expressing their concerns about the negative business impacts of the policy instruments. They participate in the stakeholder meetings, consult with the EU and national regulators, and announce their positions on key policy instruments. They are active in bargaining and attempting to force their views upon them.

Considering the size of the GHG emissions released from the energy-intensive industry sectors, more research attention shall be paid to them. It is also important to pay more attention to different regions of the world. Presently, research attention is only paid to European and U.S. firms. Section 3.7 described the research implications of analyzing firms in the different regions of the world.

3.12 Contributions of this research

One of the main contributions of this thesis research is the demonstration of the applicability of the research framework to future research on corporate climate change strategy. Financial economists examine acceptability of climate change policy instruments among firms from the economic perspective. Innovation economists demonstrate the roles of technological innovation in firm's responses to the policy instruments. Scholars who are looking at business management and practices investigate how firms receive influence from the external environment in formulating climate change strategy. While all of the research efforts equally aim at understanding of corporate climate change strategy, each of them tends to keep their focus on the individual dimension. The research methodology proposed here is an attempt to identify the factors of importance from all three dimensions.

The steel industry sector was selected for empirical analysis. While the steel industry sector is one of the most energy-intensive and GHG emissions producing sectors, there has been little research to analyze corporate climate change strategy of the steel industry sector. The industry sectors of research attention have been limited to the automobile and oil industry sectors. This study is therefore, the first empirical case that provides an in-depth analysis of corporate climate change strategies within the steel industry sector. It is also noted that the regional coverage of this research was limited to the U.S. and Europe. Consequently, this thesis research is one of the first efforts to also include Japanese and Korean firms in the analysis.

The ultimate goal of this research was to find a common strategic platform among firms to cope with global climate change. This research addressed several question including whether and to what extent strategic convergence has occurred among firms as they approach the post Kyoto period. It is this thesis author's hope that the results of this research will be useful input for policymakers in the design of the post Kyoto regime.

3.13 Limitations of this research

There are several limitations in the empirical part of this study. The details of the limitations include:

- This study was conducted based on the information gathered before February 2007. Some of the information that became available after March 2007 is not incorporated in this study.
- This study does not consider changes in corporate climate change strategy after the mergers among major steel companies. At present, there are two major mergers in the steel industry sector. In June 2006, the merger between Mittal Steel and Arcelor took place. As of February 2007, the merger between the Corus Group and the Tata Group was under way. The analysis of the Arcelor and Corus Groups was conducted based on the information provided before the mergers. It is acknowledged that there may be significant changes in corporate climate change strategy after the mergers.
- As indicated in the following chapters, this thesis author only mainly studied two steel companies in the EU region: Arcelor and Corus Group. There are many differences among European steel companies as to their business strategy and management, business models, cost structures and quantity and quality of produced steel as well as their corporate strategy on climate change. In particular, there may be distinct differences between the northern and southern EU steel producers. It is noted that the analysis of the two steel producers headquartered in the northern Europe may

not be applicable to the steel companies in southern Europe. Focusing on the two steel companies may thus have led to an inadequacy in addressing the differences and diversities among steel companies in the EU.

- There are significant differences in the level of sophistication of analysis among countries (or regions). This thesis author was able to conduct thorough analyses of European and Japanese steel companies since there was ample information and data on their corporate climate change strategy. However, it was not possible to perform the same level of analysis for the U.S. and Korean steel companies. This is mainly due to the fact that availability of the information and data on this subject in the U.S. and South Korea is extremely limited. In light of this, it is considered that the results of the analyses of Japanese and European steel companies are the main part of the empirical study for this thesis, while the analyses of data of the U.S. and Korean steel companies are preliminary and exploratory.
- This study did not consider firm-specific issues. It recognizes, however, that firm-specific issues can often play an important role in the formulation of corporate climate change strategy. It is not deniable that the differences in corporate history and culture can contribute their divergent views on climate change issues among firms. The exclusion of individual company's history and culture from this analysis may lead to failure in capturing important firm-specific factors in corporate climate change strategy.
- This study assumes that firm's corporate climate change strategy is consistent within the firm and across firm's operations. However, this assumption is not the case in reality. For example, the views among business operations such as finance, marketing and procurement may vary greatly within a firm. Their views may be different from the environmental department. In addition, firms with international operations tend to have diverse strategies depending upon a location of the business units. In the case of the steel company, Corus Group, for example, has different strategies between their UK and Dutch operations. Arcelor is another case where its strategies are different among its Belgium, French, and Spanish operations. Their strategies among the countries may be different from its headquarters in Luxemburg.
- It is acknowledged that it is impossible to remove the subjectivity with the research methods illustrated in Section 3.3. While highlighting company interviewing as the information source of utmost importance, the number of interviews is limited. In addition, the interviews were conducted based on the open-ended and semi-structured interview approach. In this approach, while the thesis author prepared a list of questions to ask of respondents, he kept the opportunity open for the respondents to elaborate further questions and to provide their insights or information that are not necessarily directly related to the original questions. It was concluded that the open-ended and semi-structure interview is the most effective approaches in collecting the information on this topic.

Summary of Chapter 3

Chapter 3 presented the research framework for the empirical research used for this thesis. Based on the framework, it was feasible for this to consider three dimensions simultaneously (economic, technological and institutional) and to identify the factors of importance in the formulation of corporate climate change strategy (Research question 3). In addition, this chapter identified two levels of subject areas for analysis. Corporate strategy and management in climate change is the first level. The following empirical study investigated similarities and differences about corporate climate change strategy and management (Research question 1). The second level is corporate views on specific climate change policy instruments. The empirical study also examined similarities and differences in corporate views on the Kyoto and post-Kyoto schemes (Research question 2).

Chapter 4 presents an introduction to the empirical part of this research. This chapter presents an overview of the steel industry sector. The chapter described 1) market trends, 2) international trade trends, 3) production process, 4) GHG emissions sources and 5) cost structure of the steel industry sector. The thesis author paid a particular attention to the economic and technological features of the steel industry sector.

Chapter 4: Empirical research: An overview of the steel industry sector

Introduction

Based on the research framework presented in Chapter 3, this thesis author conducted empirical research on the steel industry sector. This chapter presents an overview of the global steel industry sector. It describes 1) market trends, 2) international trade trends, 3) production process, 4) GHG emissions sources and 5) cost structure of the steel industry sector. He gave particular attention to both economic and technological features of the steel industry sector.

4.1 Market trends

The steel industry has been considered a key industry among the industrialized countries. Steel is used as the essential material in many major industry sectors including automobile, construction and engineering. The financial outlook of the steel industry heavily depends upon the level of demand from those industry sectors. It follows overall cyclical economic prosperity among industrialized countries.

Because of its economic and militaristic importance, the industry has been subject to government interventions in the past. The interventions have taken different forms in history. In 2002, the Bush administration placed the import tariff upon the foreign steel products, which resulted in considerable damage among European and other foreign steel producers. Although the tariff was withdrawn by the administration, the debate on the local subsidy is continuing at the WTO. Another case of government intervention can be found in the process of the merger between Arcelor and Mittal in 2006. The French as well as the Spanish and Luxemburg governments made an official announcement to oppose the merger because of possible negative impacts on the national economies.[22]

There are two important characteristics of the steel market to note here. First, the steel market is a global market. Steel is traded in the international market. Some other industrial commodities such as cement and pulp and paper are mostly traded in the local market mainly because the transportation cost is too high for the revenue earned from the sales of these commodities. Second, the steel market is a highly fragmented market. Despite a number of mergers resulting in companies such as ThyssenKrupp, Corus and Arcelor, the top ten steel producers only account for 25-30% of the global steel production (Innovest Strategic Value Advisors, 2005). This is sharply contrasted to other industry sectors such as the aluminum sector where several major companies dominate the majority of the market. The steel market is highly competitive because there are many competitors in the single global market. On the other hand, the trend for the cross-boundary consolidations among the steel companies is accelerating lately. The merger between Arcelor and Mittal that took place in June 2006 is still fresh in our memory. There are also many other joint venture operations taking place across the world.

Many steel experts indicate that Chinese steel production and consumption is the largest factor that determines the present and future trends of the global steel market. China is the world’s largest single steel producer and consumer, accounting for almost 25 percent of the world’s crude steel output and even more of the total finished steel consumption in 2003 (Reinaud, 2005). Because of the size, the development in the Chinese steel market is a source of great concerns among steel companies outside of China. For example, as Chinese steel companies are presently buying more raw materials (iron ore and coal), the short supply of the raw materials are resulting in a high record of the raw material prices (Reinaud, 2005). The increasing price of the raw materials is causing considerable business impacts among steel companies, especially when the oil price and transportation costs are

[22] Arcelor and Mittal Steel agreed to merge in June 2006. See Chapter 7 for the details.

rising simultaneously. Furthermore, it is concerned that after the Chinese steel production meets the local demand for the Beijing Olympics in 2008 or for the World Exposition in Shanghai by 2010 at the latest their exports may begin to swamp the international steel market.

Table 9 is the ranking of steel production by country:

Table 9 National ranking of steel production in 2003 and 2004 (mmt: million metric tons)

Country	2004		2003	
	Ranking	mmt	Ranking	mmt
China	1	275.5	1	222.4
Japan	2	112.7	2	110.5
United States	3	98.9	3	93.7
Russia	4	65.6	4	61.5
South Korea	5	47.5	5	46.3
Germany	6	46.4	6	44.8
Ukraine	7	38.7	8	36.9
Brazil	8	32.9	9	31.1
India	9	32.6	8	31.8
Italy	10	28.4	10	26.8
France	11	20.8	11	19.8
Turkey	12	20.5	13	18.3

(Source: International Iron and Steel Institute, 2005)

As the table indicates, China, Japan and the United States are the leading steel producing countries. In 2004, crude steel production passed the 1 billion ton mark representing an increase of 84 million tons from the 2003 level. The global steel consumption increased by 8.8% in 2004. This is due to the strong demand from the Chinese market. The strongest increase in consumption was North America (15%), China (11%) and former Soviet Union nations (13.5%). Steel demand is expected to grow by 5% driven by the continued growth in China (International Iron and Steel Institute, 2005).

Table 10 shows crude steel production by process among countries. As explained in the later section in detail, there are two dominant processes in the steel production. One process is called basic oxygen furnace (BOF). The BOF produces steel from raw materials including iron ore, coke and limestone. The other process is called electric arc furnace (EAF). The EAF produces steel from recycled scrap steel. Those processes account for more than 90% of the world’s steel production. There are other processes such as the open hearth furnace (OHF). As seen in Table 10, this process is only exercised in the CIS countries.

Table 10: Crude steel production by process

	BOF (%)	EAF (%)	Open Hearth (%)	Total (million tons)
Europe				
France	61.4	38.6	0	20.8
Germany	69.3	30.7	0	46.4
The Netherlands	98.0	2.0	0	6.8
United Kingdom	77.5	22.5	0	13.8
CIS				
Russia	61.6	16.3	22.1	65.6
Ukraine	49.8	6.8	43.4	38.7
North America				
Canada	58.6	41.4	0	16.3
Mexico	28.5	71.5	0	16.7
United States	46.4	53.6	0	98.9
South America				
Brazil	76.8	23.2	0	32.9
Asia				
China	81.6	18.4	0	272.5
Japan	73.6	26.4	0	112.7
South Korea	56.1	43.9	0	47.5

(Source: International Iron and Steel Institute, 2005)

Table 10 reveals that the BOF process is prevailing against the EAF process. This is partly because steel scrap necessary for the EAF process is very limited nowadays. In addition, it is extremely difficult to produce high quality steel or specialty products through the EAF process because there is a limiting process to control chemical composition. The exception where the EAF process is dominant is the U.S. There are more the EAF steel producers than the BOF steel producers in the United States. In the United States, more steel are produced through the EAF process than the BOF process.

Table 11 shows the company ranking of steel production. The companies located in the countries that have GHG emissions reduction target under the Kyoto Protocol are highlighted with color. It is noticeable that there are several steel companies that are outside of the Kyoto target:

Table 11: Company ranking of steel production in 2003 and 2004 (mmt: million metric tons)

2004		2003		Company	Country
Ranking	mmt	Ranking	mmt		
1	46.9	1	42.8	Arcelor	EU (Luxembourg)
2	42.8	2	35.3	Mittal Steel	EU (UK/The Netherlands)
3	32.4	3	31.3	Nippon Steel	Japan
4	31.6	4	30.2	JFE	Japan
5	30.2	5	28.9	POSCO	South Korea
6	21.4	6	19.9	Shanghai Baosteel	China
7	20.8	8	17.9	US Steel	US
8	19.0	7	19.1	Corus Group	EU (UK/The Netherlands)
9	17.9	10	15.8	Nucor	US
10	17.6	9	16.1	ThyssenKrupp	EU (Germany)
11	16.7	11	15.7	Riva Acciao	EU (Italy)
12	16.1	18	10.6	ISG	US
13	14.6	14	12.3	Gerdau	US
14	13.0	12	12.8	Sumitomo	Japan

(Source: International Iron and Steel Institute, 2005)

It is noted that the merger of Arcelor and Mittal Steel, the top 1 and 2 steel companies, forms a giant steel company, which may bring power to influence the iron ore and coal markets. The ranking is followed by the two Japanese producers, Nippon Steel and JFE and the Korean producer, POSCO. The large EU steel producers in the ranking include Arcelor/Mittal Steel, Corus Group, ThyssenKrupp and Riva Acciao. It may be surprising that there is only one Chinese company in this ranking, while China is the single largest steel producing country. This attributes to the fact that there are many small-scale steel mills in China, most of which are considered economically inefficient and environmentally damaging. The Chinese government is encouraging market consolidation among the small steel producers by shutting outmoded steel mills and consolidating them into new large integrated steel mills.

4.2 International trade

4.2.1 Trading of steel products

In order to understand the steel market situation of each country or region, it is also necessary to examine the trade data. As stated above, the steel market is a global market. How much countries are importing or exporting steel directly relates to the issue of international competitiveness of steel companies. Table 12 and Table 13 show the country rankings of steel exports and imports respectively.

Table 12[23]: Country ranking of steel exports in 2003 (mmt: million metric tons)

Ranking	Country	Net exports (mmt)
1	Japan	30.5
2	Russia	28.9
3	Ukraine	25.7
4	Brazil	12.4
5	Belgium-Luxembourg	7.6
6	Germany	6.6
7	EU (15)	5.4
8	South Africa	4.8
9	India	4.1
10	Kazakhstan	3.0
11	Slovakia	3.0
12	Turkey	2.9
13	France	2.7
14	Austria	2.6
15	Venezuela	2.5

(Source: International Iron and Steel Institute, 2005)

[23] The data for individual European countries includes steel exports within the EU countries. The data for EU (15) excludes the trade among the EU countries.

Table 13[24]: Country ranking of steel imports in 2003 (mmt: million metric tons)

Ranking	Country	Net imports (mmt)
1	China	34.7
2	United States	13.8
3	Taiwan, China	11.1
4	Thailand	7.6
5	Iran	6.8
6	Italy	6.1
7	Spain	5.7
8	Vietnam	4.5
9	Hong Kong	4.0
10	United Arab Emirates	3.3
11	Philippines	2.5
12	Portugal	2.5
13	Indonesia	2.5
14	Singapore	2.3
15	Saudi Arabia	2.0

(Source: International Iron and Steel Institute, 2005)

The export data indicate that Japan is the largest steel exporting country. Since Japanese economic growth reached its peak in the late 1980s, the local demand for steel has been stabilized and the country has begun to export steel abroad. Japan is now specialized in exporting high quality steel designed for the automobile industry sector. It is also noteworthy that the former Soviet Union countries including Russia and Ukraine are also major exporting countries. This relates to the fact that while the Communist regimes prioritized the steel industry sector until the 1990s to encourage heavy industry in the region. The steel companies in the region produced a large volume of steel for government procurement. After the regimes collapsed, however, the local demand for steel became weaker because of economic depression, while the level of steel production has remained the same. Russia and Ukraine are now providing surplus steel to the international market.

The import data shows that China was the largest steel importing country in 2003. As mentioned earlier, the Chinese demand is the growth engine of the global steel market. While China is the single largest producing country, the local steel demand for construction and infrastructure buildings greatly exceeds the production level and importing steel is necessary for China to meet the local demand. The strong trend of Chinese steel imports also relates to the fact that there are Chinese steel companies that have a limited capability of producing high quality flat steel for the essential industries such as automobiles, machinery and precision engineering. However, China is presently increasing its steel production capacity as well as its capability to produce high quality steel. Many steel experts predict that China will become an exporting country around 2010.

---

[24] The data for individual European countries includes steel imports within the EU countries. The data for EU (15) excludes trade among the EU countries.

The United States is the second largest steel importing country. During the 1990s, the US steel industry experienced a series of bankruptcies due to the loss of market share and higher labor costs, which led to labor union pressure for protective tariffs, which were eventually imposed by the Bush Administration in 2002. On the other hand, the U.S. economy has grown since the 90s with a higher demand for infrastructure building and construction. Now, a quarter of the U.S. steel demand is met by imports.

There are many developing countries in Asia including Taiwan, Thailand, Vietnam, Philippines, Indonesia and Singapore importing steel. The trend for importing steel coincides with their economic growth in this region.

Looking at both export and import data, there are two more interesting observations to make. Firstly, South Korea is not in either of the rankings, while the country is the 5th largest steel producing country. This is associated with the fact that there is a strong local steel demand, as the country's economy is still growing rapidly. On the other hand, the Korean steel company, POSCO has a capability to produce high quality steel. The volume of steel to export may increase greatly in the near future. Secondly, there are not many European countries such as the UK and the Netherlands on either of the rankings. The countries such as Belgium, Germany and France are in the export ranking but the volumes of steel export remain minor. This is relating to the fact that the majority of steel production is geared toward local consumption in the EU.

Table 14 shows the steel trade flow among regions and countries.

Table 14[25]: Trade flow of steel by area in 2003 (million metric tons)

Exporting regions ► / Importing regions ▼	European Union (15)	Other Europe	Former USSR	North America	Latin America	Africa and Middle East	China	Japan	Other Asia	Oceania	Total imports	Extra-regional imports
European Union (15)	**77.9**	15.1	5.7	0.8	2.2	1.9	0.6	0.3	0.8	0.1	105.4	27.5
Other Europe	13.5	**5.9**	7.5	0.0	0.1	0.1	0.0	0.2	0.2	0.0	27.5	21.6
Former USSR	0.8	0.3	**6.4**	0.1	0.0	0.0	0.0	0.2	0.4	0.0	8.2	1.8
North America	4.3	1.9	0.5	**8.9**	7.1	0.7	0.9	1.2	2.1	0.4	28.0	19.1
Latin America	1.6	0.3	0.7	1.9	**5.5**	0.2	0.1	1.0	0.4	0.0	11.7	6.2
Africa	2.8	1.4	4.7	0.1	0.3	**2.3**	0.2	0.4	0.2	0.0	12.4	10.1
Middle East	3.2	4.3	9.5	0.1	0.1	**1.3**	0.4	1.0	1.1	0.0	21.0	19.7
China	2.7	1.9	13.6	0.8	3.4	1.0	-	6.4	13.4	0.0	43.2	43.2
Japan	0.1	0.0	0.0	0.0	0.0	0.0	0.3	-	2.6	0.0	3.0	3.0
Other Asia	3.7	1.4	14.0	0.5	6.1	2.8	5.4	22.3	**9.5**	0.2	65.9	56.4
Oceania	0.2	0.0	0.0	0.0	0.0	0.1	0.2	0.7	0.8	**0.3**	2.3	2.0
Total exports	110.8	32.5	62.6	13.2	24.8	10.4	8.1	33.7	31.5	1.0	328.6	210.6
Extra-regional exports	32.9	26.6	56.2	4.3	19.3	6.8	8.1	33.7	22.0	0.7	210.6	
Net exports	5.4	5.0	54.4	-14.8	13.1	-23.0	-35.1	30.7	-34.4	-1.3		

(Source: International Iron and Steel Institute, 2005)

Further observations are drawn from this table. Firstly, the volume of steel that the EU traded within the region reached 77.9 million metric tons in 2003. This data confirms that the majority of the produced steel in the EU is consumed in the region. On the other hand, there is some level of trade between the EU and non-EU countries in Europe. The EU countries exported 13.5 million metric tons of steel to the non-EU countries, while the non-EU countries exported 15.1 million metric tons of steel to the EU countries in 2003. Secondly, it appears now that Russia and Ukraine (categorized as former USSR in the above table) export steel to China and other developing countries in Asia. This indicates surplus steel in Russia and Ukraine are satisfying the shortage in the Asian countries as their economies grow. Thirdly, the majority of Japanese steel also flows into China and other countries

[25] The volumes of the intra-regional trade are in bold. Extra-regional exports equal total exports minus intra-regional trade. Net exports are exports minus imports.

in Asia. According to Table 13, Japan exported 6.4 and 22.3 million metric tons of steel to China and other Asian countries in 2003 respectively. It appears from these data that the Asian region is of strategic importance for Japanese steel companies to export. Fourthly, the “other Asia” exported 22.3 million metric tons of steel to China in 2003. The “other Asia” includes South Korea. Since there are no other Asian countries with a capability to produce exportable steel, it is assumed that South Korea is responsible for the majority part of the export.

It is of a great importance to examine the trade data in the contexts of international competitiveness. As indicated earlier, the steel market is a global market. When there is a factor to increase their production cost and possibly raise the price, companies are to consider possible impacts on their sales in the market. When there is an additional cost for steel companies, companies are subject to a choice whether or not they can absorb the cost or pass through the cost to customers by increase the price of steel that they supply to the international market. While the former decision may result in a loss of revenue, the latter decision may result in a failure of offering competitive price to the customers in the market. It is important to note that there are no single steel companies with monopolistic power in the market to control the steel price. The steel market is highly fragmented where the share of the top ten steel companies remains 25-30% of the entire market unlike other industry sectors.

The Kyoto Protocol may become an additional cost for the steel companies in the Annex I countries. The policy instruments introduced by the government such as carbon tax and emission trading may lead to substantial costs for the companies to comply with the emission reduction target under the schemes. For example, as explained in the later section, the production of one ton of steel leads to 1.6 tons of CO_2 emissions on average at a modern integrated steel mill. When a company needs to purchase CO_2 emission allowance from the emission trading market, it costs US$ 40 when the emission allowance is traded at US$ 25 per ton of CO_2 (US$25X1.6 tons of CO_2). On the other hand, hot-rolled coil steel was traded in the EU in the range of US$ 400-650 per ton of steel in 2004 (International Iron and Steel Institute, 2005). The cost to purchase the emission allowances reaches in the range of 6-10% (US$ 40/US$ 400 and US$ 40/US $650). The option to reduce CO_2 emissions at their steel mill possibly by improving energy efficiency or utilizing renewable energy requires investments on the larger scale.

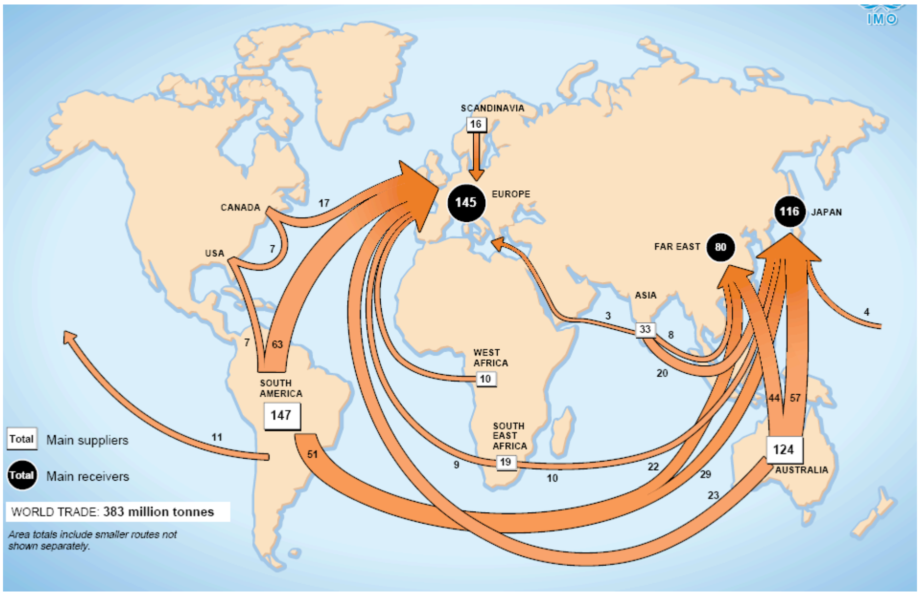
From this author’s standpoint, there are three possible scenarios where the GHG policy instruments become an international competitiveness issue. The first scenario is where an Annex I country imports steel from a non-Annex I country. When the production cost of steel in an Annex I country increases due to a regulatory scheme under the Kyoto Protocol and local steel companies have no options but to increase the steel price, they may lose a competition against the cheaper imported steel in the market. This may result in loss of the market share of the local steel companies. This may lead to loss of employment at the local steel mills due to the decreased steel production and negative impacts on the overall economy. The second scenario is where an Annex I country exports steel to a non-Annex I country. The customers in a non-Annex I country may no longer buy steel from a steel company in an Annex I country due to the increased price of steel. This may result in a decreased volume of steel exports for the steel companies in an Annex I country. The third scenario is where there is a competition between steel companies from an Annex I country and from a non-Annex I country in the third country. The customers in the third country may shift their purchase to steel company from a non-Annex I country because of more attractive price that it may offer.

The subsequent empirical study investigated how the steel companies in the Annex I countries consider the possible economic impacts of the policy instruments under the Kyoto and post-Kyoto regimes. This thesis author’s hypothesis is that the steel companies, with a high reliance upon exportation of steel, consider the economic impacts seriously. The steel companies with low exporting volume may still be concerned about the competition against the cheaper steel coming to the local market.

4.2.2 Trading of raw materials

Almost all of the steel companies that were analyzed in the study import raw materials from abroad. As explained in detail in Section 4.3, the two main raw materials in the steel production are iron ore and coke. Figure 9 shows data of the trade flows of iron ore. Although the data on the graph are not updated, they are appropriate to grasp the general trade flows.

Figure 9: Trading of iron ore (mmt: million metric tons)

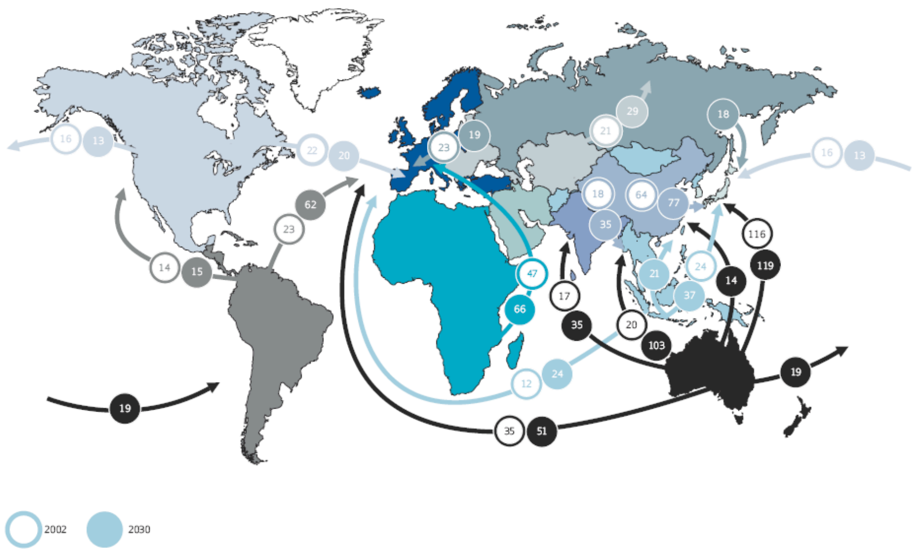


(Source: United Nations Atlas of the Oceans, 1994)

As seen in this graph, the major exporting regions of iron ore are Australia and South America (especially, Brazil). The steel companies in the EU, Japan, China and other countries are purchasing coal from these regions. Since no steel companies have monopolistic power to control the price of iron ore, they are vulnerable to price increases of iron ore.

The following graph shows the trade flows of coal. The integrated still plants typically import coal by ship and process it at a coke production plant located on the same site.

Figure 10: Trading of coal (mmt: million metric tons)



(Source: International Energy Agency, 2004)

As seen in Figure 10, Australia is the world's largest coal exporter. In 2003, the country exported 207 Mt of coal out of its total production of 274 Mt. Three quarters of Australia's exports go to the Asian market (International Energy Agency, 2004).

4.3 Production process

4.3.1 Overview of steel-making process

There are two dominant processes in the steel production. One process is called basic oxygen furnace (BOF) or the “primary route”. The other process is called electric arc furnace (EAF) or the “secondary” route. Those processes account for more than 90% of the world’s steel production. There are other steel-making processes such as the OHF. Steel experts, however, expect that the OHF will be phased out in the near future due to the outmoded technology and process. Some new processes were also introduced recently including the Corex and CCF (Cyclone Converter Furnace). Due to the small size of their market share, however, those processes were not examined in this research.

The BOF and EAF processes are considered completely separate steel making processes because of the differences in required material and energy inputs, economic and technological scales of production process, and quantity and quality of final outputs. The volumes of the GHG emissions produced through each process also vary significantly. Those two processes shall be discussed separately.

The BOF route produces steel from raw materials including iron ore, coke and limestone. The production of 1 ton of steel generally requires 1.5 tons of iron ore, 0.4 tons of coke and 0.2 tons of limestone (Nippon Steel Corporation, 2005b). The integrated BOF process is very capital intensive. The economic scale of investment and plant operation is very high. In the industrialized countries, the plant is located near a large port or railway facility to transport a large size of the raw materials into the plant and ship the final products out of the plant. An access to large water resources is necessary since the process consumes a large volume of water. Vertical integration is, with few exceptions, the rule. Many BOF producers control an important part of the raw material production chain and most of them integrate downstream including the initial transformation and distribution of the products (Reinaud, 2005).

The steel produced through the integrated BOF process is an important and often the key material in many manufacturing sectors. It is noteworthy that the integrated BOF steel-making frequently has policy and sometimes even political implications in many countries. Governments are historically involved in the steel-making decisions. In many cases, governments provide orientation and guidance (sometimes in the form of subsidies) on many aspects of the steel-making so that the steel production goes in line with country’s industrial policy. The areas of the government’s influence range from technology innovation to the volume of steel production.

Although the integrated BOF process consumes more energy than the EAF process, it produces higher quality products such as flat products for automobiles, machinery and precision engineering. As the consumer products are further specialized in many manufacturing sectors nowadays, the demand for the high quality steel has been increasing greatly. The lightweight high performance vehicle is an example of such products. With the present technology, the EAF process is not capable of producing steel at the similar level of quality and quantity.

The EAF process produces steel from recycled scrap steel. The plants producing steel through the EAF process are often called mini-mills. The EAF process involves melting scrap, removing impurities and casting it into desired shapes. The EAF melt the scrap in the presence of electric energy and oxygen. The process does not require the energy and capital-intensive production steps that are needed to produce steel from ore through the integrated BOF process. The capital cost of the EAF can be as low as half of the cost of the BOF per ton of steel (Crampton, 2001). On the other hand, the EAF process consumes a large amount of electricity since electricity is the main source of energy to melt scrap steel.

The main advantage of the EAF process is its ability to produce less expensive steel on a smaller scale (North Carolina Department of Environment and Natural Resources, 2005). The EAF plants or mini-mills can be located near the end-user markets. They can flexibly adjust the steel production rate depending upon the demand of the end-users. The EAF plants can even design specific products to meet individual requests.

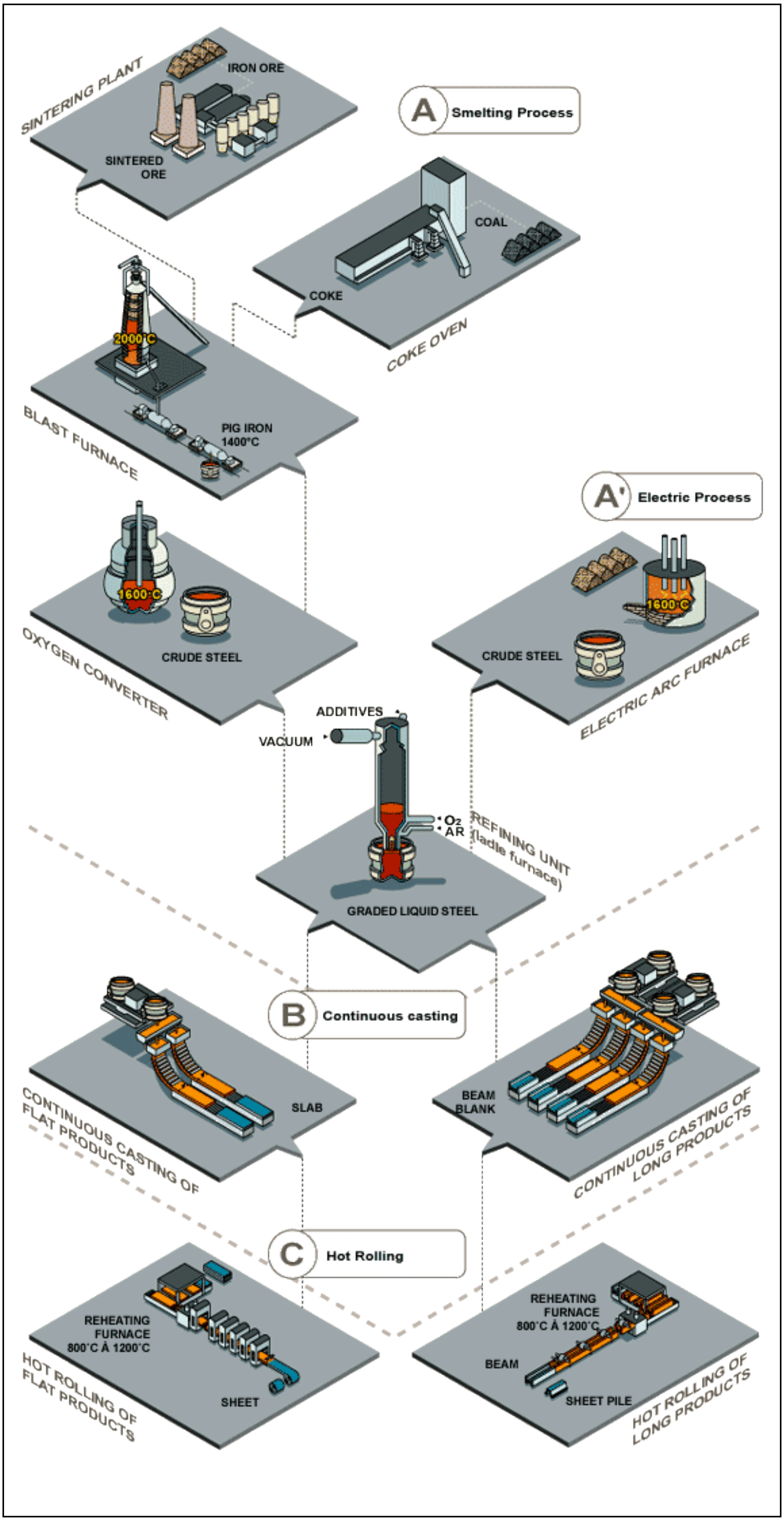
It is impossible, however, to replace the integrated BOF process with the EAF process in the steel industry. Since there is a limit in the EAF process to control chemical composition, the EAF plants cannot produce consistently high quality steel or specialty products demanded by consumers. In addition, an availability of steel scrap is very limited nowadays. Many steel companies claim that the general perception of an abundance of steel scrap is no longer true.[26] While the recent advances in casting technology make it possible for the EAF producers to expand their product range into high quality steel, the limitation to control chemical composition is hardly possible for them to overcome. The market demands steel from virgin materials. It is not surprising for that the BOF is the dominant steel-making route until now.

4.3.2 BOF steel-making process

The following graph illustrates the BOF steel-making route (This graph was drawn from Arcelor's website. See the footnote for the detail of the source).[27] It is necessary to review several essential processes in some detail to discuss GHG emissions through the route. Section 4.3.2.1 to Section 4.3.2.5 explains some details of each process in the route including coke production (Section 4.3.2.1), sinter production (Section 4.3.2.2), blast furnace (Section 4.3.2.3), oxygen converter (Section 4.3.2.4) and continuous casting (Section 4.3.2.5).

[26] This is because steel scrap is indeed a valuable commodity that is traded in the international market. Many industry sectors use steel scrap as inputs to their manufacturing processes. There is a high demand for steel scrap in the market. Because of the high price, a steel company has a limited amount of steel scrap that it can purchase from the market.

[27] The image also includes the EAF route. The EAF process is identical to the BOF process in the refining and product shaping processes. This image is a property of Arcelor and drawn from its website at www.arcelor.com.



A Smelting Process
SINTERING PLANT
IRON ORE
SINTERED ORE
COAL
COKE
COKE OVEN
2000°C
BLAST FURNACE
PIG IRON 1400°C
A' Electric Process
1600°C
OXYGEN CONVERTER
CRUDE STEEL
1600°C
CRUDE STEEL
ELECTRIC ARC FURNACE
ADDITIVES
VACUUM
O2
AR
REFINING UNIT (ladle furnace)
GRADED LIQUID STEEL
B Continuous casting
SLAB
CONTINUOUS CASTING OF FLAT PRODUCTS
BEAM BLANK
CONTINUOUS CASTING OF LONG PRODUCTS
C Hot Rolling
REHEATING FURNACE 800°C Á 1200°C
SHEET
HOT ROLLING OF FLAT PRODUCTS
REHEATING FURNACE 800°C Á 1200°C
BEAM
SHEET PILE
HOT ROLLING OF LONG PRODUCTS

4.3.2.1 Coke production

Coke is used in the BOF route for two purposes. First, it is used as fuel to burn raw materials in the blast furnace. Second, it is used as one of the raw materials in the blast furnace. When coke is fed into blast furnace as a raw material, it functions as a chemical reducer to remove oxygen from iron ore. Iron is present in iron ore in the oxidized form. In order to produce pig iron, oxygen needs to be removed from iron ore. Iron ore is mixed with coke and heated to the melting point of ore to remove oxygen in the blast furnace.

Coke is produced in a coke battery where coal is transformed into coke through the heating process. Coal is fed into a coke battery, sealed and heated at very high temperature for carbonization for 14-36 hours. As discussed below, a substantial amount of CO_2 emissions is produced through this process.

Coke batteries are typically located in the same area of an integrate BOF steel plant in order to transport coke to the BOF plant conveniently. In some cases, however, they are located in a remote coal mining area.[28] Those cases are not uncommon especially in the coal-rich countries such as China, Ukraine and Poland.

The coke making process generates a large volume of coke oven gas. The major component of coke oven gas is hydrogen (approximately 50%). Modern integrated BOF plants typically utilize coke oven gas as fuel gas for steel-making and/or power generation. The electricity is used in the different steel-making processes.[29] Coke oven gas is also used as a fuel gas to be used in different steel-making processes. To illustrate the scale of the gas, a coke oven plant located in the largest integrated BOF steel compound in Japan produces 2 million m^3 of coke oven gas per hour. The volume of the gas is sufficient for 1,000MW power generation. If coke oven gas, together with blast furnace (discussed in Section 4.4.1) is fully utilized, the electricity generated from the gases can cover a large portion of the electricity requirement in an integrated BOF plant. The utilization of the gases can substantially reduce purchase of electricity from a local utility company.

4.3.2.2 Sinter production

Sintering is a process to prepare iron ore for the subsequent blast furnace process. The material prepared for blast furnace through the sintering process is called sinter. The process involves heating of fine ore to aggregate into large grains.

In the natural environment, ore exists either as lump ore or fine ore. Fine ore is not suitable for the blast furnace process since it would prevent a flow of reducing gas from coke to flow up through the furnace. However, fine ore is cheaper than lump ore. This results from the fact that lump ore has a wider applicability in various industrial sectors and the demand for lump ore is higher. The performance of fine ore as a feeding material into the blast furnace is, however, greatly improved by being aggregated into grains. In fact, the aggregated fine ore becomes more suitable than lump ore for the blast furnace. Fine ore, for those reasons, tends to be used more than lump ore in the integrated steel-making route.

---

[28] In the case of Japan, there are two independent coke producing plants (Mitsui and Mitsubishi) that account for 12% of the country's coking capacity. See Gielen, D. J. & Moriguchi, Y. (2002) CO_2 in the iron and steel industry: an analysis of Japanese emission reduction potentials. *Energy Policy,* 30**,** 849-863.

[29] This thesis author observed that when a coke production plant is independently located from an integrated BOF plant, coke oven gas is not utilized for electricity generation and is uselessly flared in many cases. In those cases, there is a potential to implement a coke oven gas utilization project as a CDM in Non-Annex I countries or JI in the countries in economic transition.

4.3.2.3 Blast furnace

The blast furnace process is the most dynamic and capital- (and energy-) intensive process in the BOF route. It is recognized as the heart of the integrated steel-making process. Blast furnace contains a large steel structure about 30 meters high. The operation of the furnace is kept running throughout a year except the short maintenance hours (15-20 hours/year).

Sinter (or iron ore) and coke produced in the previous processes are alternately charged into the furnace together with limestone and other minor materials. The hot air reaching at 1,200° C is blown into the furnace from the bottom to combust coke inside. This process removes oxygen from ore through a series of chemical reactions. The reactions can be expressed in the following simple formula[30]:

Iron (III) oxide	+	carbon monoxide	➔	iron	+	carbon dioxide
$Fe_2O_3(s)$	+	$3\ CO(g)$	➔	$2\ Fe(s)$	+	$3\ CO_2(g)$

As seen in this formula, the blast furnace process leads to CO_2 emissions. The volume of the emissions is significantly large (See Section 4.4.1.1). This process is the largest source of the CO_2 emissions in the entire steel-making process. The production of the emissions results from the use of coke as the oxygen reducing agent. According to the interviewed steel companies, there are no alternative ways to remove oxygen from ore or eliminate the CO_2 emissions. In addition, the steel companies stress that since they utilize the state of the art technology in the blast furnace process, it is already impossible to improve the emission level unless a drastic system innovation or technological breakthrough takes place. This discussion is further elaborated in Section 5.3.1.

As mentioned above, the process produces blast furnace gas as by-product. Together with coke oven gas, the gas can be utilized as fuel gas for steel-making and/or electricity generation. The modern integrated steel plants are generally making use of the gas to meet the internal demand of electricity.

The temperature in the blast furnace can go up to 1,500°C. Iron is produced in a molten state and runs down to the base of the furnace. The iron at this stage is known as pig iron. Pig iron is transformed into the final steel products through the continuous processes. The furnace temperature is also high enough to decompose limestone into calcium oxide. This reaction leads to some CO_2 emissions. The reaction can be expressed in the following formula:

[30] Some detail explanation about the chemical reactions in the blast furnace is available at AISI's website.

$$\text{calcium carbonate} \rightarrow \text{Calcium oxide} + \text{carbon dioxide}$$

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

The calcium oxide becomes part of the residue or slag generated through the process. The slag is formed from other remaining elements including silica (SiO_2), alumina (Al_2O_3) and magnesia (MgO) that entered in the furnace with limestone, sinter or coke. It can be used and being used in many cases as a material in other industrial applications such as road construction and cement production.

4.3.2.4 Oxygen converter

The process converts the molten pig iron from the blast furnace into refined steel. Oxygen is blown through the molten bath to lower the level of unnecessary contents including carbon, silicon, manganese, phosphorous and sulfur. The carbon oxidation process leads to CO_2 emissions. The impurities and a small amount of oxidized iron are carried off in the molten slag that floats on the surface of the hot metal.

It is particularly noteworthy that up to 30% of steel scraps are added in this process. The blending of cheaper steel scraps into pig iron makes economic sense. It also contributes to CO_2 emissions reduction. It is not possible, however, to mix more than 30% since it will begin to affect the steel quality. In addition, as mentioned earlier, the volume of available steel scraps is limited.

4.3.2.5 Continuous casting

In the continuous casting process, the molten steel after the composition adjustment is continuously cast and solidified through the water-cooling process into semi-finished products including slabs, blooms and billets. Slabs are used for flat-rolled products, blooms for section and shape products and billets for wire-rod products. The blanks are transformed into finished products through the final rolling process.

4.3.3 EAF steel-making process

At present, nearly 40% of the worldwide steel production is conducted through the EAF route. Although this is an exceptional case, more steel is produced from recycled scrap than from iron ore in the United States (American Iron and Steel Institute, 2005a). As stated above, steel is produced through the EAF process from recycled scrap steel. Scrap consists of discarded steeling packages, construction materials, machine and vehicle parts, scrap pig iron and steel recovered from the integrated steel-making process. Since the quality of those scraps vary greatly, it becomes necessary to select a specific type of scraps or level of impurities contained in the scraps based on the desired quality of final steel products.

Steel-making from steel scrap involves melting scrap, removing impurities and casting it into the desired shapes. The process does not require the energy-intensive steps as needed to produce steel from ore. In the EAF process, steel scrap is melted and converted into crude steel in an electric arc furnace. The heat required for melting scrap is provided by electric arcs generated between electrodes and the scrap in the furnace. The process consumes a large amount of electricity. Electricity is the main source of energy in the process.

4.4 GHG emissions

Several major activities lead to GHG emissions in the integrated BOF steel-making. This section examines a magnitude of the emissions derived from each activity and identifies the major sources of the emissions. The levels of the emissions were identified through a literature review. They are discussed in the order of the following list:

- Direct emissions (including both combustion and process emissions)
    - Emissions from steel production
        - Coke production
        - Sintering
        - Blast furnace
        - Oxygen converter
        - Continuous casting and rolling
    - Emissions from the use of by-product gases
        - Coke oven gas
        - Blast furnace gas
        - BOS gas
- Indirect emissions
    - Use of electricity
    - Transportation of raw materials and distribution of final products

In addition to the above activities, the original mining of coal and iron ore leads to significant volume of GHG emissions production. This research does not include the evaluation of GHG emissions from the mining activities, however.

4.4.1 Direct emissions

4.4.1.1 Emissions from steel production

The main GHG emissions in the integrated BOF steel-making are derived from the combustion of the fuel used to heat the furnaces and from the chemical reactions to reduce iron ore to iron by removing carbon from iron. The former and latter are respectively recognized as “combustion emissions” and “process emissions”. The previous section discussed the process emissions in some detail.

In consultation with the UK’s Department of Trade and Industry, two consulting companies in the UK compiled and analyzed jointly the CO_2 emission factors or the volumes of CO_2 emissions per ton of production in each process (Entec UK Limited and NERA Economic Consulting, 2005). The results are the following:

Table 15: CO_2 emission factors in steel production processes

Process	Emissions factor	Unit	Previous sub-section that describe each process
Coke production	0.284	ton CO_2/ton coke	Section 4.3.2.1
Sintering	0.157	ton CO_2/ton sinter	Section 4.3.2.2
Blast furnace	1.410	ton CO_2/ton iron	Section 4.3.2.3
Oxygen converter	0.136	ton CO_2/ton steel	Section 4.3.2.4

(Note: The above emissions factors take into account both combustion and process emissions.)
(Source: Entec UK Limited and NERA Economic Consulting, 2005)

It is apparent from the information in Table 15 that the CO_2 emissions from the blast furnace process are significantly large relative to CO_2 emissions from the coke production, sintering and the oxygen converter processes.

Coke production also leads to some level of CO_2 emissions. As discussed above, in some few cases, coke production is remotely conducted from a steel plant. In this case, the coke production is not generally considered as a part of the steel-making process. When the coke production site is located within the same area, however, it is consider as a part of the process. In this case, the CO_2 emissions from the coke production are normally included in the total CO_2 emissions from the steel plant.

There are other processes that lead to CO_2 emissions, especially at the product shaping stages such as continuous casting and rolling. The levels of those emissions are not as significant as the above emissions. In case of the EU emissions trading, the emissions are not presently covered by the scheme in the first phase, while they may be covered in the subsequent phases. Those emissions are not further elaborated in this study.

4.4.1.2 Emissions from the use of by-product gases

The modern integrated BOF plants make use of most or all of the by-product gases as fuel gas for steel-making and/or power generation. Burning the by-product gases, however, also leads to CO_2 emissions. The information in Table 16 illustrates net calorific values and CO_2 emission factors of each by-product gas in comparison to natural gas:

Table 16[31]: Net calorific values and CO_2 emission factors of by-product gases

Gases	Net calorific values		Emission factors[32]	
Natural gas	50 GJ/ton	35.7 MJ/m^3	15.3 ton-C/TJ	56.1 ton-CO_2/TJ
Coke oven gas	37.5 GJ/ton	17.5 MJ/m^3	13 ton-C/TJ	47.7 ton-CO_2/TJ
Blast furnace gas	2.3 GJ/ton	3 MJ/m^3	66 ton-C/TJ	242 ton-CO_2/TJ
BOS gas[33]	N/A	N/A	50.7 ton-C/TJ	186.6 ton-CO_2/TJ

(Sources: IPCC, 1996 and European Commission, 2004)

Table 15 shows the significance of CO_2 emissions from the use of blast furnace gas. Although the calorific value of blast furnace gas (3 MJ/m^3) is comparatively small to natural gas (35.7 MJ/m^3) and the other gases, the emission factor of blast furnace gas is substantially large (242 ton-CO_2/TJ). It is more than four times greater than the emission factor of natural gas (56.1 ton-CO_2/TJ). Considering the fact that 2-3 tons of blast furnace gas is produced per ton of iron, it is obvious that a full utilization of blast furnace gas leads to substantial CO_2 emissions.

Burning coke oven gas also leads to significant CO_2 emissions. The calorific value of the gas (17.5 MJ/m^3) is approximately half of natural gas (35.7 MJ/m^3). On the other hand, the emission factor of the gas (47.7 tons-CO_2/TJ) is nearly as large as natural gas (56.1 tons-CO_2/TJ).

A question arises now: should the CO_2 emissions be counted as part of the total emissions of a steel plant? To put it differently, should the CO_2 emissions be considered within the system boundary of GHG emissions at the integrated BOF steel plant? Since the volume of the CO_2 emissions from by-product gases is substantially large, the answer can change the entire picture of the total GHG emissions from a steel plant. Answering these questions is not straightforward, however. Considering the fact that the debate on this issue may have important economic, technological and somehow political implications, it is necessary to elaborate on the question.

When by-product gases are used as fuel gas for steel-making, it is clear that CO_2 emissions should be counted as part of the total emissions of a steel plant. When by-product gases are used to generate electricity and the generating unit is a property of a steel plant, CO_2 emissions should be also counted as part of the total emissions of a steel plant. There is an issue, however, when the generating unit is owned by a different company and a steel plant sells by-product gases to the owner of the electricity generation plant. The CO_2 emissions can be hypothetically allocated either to the steel plant or to the electricity generation plant.

In the current practice, the CO_2 emissions tend to be allocated to electricity generation companies. Gielen and Moriguchi discusses that this is the case with Japan (Gielen and Moriguchi, 2002). Reinaud argues that while it is a matter for Member States to decide in Europe, Germany indicates in its national allocation plan that the CO_2

[31] The figures for natural gas, coke oven gas and blast furnace are drawn from the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. The figures for BOS gas are drawn from the European Commission Guidelines for the Monitoring and Reporting of Greenhouse Gas Emissions. It is important to note that while those figures are widely used for calculations of energy intensity and CO_2 emissions, they only serve as suggested default values. The calorific values and emission coefficients for the by-product gases are affected by many factors including a quality of input materials and operating conditions. Most importantly, technological innovations could lower the emission level.

[32] The conversion rate from C to CO_2 is 44/12.

[33] BOS stands for basic oxygen steel-making. The BOS gas is a by-product gas produced through the oxygen converter process.

emissions attribute to electricity generation companies (Reinaud, 2005).

Several issues occur with this allocation approach. The issue of utmost importance is a loss of economic incentives for steel plants. Under the present design of the European emissions trading scheme, the emissions allowances are granted based on historical emissions. If the emission allowances are not allocated to steel plants, there are no economic incentives for them to reduce the CO_2 emissions through a possible technological innovation. On the other hand, power generation companies could be granted with a large size of the emission allowances based on their historical CO_2 emissions. As discussed above, the emission factor of blast furnace gas is approximately four times greater than natural gas. Presumably, power generation companies can use other fuels to lead the CO_2 emission level lower and obtain surplus emission allowances granted through the initial allocation.

Another problem relates to the fact that electricity generation companies can reflect their carbon costs into electricity price and pass them onto steel plants. This will result in higher electricity prices for steel plants.

It is important to recognize that the steel plants are the only party to manage by-product gases. The steel plants can examine technological options to utilize by-product gases that may reduce CO_2 emissions. The allocation of the emission allowances to steel plants will impose a good economic incentive to encourage technological innovation to reduce CO_2 emissions.

This case illustrates that a determination of the system boundary for steel plants requires a careful attention to potential economic and technological implications. The scales of the GHG emissions from steel plants also vary greatly by a selection of a system boundary.

4.4.1.3 Indirect emissions

4.4.1.2.1 Use of electricity

The emissions discussed so far are categories as “direct emissions” since those emissions are directly produced through the steel-making process. There are other CO_2 emissions namely “indirect emissions”. The indirect emissions are generated through the activities that are not part of steel-making but indispensable in steel production. The most notable indirect emissions are the emissions associated with electricity purchase from a local utility company. In most cases, the electricity is produced by burning fossil fuels such as coal, oil and natural gas and using carbon-free energy resources such as nuclear, hydroelectric, wind, biomass and others. This activity leads to CO_2 emissions unless the energy sources are completely renewable. The indirect emissions (per ton of steel production) associated with the use of electricity can be calculated as follows:

CO_2 emissions per ton of steel production (CO_2 ton/steel ton) = Electricity use (MWh/steel ton) x Carbon emission factor (CEF) of the grid-based electricity generation (CO_2/MWh)

Therefore, the total indirection emissions with the use of electricity can be calculated as follows:

Total CO_2 emissions (ton) = Volume of steel production (steel ton) x CO_2 emissions per ton of steel production (CO_2 ton/steel ton)

The CEF of the grid-based electricity generation depends upon a fuel mix of electricity generation. If coal occupies a large proportion of power generation, for example, the value of the CEF becomes high. If natural gas occupies the large proportion of power generation, the CEF becomes lower than the coal case.

As discussed in Section 4.3.2.3, the integrated BOF steel plants make use of the by-product gases for power generation. The use of the by-product gases lowers the level of the indirect emissions from electricity purchase. The indirect emissions, however, are not generally recognized as part of the total emissions associated with steel-making. The European emissions trading scheme, for example, does not integrate the indirect emissions into the scheme. The integrated steel producers, therefore, do not factor into the level of the indirect emissions into their decision-making as to whether or not they decrease a volume of electricity purchase from a local utility company.

4.4.1.2.2 Transportation of raw materials and distribution of final products

The transportation of raw materials and distribution of final products lead to CO_2 emissions. Some life cycle assessments cover the emissions as part of an assessment of the GHG emissions of a steel product. As the CO_2 emissions relating to electricity purchase, the CO_2 emissions relating to transportation and distribution are not generally counted as part of the total emissions associated with steel-making.

It is important to note, however, that the size of the CO_2 emissions is not insignificant. According to Reinaud's report published by the IEA, the steel industry is responsible for nearly 20% of world seaborne trade and close to 40% of the dry bulk transport market. It is estimated that the CO_2 emissions from the seaborne trade of iron ore, coal and steel products amount to 105 million tons CO_2/year or 0.14 tons CO_2/ton of steel products (Reinaud, 2005).

4.4.1.2.3 GHG emissions per production

The above sections reviewed the magnitudes of the CO_2 emissions at each steel production stage. It is important now to grasp the scale of the total CO_2 emissions from the entire steel-making process.

The simplest approach to estimate the volume of total CO_2 emission is to multiply the volume of CO_2 emissions per steel production (CO_2 emission factor) by the volume of steel production.[34] There are many engineering studies conducted to estimate the volume of CO_2 emissions per ton production. Whether or not they are willing to disclose the data, the steel companies, particularly in the Annex I countries, have begun to conduct their own study in a preparation for possible regulations such as European emissions trading scheme.

To single out an accurate value for the CO_2 emission factor faces technical challenge. The value is plant-specific. It depends upon maintenance conditions, fuel mixes and other factors.[35] Most importantly, it is necessary to take into account technological improvements of steel plants to reduce the CO_2 emissions. As discussed above, the value also depends on the setting of a system boundary.

The default values for the emission factor are available among independent researches as well as company researches. While the values tend to be similar among the OECD countries, they differ greatly between OECD and

[34] The EU ETS employs different approaches to calculate the CO_2 emissions. One of the approaches is called "mass balance approach". With this approach, the CO_2 emission is estimated as follows (EC, 2004): CO_2-emissions [t CO_2] = (Σ (activity data$_{input}$ * carbon content$_{input}$) – Σ (activity data$_{products}$ * carbon content$_{products}$) –Σ (activity data$_{export}$ * carbon content$_{export}$) – Σ (activity data$_{stock\ changes}$ * carbon content$_{stock\ changes}$)) * 3,664.

[35] It is also important to note that the actual volume of CO_2 emissions derived from monitoring-based measurements always differ from estimations derived from theoretical calculations. In addition, uncertainty is inevitable in the case of estimations.

non-OECD countries. The followings are the suggested default values for the integrated BOF steel plants in the OECD countries:

Table 17: Default values of the CO_2 emissions for the integrated BOF steel plants

International organizations/companies	Suggested default values for the CO_2 emission factor (tons-CO_2/ton-steel)	Data sources
IPCC	1.6	IPCC, 1996
IISI	1.6	IISI, 2005
Corus Group	1.86	Entec and NARA, 2005
IEA	1.93	Reinaud (IEA), 2005
POSCO	1.99	POSCO, 2003

(Sources:Various sources. See the last column in the table.)

4.4.2 GHG emissions through the EAF steel plants

As described in Section 4.3.3, the EAF steel-making process requires much less energy than the BOF process. The level of the GHG emissions through the EAF process is accordingly lower. There are two sources of CO_2 emissions. One source is related to the use of solid and gaseous fuels including coke and natural gas. While the main source of energy for heating steel scrap is electricity in an electronic arc furnace, there are some additional fuels used for the purpose. The level of the CO_2 emissions derived from the use of the fuels is as low as 0.15 tons-CO_2/ton-steel.

The other source of CO_2 emissions is related to the use of electricity. In the modern EAF operations, the electricity consumption ranges from 560 to 680 KWh (Kwong, 2002). Although the volume of electricity use is large, the CO_2 emissions are considered to be indirect emissions. As is the case with the electricity use in the BOF process, the CO_2 emissions are not produced through the steel-making process. They are produced through the use of fossil fuels by an electricity generation company. The CO_2 emissions associated with the electricity use at an EAF plant can be calculated as follows. It is the same approach showed in Section 4.4.1.2.1.

CO_2 emissions per ton of steel production (CO_2 tons/steel ton) = Electricity use (MWh/steel ton) x Carbon emission factor (CEF) of the grid-based electricity generation (CO_2/MWh)

Total CO_2 emissions (ton) = Volume of steel production (steel ton) x CO_2 emissions per ton of steel production (CO_2 tons/steel ton)

4.4.3 Sector-wide GHG emissions

The GHG emissions from the steel sector are among the largest in the whole industry sector. In Japan, the volume of CO_2 emissions from the steel sector reaches 184.72 million tons in 2004.[36] It accounts for nearly 15% of the country's total CO_2 emissions. The steel sector is the largest CO_2 emitter after the electricity generation sector in Japan. In the Netherlands, it was 9.8 million tons on average per year between 2000 and 2002. It is the fourth

[36] This information is drawn from Nippon Keidanren (2005b) Results of the Fiscal 2005 Follow-up to the Keidanren Voluntary Action Plan on the Environment Tokyo.

largest CO_2 emitter in the Netherlands after the electricity generation, chemical and oil refinery sectors.[37]

Table 18 presents information on the worldwide GHG emissions. The share of the GHG emissions from the steel sector is approximately 3% of the global GHG emissions in the world.

Table 18[38]: Worldwide GHG emissions

	Annex I regions	Non-Annex I regions
Electricity	23%	20%
Unallocated automobile producers	3%	1%
Other energy industries	9%	8%
Iron and steel	**3%**	**3%**
Chemical and petrochemical	3%	3%
Non-metallic minerals	4%	6%
Non-CO_2 GHG emissions from industrial processes	2%	1%
Other manufacturing industries and construction	6%	6%
Total of GHG emissions from the industry sector	**53%**	**48%**
Transportation	15%	9%
Agriculture	**14%**	**19%**
Residential	6%	4%
Other sectors	8%	10%
Unallocated non-CO_2 GHG emissions	4%	10%
Total of GHG emissions from all sectors	100%	100%

(Source: Helme, 2005)

It is noteworthy that while the shares of the GHG emissions from the industry sector differ between the Annex I and non-Annex I regions (respectively, 53% and 43%), the share of the GHG emissions from the steel sector is the same between the Annex I and non-Annex I regions. On the other hand, the share of the GHG emissions from agricultural sector in the non-Annex I regions (19%) is larger than in the Annex I region (15%). The agricultural activities are generally more active in the non-Annex I regions. This data may indicate that the steel industry is an important industry sector even in the agriculture-oriented parts of the world. The level of the GHG emissions from the steel sector remains high worldwide.

[37] Under its national allocation plan, the Dutch government allocated the EUA in the period of 2005 and 2007 as follows: 39.1 million tons to the electricity generation sector, 15.6 million tons to the chemical sector, 14.0 million tons to the oil refinery sector and 10.3 million tons to the steel sector. This information was drawn from the following: Point Carbon (2004) Dutch companies must reduce 8MtCO2 yearly. *Point Carbon Newsletter.*

[38] The figures were drawn from the following report: Helme, N. (2005) Sector-Based Approach for "Post-2012". Washington D.C., Center for Clean Air Policy. The figures include CO_2 and other GHG gases.

4.5 Cost structure

This section presents a cost structure of a typical integrated steel plant. It is important to understand it especially when considering the economic impacts of climate change policy instruments and corporate strategy to cope with them. Table 19 illustrates a cost structure of a typical integrated steel plant. While the numbers can vary depending upon the individual characteristics of a steel plant, it is possible to understand some typical features of the cost structure.

From Table 19, it can be first understood that the procurement costs of raw materials including iron ore, coal and limestone occupy a large proportion of the total cost (35%). The labor cost is the second highest cost in the steel making (22%). On the other hand, the electricity cost is relatively low (3%). This is mainly because the BOF steel making process does not require electricity as much as the EAF process. The cost to purchase electricity in the EAF process can be up to 15%. The electricity cost proportion of the total cost is low even compared to the other energy-intensive industry sectors such as the pulp and paper (12%) and aluminum (35%) (Reinaud, 2005). Another reason for the low figure of electricity use relates to the fact that this steel plant utilizes waste heat and gas from the coking and BOF processes for electricity generation. The electricity is used for steel making. Without any measures to utilize waste heat and gas, the cost of electricity procurement can higher. As discussed above, under the present European Union ETS, the higher the electricity proportion of the total cost is, the higher the costs of the EU ETS is for the steel plant. This is because the price of electricity is increasing partly because the electricity generation companies in the EU are likely reflecting the opportunity cost of the EU ETS in the electricity price.

Table 19 shows that the cost to produce 1 ton of steel is €410. This is the average cost of the steel production among OECD countries. However, the cost of the steel production in the developing countries tends to be lower. Steel experts indicate that the steel production in China and Russia can be as low as €310 and €200 in China and Russia respectively. This is mainly because the labor costs in these countries are much lower than in the OECD countries, while the cost to purchase raw materials tends to be the same among across all countries.

Table 19: Cost structure of an average integrated steel plant in an OECD country

Plant information				
	Capacity		5,000,000	tons/year
	Operating efficiency		0.90	%
	Annual production		4,800,000	tons/year
Cost breakdown				
	Fixed costs			% of total cost
		Depreciation		6
		Labor		22
		Maintenance		3
		Consumptions (others)		3
		Overhead		8
	Variable costs			% of total cost
		Iron ore and limestone		22
		Coal		13
		Combustibles		2
		Electricity		3
		Consumptions (others)		4
		Oxygen and nitrogen		1
		Transportation		2
		Renting		1
		Work by third parties		10
	Total			**100**
	Cost per ton of product			**EUR 410**

(Source: A steel company in an OECD country)

Summary of Chapter 4

This chapter presented an overview of the steel industry sector. It described 1) market trends, 2) international trade trends, 3) production process, 4) GHG emissions sources and 5) cost structure of the steel industry sector. It is important to understand the characteristics of the steel industry sector before the empirical study. Some of the industry sector-specific characteristics are in fact inevitable to consider research questions. For example, the thesis author recognized the fact that the steel market is a global market raises the issue of "international competitiveness" directly linked to the economic dimension of the corporate climate change strategy. The issue of "international competitiveness" is more relevant for the steel industry sector than the industry sectors that are geared toward the domestic markets (such as the cement and pulp and paper sector).

Chapter 5 begins to present the results of the empirical study. The chapter examined the economic and technological dimensions of the steel industry sector. With respect to the economic dimension, the thesis author reviewed literatures that examine the economic impacts of climate change policy instruments on the steel industry sector. He considered whether and to what extent of economic impacts the climate change policy instruments may bring to the steel industry sector. With respect to the technological dimension, he reviewed literature that examines technological options to reduce emissions in the steel industry sector. The review of the literature in the economic and technological dimensions helps us to understand how the economic and technological factors are important in the formulation of corporate climate change strategy in the steel industry sector (Research question 3). Chapter 6-9 examined the institutional dimension of each country/region and corporate climate change strategy of the steel companies (Chapter 6: Japan, Chapter 7: the EU, Chapter 8: the U.S. and Chapter 9: South Korea). These chapters paid particular attention to the "home country effects" and discussed how the societal concerns about climate change and regulatory culture and schemes on climate change differ among countries.

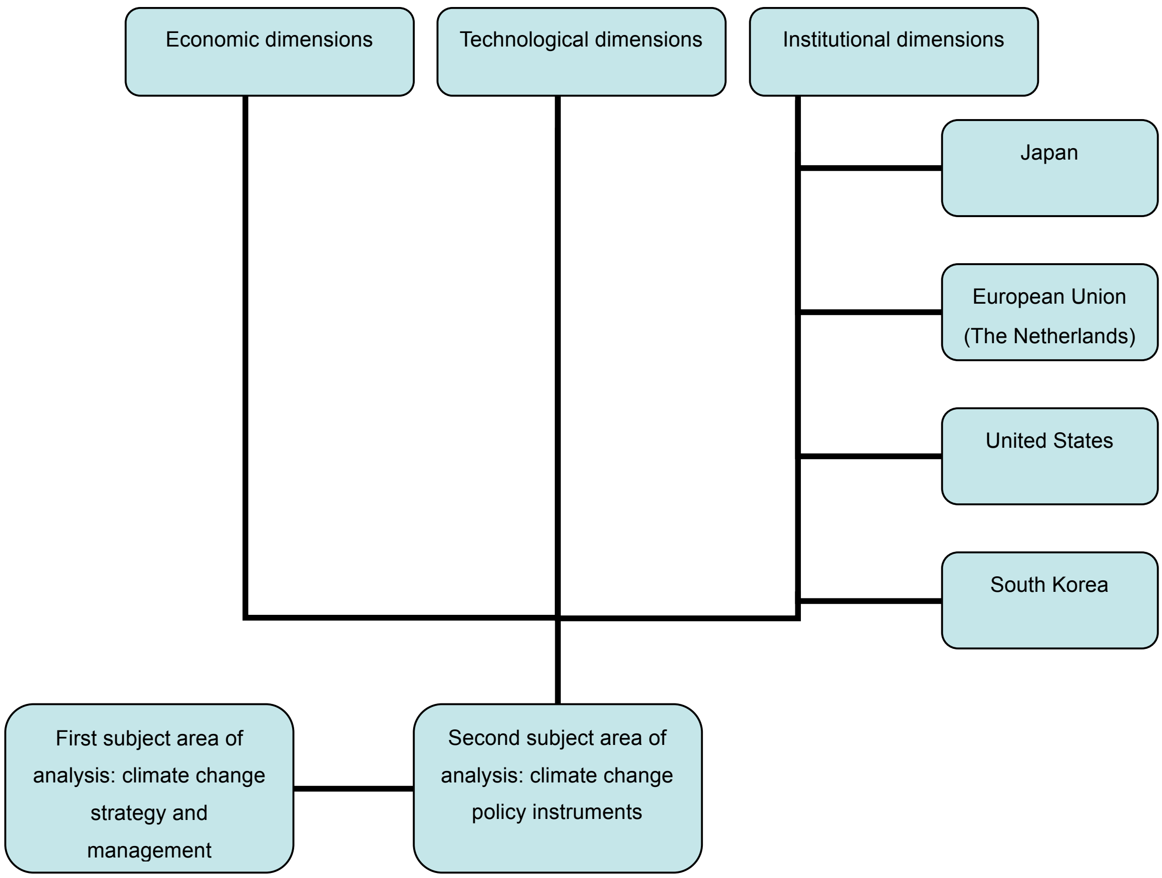
Chapter 5: Empirical research: Economic and technological dimensions

5.1 Framework and methodology

Chapter 3 proposed a research framework to analyze corporate climate change strategy. As described in the chapter, this author's approach is to examine three dimensions: economic, technological and institutional. This chapter as well as the following chapters (Chapter 6-9) presents an empirical study on the steel industry sector based on the research framework.

Figure 11 illustrates the structure of the empirical research. It is a reversed version of Figure 6 in Chapter 3. The first level of analysis is corporate strategy and management in climate change. As described in Chapter 3, the areas for investigation include 1) policy statement, 2) organizational structure, 3) information disclosure, 4) measurement, 5) accounting, 6) technological innovation, 7) product development, 8) integrated chain management/life cycle assessment, and 9) partnership/membership. The second level of analysis is corporate strategy on specific climate change policy instruments including both the Kyoto and post-Kyoto schemes.

Figure 11: Structure of the empirical research



It is noted that the institutional dimensions is divided into two separate parts: 1) home country factors and 2) convergent factors. Research on home-country factors is exercised on the country or region basis. As discussed in the previous chapter, there are local pressures that tend to differ from one country to another.[39] Sethi and Elango call them "home country effects" that are considered to generate heterogeneity among firm's climate change strategy (See Chapter 3). This research places a strong focus on the analysis of the home county effects.

5.2 Economic dimensions

Chapter 2 reviewed the theoretical framework of economic analysis of climate change policy instruments (2.1.2). This section continues the examination of the economic impacts of the climate change policy instruments. It explores whether and to what extent of economic impacts the climate change policy instruments may bring to the energy-intensive industry sectors including the steel industry sector. The policy instruments considered in this section include emissions trading scheme, carbon tax and voluntary agreements.

5.2.1 Emissions trading scheme

The IEA report discussed in Chapter 2 analyzes economic impacts of the EU ETS in five energy-intensive industry sectors including the steel (BOF), steel (EAF), cement, pulp and paper and aluminum sectors. The results of the IEA study suggest that the EU ETS would have modest impacts on the cost structure of the analyzed industries in the short run (Reinaud, 2005). Table 20 shows the result of the analysis. There are two scenarios in the table where firms need 2% and 10% emission allowances to meet their emissions reduction target.[40]

Table 20: Cost increase in relative to production costs among energy-intensive industry sectors

Scenarios/Sectors	Steel (BOF)	Steel (EAF)	Cement	Pulp Paper	Aluminum
2% allowance needs	0.7%	0.8%	1.9%	1.1%	3.7%
10% allowance needs	1.3%	0.9%	3.4%	1.6%	3.7%

(Source: Reinaud, 2005)

The results suggest that the aluminum sector would incur the highest increase in production cost, although the sector is not covered by the EU ETS. This is because the aluminum production consumes a large volume of electricity being susceptible to the price increase of electricity. The cement sector also faces a relatively high cost increase resulting from high CO_2 production per unit production of cement.

The IEA study also examined a degree of possible demand reduction and loss in competitiveness in the international market due to the introduction of the EU ETS. It indicates that the impacts on possible demand reduction remain modest except for the aluminum sector. It also suggests that the high transportation cost would protect the European industry from the products that are imported from the countries without climate change regulations. Among the analyzed sectors, however, the aluminum sector is more open to international competition and exposed to a loss in competitiveness in the international market.

---

[39] As discussed later, we examine the institutional aspect of the Netherlands in some detail including its societal concerns about climate change as well as regulatory cultures and schemes. The cases of other EU countries will be illustrated in this thesis in a brief fashion.

[40] Several assumptions are made in the analysis. The price of an EUA is assumed to be €10 per tons of CO_2. It is also assumed that the electricity generation sector passed through the full opportunity costs to consumers leading to a price increase of electricity of 11%.

Commissioned by the Carbon Trust, a consulting firm based in the UK, Oxera, conducted a similar analysis. It focused on the British energy-intensive industry sectors (Oxera, 2004). The analysis has the same industry coverage with the IEA study. Interestingly, the study concurs with the IEA study with respect to the possible impacts of the EU ETS on the energy-intensive industry sectors. This following sentence is cited from the executive summary of the study report:

> The results of the modeling challenge the widely accepted belief that the EU ETS will have a major negative impact on the profits of UK firms. In four of the five markets examined in this study, UK participants are not predicted to suffer a reduction in profits, indeed making gains in some cases. The fifth sector studied here (indicating the aluminum sector) faces a loss of market share to competitors operating outside the EU and a reduction in profits, and similar results might be expected in other sectors with similar characteristics (Oxera, 2004).

The results of the IEA and Oxera studies indicate that the economic impacts of the EU ETS on the energy-intensive industry sectors are moderate. As for the steel industry sector, the IEA study suggests that an introduction of emissions trading scheme only lead to modest economic impacts on the steel industry sector (Reinaud, 2005). Under the assumption that carbon credits are traded at €10/ton-CO_2 and companies are short of 10% of the total necessary allowances, the cost increase of the total BOF steel production cost is 1.3%. This rate is lower than the increase of the cement and aluminum sectors (3.4% and 3.7%) and higher than the increase of the EAF steel production (0.9%). The study conducted by Oxera reached a similar conclusion.

The result of these studies are a good indication to understand a magnitude of an emissions trading scheme on the production cost of average integrated steel plants, while there are several assumptions in the study that requires a careful attention for a full understanding of the impacts. For example, the rate of 1.3% can become much higher if the steel producers cannot pass the cost to the consumers. As mentioned above, indeed, the steel industry market is a highly fragmented and competitive market. The share of the top 10 steel companies remains 25-30% of the entire market unlike other industry sectors. There is no steel companies likely influencing on the price of the steel products in the market. All major steel companies are most likely price-takers rather than price-makers. (The IEA study indeed estimates a reduction in the operational earning in the perfect competition in the steel industry market and the result indicates 6.8% loss in the operational earning with the assumptions of €10/ton-CO_2 and 10% shortage of the allowances.)

In addition, carbon credits are traded at a higher price in 2006. Many experts in the carbon credit trading market forecast that the price of carbon credits settle around €20/ton-CO_2 in the future. Figure 12 indicates the price flow of the EUA in the EU spot market from June 2005 to May 2006.

Figure 12: Price flow of the EUA in the EU spot market from June 2005 and May 2006

(Source: International Emissions Trading Association and the World Bank, 2006)

The IEA study also investigated a possible demand reduction of steel products if steel companies pass the costs associated with the emissions trading scheme to customers. Assuming the price elasticity of steel products to be –1.56, the demand reduction of steel products was estimated to be –1.6% in the case that the price of carbon credits is to be €10/ton-CO_2 and shortage of the allowances remains 10%. Compared to the possible demand reductions in the pulp and paper (-2.3%) and aluminum (-2.9%) industries, this figure is low. The study also assessed a competition between EU and Chinese products in the international trade. It takes into account transportation cost and international border tariff to compare the price differences between the EU and Chinese products. This study suggests that the price of the local steel products is more attractive than Chinese products. It recognizes, however, that the fright costs from the nearer regions such as the Southern Mediterranean can be lower and may threaten the European steel market.

Some steel experts point out non-economic factors to explain that an introduction of an emissions trading scheme would not address an immediate threat to the steel companies in the Annex I regions. Firstly, steel products are not identical among them and there is a wide range of products with different quality. Steel industry experts maintain that the steel producers in the emerging markets are still limited in capacity of producing high quality flat steel for the essential industries such as automobiles, machinery and precision engineering. Therefore, high quality steel produced in Europe, Japan or other Annex I countries cannot be replaced by foreign low quality steel. Secondly, the operation and maintenance of a large-scale steel production process requires high level of technological capabilities and "craftsmanship" skills which make it impossible to produce high-quality steel in the short period of time. Steel industry experts argue that it takes at least several years until the steel producers in the developing countries acquire such technologies and skills. According to steel experts, therefore, the steel production in the developing countries does not address an immediate threat to the steel makers in the Annex I regions in the international market.

5.2.2 Carbon tax

There are several research initiatives to estimate a magnitude of economic impacts of carbon tax. One of the initiatives was taken by the Institute for Research in Economics and Business Administration in Norway (Mœstad, 2002, Mathiesen and Mœstad, 2002). The Institute conducted an experimental simulation using the steel industry model (SIM) to estimate the degree of the economic impacts. The main results of the analysis are described as follows:

1. An OECD-wide carbon tax would reduce OECD steel production significantly, by an estimated –9%. The reduction is much greater for the integrated steel mills (-12%) than for the scrap-based mini-mills (-2%). Non-OECD production would increase by almost 5%, implying a fall in world steel production of –2%.
2. The carbon tax would induce some substitution from the use of pig iron towards more intensive use of scrap in BOF steel market.
3. An OECD-wide tax would reduce OECD emissions of CO_2 from the steel industry by 19%. Despite relatively high emission intensities in non-OECD countries, global emissions from the sector would decline by 4.6%.
4. Unilateral policies by single regions or countries may lead to quite dramatic cut-backs in the production of BOF steel, because unilateralism leaves smaller opportunities to shift the tax burden over to suppliers or customers.

The results of the analysis indicate that an introduction of a carbon tax may lead to a significant reduction of steel production through the BOF process in the OECD countries. When a carbon tax is introduced unilaterally by a country or region, the impacts of the reduction are or may be greater in that country or region. The study also suggests that relocation of steel plants may take place from OECD countries to non-OECD countries. This may lead to "carbon leakage"[41]. Another study conducted by Gielen and Moriguchi suggests that if carbon tax is introduced in Europe and Japan at the rate of $23/ton of CO_2, the leakage rate is estimated to be 50% by 2020. If the tax rate is $10/ton of CO_2, the leakage rate is estimated to be 35% (Gielen and Moriguchi, 2002). Since the estimated figure of carbon leakage is high, Mathiesen and Mœstad as well as Gielen and Moriguchi suggested establishing trade barriers such as import tariff. According to Gielen and Moriguchi's analysis, the break-even point (0% carbon leakage) for carbon tax of $23/ton of CO_2 is reached at an import tariff between $23-$45/ton of CO_2. It is, however, extremely unclear whether and how such a tariff can be introduced, in practice. There are several different opinions as to whether or not an introduction of such a tariff may abuse the WTO regulations and furthermore, the regulatory cost may be too high.

5.2.3 Voluntary agreements

The economic impacts of voluntary environmental agreements have not been receiving much research attentions because of the non-legally binding nature of the agreements. The OECD report published in 1999 pointed out that "unlike economic instruments [indicating such as emissions trading and carbon tax], voluntary approaches do not originate from economic theory" (Organisation for Economic Cooperation and Development, 1999). According to Albrecht, however, voluntary agreements can become an expensive commitment for some industry sectors. Albrecht argues, "For industries with heterogeneous producers like specialty chemicals for which unique technologies are used, standard goal assessment and monitoring of voluntary agreement targets will become very

[41] As explained in the later section (Section 6.4.2.2), carbon leakage refers to the indirect impacts of climate change policy, specifically, the replacement of GHG emissions from one source to another source. The replacement from one Annex I country to another Annex I country is acceptable since the total volume of GHG emissions between the countries is capped under the Kyoto Protocol. However, the replacement from an Annex I country to a non-Annex I country is problematic since there are no-cap on the GHG emissions release for the non-Annex I countries under the Protocol.

difficult. Given the asymmetrical nature of technical information at the company level, one can expect high and recurrent assessment costs for this type of industries" (Albrecht, 2004). This point is true in some cases in the steel industry sector. As illustrated in Chapter 4, the steel industry is not as diverse or complex as the specialty chemical or oil refinery sectors as far as the products and production processes are concerned. It is not technically simple, however, to assess an improvement of energy efficiency or reduction of GHG emissions release when some improvement measures are conducted in the steel making process. The monitoring cost can be high in some cases in the steel industry sector.

5.3 Technological dimensions

Chapter 2 demonstrated that technological innovation plays an important role in the formulation of corporate climate change strategy (2.2.1). A particular attention was paid to a theory presented by George Stigler. Based on Stigler's theory, it was contended that when firms have a prospect for "transitional" technological changes, a significant change in corporate climate change strategy may be observable. This section explores a possibility of such a transitional change in the steel industry sector in the near future. It reviews engineering literatures that examine technological options to reduce emissions in the industry sector.

5.3.1 Technological capabilities: Short-term GHG emissions reduction

Many steel companies in the developed countries claim that their energy efficiency level is reaching the theoretical minimum. They maintain that there is not much room left for the improvement. On the other hand, many steel experts contend that there are still rooms for improvement. De Beer conducted an in-depth analysis of possible opportunities to improve energy efficiency in three industry sectors including steel, paper and ammonia. He concluded that new industrial processes hold the promise to reduce the current gap between industrial best practice and theoretical minimum by 50% (De Beer, 1998). Kim and Worrell presented a study to analyze the energy efficiency levels of the steel industry sector in different countries. Assuming the best practice technology are applied to the steel industry sector in the countries, they concluded that there are potentials for energy efficiency improvement varying from 15% (Japan and South Korea) to 40% (India, China and the U.S.) (Kim and Worrell, 2002, Gielen and Podkanski, 2006).

In 2001, the IPCC studied GHG emissions reduction potentials in several industry sectors including the steel industry sector through a utilization of readily available technologies. Table 21 is a list of the technologies in the steel industry sector that were identified in the IPCC study. The list also indicates the costs to install each technology per CO_2 ton:

Table 21: Technologies with GHG emissions reduction potentials in the steel industry sector

Technologies	**Potential in 2010**	**Emission reduction costs**	**Remarks**
Pulverized coal injection up to 40% in the blast furnace	■■	-	Maximum injection rate is still a topic of research
Heat recovery from sinter plants and coke ovens	■■	+	
Recovery of process gas from coke ovens, blast furnaces and basic oxygen furnaces	■■■	-	
Power recovery from blast furnace off-gases	■	+	
Replacement of open-hearth furnaces by basic oxygen furnaces	■■■	-	Mainly former Soviet Union and China
Application of continuous casting and thin slab casting	■■■	-	Replacement of ingot Casting
Efficient production of low-temperature heat (heat recovery from high-temperature processes and cogeneration)	■	++	Heat recovery from high temperature processes is technically difficult
Efficient ladle preheating	■		
Second generation smelt reduction processes	■■■	-	First commercial units expected after 2005
Near-net-shape casting techniques	■■	-	Not yet commercial

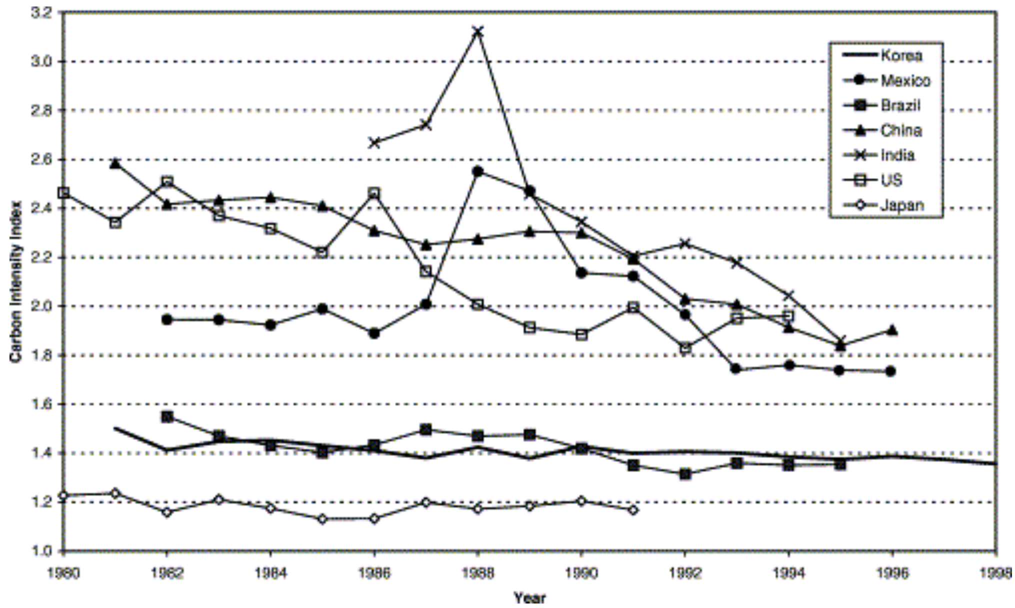
(Notes: Potential: ■= 0-10MtC; ■■= 10-30MtC; ■■■= 30-100MtC; ■■■■> 100MtC. Annualized costs at discount rate of 10%: - = benefits are larger than the costs; + = US$0-US$100/tC ; ++ = US$100-US$300/tC; +++ > US$300/tC)
(Source: Intergovernmental Panel on Climate Change, 2001)

It appears that there are several technologies with large potentials in GHG emissions reduction. The study indicated that some technologies even bring larger benefits than costs. Those technologies with larger benefits are 1) pulverized coal injection up to 40% in the blast furnace, 2) recovery of process gas from coke ovens, blast furnaces and basic oxygen furnaces, 3) replacement of open-hearth furnaces by basic oxygen furnaces, 4) application of continuous casting and thin slab casting (such as replacement of ingot casting) and 5) second-generation smelt reduction processes. The results of the study indicate that there are still technologies available both in the developed and developing countries to reduce GHG emissions.

5.3.2 Technological diffusion

Section 2.2.3 presented a theory illustrating how new technologies tend to diffuse in a new market. Based on the theory, it is possible to expect that the GHG emissions reduction technologies diffuse from the developed countries to the developing countries in the future. Presently, there is a large technological gap between the developed and the developing countries in the steel industry sector. Kim and Worrell's study presented an international comparison of CO_2 emission intensity of the steel industry sector among countries. Table 22 shows the results of the study.[42]

Table 22: Comparison of CO_2 intensity of the steel industry sector among Korea, Mexico, Brazil, China, India, the U.S. and Japan



(Source: Kim and Worrell, 2002)

Table 22 indicates two interesting points. The first point is that South Korea and Brazil are clearly separated from the rest of the groups with respect to the CO_2 intensity. This indicates that the CO_2 intensity level of the Brazilian and Korean steel producers are better than the other steel producers, while it is higher than Japanese steel producers. According to Kim and Worrell, the fact that South Korean and Brazilian steel producers have better performance in CO_2 intensity is associated with a rapid phase-out of less energy efficient OHF-based steel making technology and a rapid penetration of continuous casting technology in both countries (Kim and Worrell, 2002).

The second interesting point is that all countries analyzed in the study showed a downward trend toward more energy efficient production systems. This trend may be associated with the diffusion of new technologies among the countries. Technological convergence toward more energy efficient and less CO_2 emissions/unit of production has taken place from the 1980s to the 1990s in the steel industry sector.

5.3.3 Technological innovation

The technologies listed on Table 21 lead to GHG emissions reduction. It seems, however, that these technologies are along the line of the “best available techniques”. In order to reduce GHG emissions in a greater scale, more dynamic changes are necessary, possibly along the line of the transformation or transition process described by innovation economists in Section 2.2.1. When firms successfully bring about technological innovation, they may enjoy the benefits of technological innovation as illustrated as the Stiglerian situation. This may lead to drastic changes in company’s climate change strategy.

---

[42] In order to compare differences in CO_2 intensity, Kim and Worrell used the Carbon Intensity Index with the benchmarking value of 1.0.

At present, however, there are not breakthrough technologies to reduce GHG emissions in the steel industry sector. The Stiglerian situation cannot be expected in the steel industry sector in the near future. The steel industry experts recognize that for the drastic GHG emissions reduction, the transformation from carbon to hydrogen energy is ultimately necessary in the steel production process. On the other hand, Carbon Capture and Storage (CCS) is receiving a particular attention among the steel industry experts as a technology that may become a major path for reducing CO_2 emissions over the coming decades, (Gielen and Podkanski, 2006). Gielen and Podkanski estimate that the volume between 0.5Gt and 1.5Gt of CO_2 emissions can be reduced through the utilization of the technology in the steel industry sector. According to Gielen and Podkanski, a cost for CCS is estimated to be less than US$20/ton CO_2 (Gielen and Podkanski, 2006).

Summary of Chapter 5

This chapter examined the economic and technological dimensions of the steel industry sector. With respect to the economic dimensions, it reviewed literatures that examined the economic impacts of climate change policy instruments on the steel industry sector. The economic literatures indicated overall that the economic impacts remain minor. With respect to the technological dimensions, this chapter reviewed engineering literatures that examine technological options to reduce emissions in the steel industry sector. The literature showed that while there are several technologies available with large potentials in GHG emissions reduction, there are no breakthrough technologies that may encourage the transitional process to result in more drastic GHG emissions reduction. At present, an occurrence of the Stiglerian situation cannot be foreseen in the steel industry sector.

Chapter 6-9 examines the institutional dimensions of each country/region and corporate climate change strategy of the steel companies. In these chapters, this thesis author paid a particular attention to the “home country effects” and discussed how the societal concerns about climate change and regulatory culture and schemes on climate change differ among countries. This thesis author began with Japan in Chapter 6. In Japan, an industry voluntary program called the Keidanren Voluntary Action Plan on the Environment is becoming a focal point for GHG emissions in the industry sectors. Chapter 6 discusses how this scheme differs from the voluntary schemes in Europe. There are four steel companies with BOF operations in Japan. The largest steel company is Nippon Steel and the second largest is JFE Holdings. This chapter examines corporate climate change strategy of these two steel companies.

Chapter 6: Japanese firms

6.1. Overview of Japanese steel industry sector

The steel industry has been a leading industry in Japan. The Japanese government recognized it as a critical industry for economic recovery after the World War II. It provided a favorable loan package to the industry in order to facilitate a rapid modernization and expansion of other industry sectors. By the beginning of the 1970s, steel became the leading export commodity, accounting for US$2.8 billion or 14.7% of the total export of the country. This export share peaked at 19% in 1974. Despite the emphasis on the steel industry in the Japanese economy and its export success, the industry was considered matured and declining in the 1980s and the 1990s. In recent years, however, the improved outlook for global economy as well as the strong demand from the expanding industry sectors such as automobile, construction and engineering in China has helped the Japanese steel industry to regain its growth. The volume of crude steel production reached 112.7 million tons in Japan in 2004, out of which 73.6% produced through the BOF and 26.4% produced through the EAF (International Iron and Steel Institute, 2005).

As indicated in Chapter 4, Japan is the largest steel exporting country in the world. In 2003, Japan exported 6.4 million metric tons of steel to China and 22.3 million metric tons of steel to other Asian countries. The approximate shares of the exporting countries are 24% (South Korea), 21% (China), 10% (Taiwan), 10% (Thailand), 19% (other countries in Asia) and 16% (the rest of the world including the U.S.) (ISSB, 2004). Asia is a critical market for Japanese steel companies.

There are four major steel companies in Japan with BOF operation. The largest steel company is Nippon Steel Corporation ("Nippon Steel" hereafter). The company is the third largest steel producer in the world with 32.4 Mt of crude steel production in 2004. It has four blast furnace plants including Yahata, Nagoya, Kimitsu and Ooita. The second largest steel company is JFE Holdings ("JFE" hereafter). The company is the fourth largest steel producer in the world with 31.6 Mt of crude steel production in 2004. It has three blast furnace plants including East Japan (Keihin and Chiba), West Japan (Fukuyama and Kurashiki) and Chita. These two companies are followed by other two steel companies: Sumitomo Metal Industries ("Sumitomo" hereafter) with 12.8 Mt and Kobe Steel with 7.7 Mt of crude steel production in 2004.

As shown in Chapter 4, the GHG emissions released from the steel industry sector take up a large portion of the country' total GHG emission production. In 2004, the volume of CO_2 emissions from the steel sector reached 184.72 million tons. This volume accounts for nearly 15% of the country's total CO_2 emissions. The steel sector is the largest CO_2 emitter after the electricity generation sector in Japan.

6.2 Japanese institutional dimensions

6.2.1 Divergent factor: Societal concerns about climate change

Japan is the host country of the Kyoto Protocol and committed to reduce GHG emissions by 6% in the period of 2008 and 2012 relative to the 1990 level. A public opinion survey conducted in 2006 indicates that 75% of the surveyed people recognized as climate change as serious phenomena, 23% as somewhat serious, 2% as not very serious (GlobeScan, 2006).[43] The rate of the people who answered serious is considerably higher among other developed countries: Germany (73%), France (70%), Finland (59%) and the United States (49%). Yet, it is premature for us to conclude that there are strong social pressures on the firms to cope with climate change in Japan.

Japanese social movement for environmental protection has developed in response to the water pollution and air contamination issues caused by the process of industrialization and urbanization. In the initial stage of the economic reconstruction after the World War II, however, public awareness of environmental problems remained low. The problems were not identified as important social issues. By the end of the late 1960s, however, air pollution as well as water and ground contamination became visible in cities, towns and industrial sites in Japan. The number of victims increased, as the pollution and contamination problems became critical. In 1964, social movement was able to stop, for the first time, a construction of a petrochemical complex expected to cause environmental problems in the vicinity (Ui, 1992). Subsequent to this, the victims who suffered from previous pollution-related health problems filed lawsuits against large companies and the court judged in favor of the victims (McKean, 1981, Huddle et al., 1975). Those lawsuits included two symbolic cases against a mining company that spilled cadmium and a petrochemical company that emitted sulphurous acid gases causing asthma in a local community surrounding the industrial complex.

Given the seriousness of the environmental problems and social pressures presented by the local communities, a special session of the National Diet was opened to examine the environmental problems. The session introduced a series of environmental regulations with national-wide emission reduction targets and strict non-compliance mechanisms. A penalty was imposed on the companies that did not comply with the regulations. As an agency to monitor and enforce the regulations, the Japanese Environmental Agency was formed in 1971. Fukui succinctly illustrates the Japanese social movements for the environmental problems as follows:

> In Japan, citizens' activism in the local community, supported by judicial decisions, became the driving force behind pollution control measures. Scientists and lawyers support the activism of ordinary citizens, making it difficult for government and industry to ignore their efforts. Although NGOs, a more sophisticated form of citizen activism, have been weak constituencies in Japan, public awareness about environmental issues has substantially increased in the past three decades (Fukui, 2002).

In the beginning of the 1970s, the air pollution caused by the steel industry sector started to become visible in the local communities in Japan. The air pollution was mainly coming from the coking and BOF steel-making process leading to a large volume of pollutants such as sulfur oxide (SO) and nitrous oxide (NOx). For a long time, the steel industry sector did not receive a social pressure to improve the conditions. In the beginning of the 1970s, however, the pressures to improve the health-related conditions in the local communities mounted toward them. The control

---

[43] This study was conducted by GlobeScan, the global public opinion and stakeholder research firm based in the North America. The details of the study are available at http://www.globescan.com/news_archives/csr_climatechange.html.

of the pollutants began due to strict regulations that were introduced by the above-mentioned special session of the National Diet. In response to the social and legal pressures, the steel industry sector made a large scale of investment for desulfurization and denitrification of its flue gases. For example, the investment cost accounted for 34% of their total investment in 1976 (Okazaki et al., 2002).

It does not seem, however, that the origin of the Japanese steel industry initiatives to reduce GHG emissions is directly associated with the social movement for environmental protection in the 1970s. It can be said that the climate change initiatives were attributed to the industry's efforts and measures to save energy and to lower energy cost. A manager of the JFE stated in an interview "the high level of energy efficiency in the Japanese steel production process is the result of our financial calculation of the energy cost and it was unrelated, in the beginning, to the climate change concerns". The first oil shock or crisis occurred in 1973 after the members of the OAPEC (Organization of Arab Petroleum Exporting Countries consisting of the Arab members of OPEC plus Egypt and Syria) announced that they would no longer ship petroleum to nations supporting Israel in the conflict with Syria and Egypt. As the oil price skyrocketed, the Japanese steel industry realized the importance of improving energy efficiency and reducing fuel costs. The environmental managers of Nippon Steel illustrate the energy-saving measures in the 1970s as follows:

> Responding to the first oil shock, energy-saving measures during the 1974-78 periods focused on relatively small-scale capital investment such as operational improvement and small-scale waste heat recovery. Dependency on petroleum fuels for 20% of its energy consumption in the late 1970s, the Japanese steel industry realized the importance of significantly reducing its dependency on oil. A shift from heavy oil to coke was achieved by replacing the heavy oil used in reheat furnaces by coke oven gas. By 1982 there was a shift to 100% use of coke. After the second oil shock in 1979, continuous casting was implemented and large-scale capital investment in process development, such as introduction of large-scale waste heat recovery equipment, was undertaken. Examples are the coke dry quenching (CDQ) system, blast furnace top pressure recovery turbine (TRT), and sinter waste heat recovery equipment. As oil and coal prices stabilized in the mid-1980s, the steel industry made an effort to reduce its purchase of electricity, which had become a relatively expensive form of energy. Companies built power generation facilities that made use of the waste energy that was generated in the steel-making process. Consequently, the electricity purchase ratio declined from 31% in 1980 to 13% in 1995 (Okazaki et al., 2002).

The Japanese industry sectors import a majority of energy sources from overseas. Since their business operations are vulnerable to the energy price increases, they began to realize that it is critical for them to lower their energy usage. Their initiatives in energy-saving measures are the source of the climate change initiatives that were implemented in the 1990s.

Despite the great degree of social movement for environment protection in Japan, there are presently no visible social movements for climate change protection. This is partly related to the fact that while the local environmental problems have direct impacts on human health and raised serious health concerns in the society, the effects of climate change are not visible in their life. There is a perceptional disconnection between the global agenda and the local reality. In addition, NGOs are relatively weak constituencies in Japan. Fukui pointed out that the societal foundation for NGOs activism is not strong.[44] Although the Japanese steel industry sector releases a significant

[44] Vermont also contends "unlike similar public opinion changes in the United States, however, the transformation of Japanese public opinion from indifference to commitment was not accompanied by the development of strong national organizations or by the appearance of organized pressure groups in the capital. The struggle that eventually produced a shift in national policy was

volume of GHG emissions, there is no vocal criticism among the NGOs community. Vermont argues at this point that "despite Japan's domestic activism in environmental matters, there has been no accompanying development of national movements devoted to preserving the environment, such as the Greens in Europe or the Sierra Club and the Natural Resources Defense Council in the United States" (Vernon, 1993). There are no direct pressures from stakeholders either to the steel industry sector to take climate change initiatives in Japan. It seems, however, that the public together with the NGOs community are also taking into account the importance of the steel industry sector for its economy.

Despite the absence of social pressures to the steel companies in Japan, all of the interviewed managers stated that they take climate change initiatives to avoid future "reputation risk" in the society. They are attempting to avoid the risk by establishing a voluntary GHG emissions reduction target. It seems, in fact, that the concerns among the steel companies about their future reputation are a strong driver for having established the voluntary target. In addition, there is also a strong sense in the Japanese steel industry sector that a failure of meeting the voluntary target results in a loss of company's reputation.

At this point, several interviewed managers also mentioned that considering the fact that the industry is releasing a major part of the country's GHG emissions, they feel responsible for reducing the emissions. It seems that a sense of morality also plays an important role in the formulation of corporate strategy. Amartya Sen argues that "the immense contribution of business morality and ethical behavior to economic success is very hard to dispute" (Sen, 2003). Although the extent of the contribution is unclear, it is clear that some parts of the climate change initiatives in the Japanese industry sector are attributable to the sense of morality as well as to the sense of commitment to the society.[45]

6.2.2 Divergent factor: Regulatory culture and schemes

Japan presently faces a difficulty in achieving its 6% GHG emissions reduction target under the Kyoto Protocol. In 2002, the country's GHG emissions release increased by 7.6% relative to the 1990 level. This suggests that the country must reduce GHG emissions by 13.6% in order to meet the Kyoto target. While the GHG emissions from the industry sector decreased marginally relative to the 1990 level (-1.7%), the GHG emissions from the transportation, commercial and residential sectors increased greatly by 20.4%, 36.7% and 28.8% respectively.(Mizuno, 2005) The gap between the Kyoto target and the present level of the GHG emissions is the second largest next to Canada among the countries that established a GHG emissions reduction target under the Kyoto Protocol.

Based on the ratification of the Kyoto Protocol, the government introduced a series of legislations including the Climate Change Policy Law. The law serves as a framework legislation to meet the emissions reduction target under the Kyoto Protocol, the Climate Change Policy Program introducing a cross-ministerial program to

---

conducted through more ephemeral means - such as local movements and the media - that led eventually to recognition among policymakers that the public had developed some new expectations of environmental policy. With that change in expectations recognized by the bureaucracy, the Liberal Democratic Party, and the Keidanren, the stage was set for concerted national action." See Vernon, R. (1993) Behind the scenes - how policy-making in the European-Community, Japan, and the United-States affects global negotiations. *Environment,* 35**,** 13-&.

[45] Nakamura, Takahashi and Vertinsky conducted an empirical analysis to investigate the determinants that lead large Japanese manufactures to incorporate environmental goals in their decisions and obtain a certification of the Environmental Management System. Their result suggests that while the costs and benefits of voluntary actions to enhance or protect the environment and the capacity to act are significant determinants of voluntary environmental commitment, so are the environmental values, beliefs and attitudes of managers. See Nakamura, M., Takahashi, T. & Vertinsky, I. (2001) Why Japanese firms choose to certify: a study of managerial responses to environmental issues. *Journal of Environmental Economics and Management,* 42**,** 23-52.

implement GHG emissions reduction projects and the Energy Conservation Law establishing mandatory energy efficiency standards. In addition, the Japanese government announced its blueprint for achieving “The Kyoto Target Achievement Plan”. The Cabinet approved the plan in 2005. The plan established GHG emissions reduction targets as follows; 6.5% reduction by domestic measures, 3.9% by removal by sinks and 1.6% by the utilization of the Kyoto mechanism. The GHG emissions reduction by the industry is counted as part of the domestic measures. It is not clear however, whether or not the government will introduce a mandatory GHG emission reduction scheme. The attempt by the Ministry of the Environment to introduce a carbon tax has been facing strong opposition from the industry sectors.

It is noted that the Japanese regulatory scene on climate change greatly differs from other countries. The Japanese government has been unsuccessful in introducing climate change policy instruments such as a carbon tax and a domestic emissions trading scheme. Both were widely accepted and have been already implemented in the EU. Thus far, the voluntary GHG emissions reduction plan announced by Nippon Keidanren is the only major ground for the companies to reduce emissions. Despite the absence of a mandatory scheme or policy instrument, however, the Japanese industry sector has taken some initiatives to reduce GHG emissions. There are, in fact, some progressive initiatives. The following sections illustrate the regulatory (and voluntary) schemes on the GHG emissions reduction in the Japanese industry sector and discuss how they are related to the initiatives.

6.2.2.1 Keidanren Voluntary Action Plan on the Environment

The Japan Business Federation (Nippon Keidanren) is the most influential business association in Japan. It was originally founded in 1946 as a lobbying group representing the interests of large Japanese companies. One of its roles today is to find a common ground among Japanese companies on the climate change issues and to transform it into the government policy.

In 1997, Nippon Keidanren announced the Voluntary Action Plan on the Environment (KVAP). There are 50 industry sectors participating in the plan and each of them established a voluntary emissions reduction target by 2010. According to Nippon Keidanren’s statement, the common goal among the industry sectors is “to endeavor to reduce CO_2 emissions from the industrial and energy-converting sectors in fiscal 2010 to below the levels of fiscal 1990” (Nippon Keidanren, 1997). The progress towards the targets is annually reviewed and the results of the review are published every year. In 2005, the processes of 35 industry sectors were reviewed, corresponding to 82% of the total GHG emissions release from the industry sectors.

Nippon Keidanren’s voluntary plan has been receiving a number of criticisms with respect to its effectiveness and accountability. The criticism centered upon its unilateral nature of the plan. First, as the above Nippon Keidanren’s statement indicates, the plan aims at 0% GHG emissions reduction relative to 1990 level. This goal is inconsistent with the county’s 6% reduction target under the Kyoto Protocol. Second, Nippon Keidanren established the target without a formal negotiation with the government or a consultation process with stakeholders. Third, there is no clear third party auditing process (Ikuta, 2003). In response to the criticism against the lack of an auditing process, Nippon Keidanren formed an evaluation committee in 2003 to review and audit the plan annually. Criticism remains, however, that the review process itself is not transparent and credible (Nippon Keidanren, 2003). Usui illustrates the first two points as follows:

> Keidanren remains responsible for following up and publishing annual branch-by-branch summary progress reports, not subject to any officially recognized third party auditing. The government has not taken part in these progresses, except that the environmental councils of different ministries

occasionally hold joint hearings that entail no more than “questions and comments” (Usui, 2003).

It is important to point out that the Japanese voluntary plan is very different from European voluntary schemes. As discussed in Chapter 7, the European voluntary schemes such as the Long-term Agreements and Benchmarking Agreement in the Netherlands and the climate change programs in the UK, Germany and France are recognized as “negotiated” environmental agreements (NEAs). The European agreements were reached through negotiations between the government and industry. They are commonly equipped with an auditing and reporting scheme and linked to public incentive policy. On the other hand, the Japanese voluntary plan does not go beyond a unilateral announcement. It can be said that based on the OECD classification of VEAs indicated in Section 1.3.2.3, the Japanese scheme falls into the type 3: unilateral voluntary environmental codes and action plans (UVEPs) remaining outside the formal governmental policy framework.

Nevertheless, the Japanese industry sectors are generally moving toward meeting their “pledged” emissions reduction targets. A manager of the Japan Iron and Steel Federation (JISF) stated in an interview that “for us, the emissions reduction target established under Nippon Keidanren’s voluntary action plan is much alike a legally binding obligation. While there is no penalty for a failure of non-compliance under the plan, a failure in meeting the targets will result in a serious damage on company’s reputation. We learned from our experience in the industrial pollution period how it could be devastating once we have a negative reputation in the Japanese society. Our efforts to reduce GHG emissions are much beyond the philanthropic approach or CSR.”

The Japanese steel industry sector has relatively successfully reduced the GHG emissions under Nippon Keidanren’s voluntary action plan. It decreased GHG emissions by 8.7% in 2001 relative to the 1990 level (Ikuta, 2003). The JISF consisting of all steel producers in Japan established its goal to reduce energy consumption by 10% by 2010 relative to the 1990 level under the plan (Japan Iron and Steel Federation, 2006). The Japanese steel industry sector recognizes it as the master plan for GHG emissions reduction.

6.2.2.2 Carbon tax

Japan’s Ministry of the Environment (MoE) has been eagerly proposing to introduce carbon tax in Japan. The Ministry suggested a levy to impose a surcharge on processors and importers of fossil fuels of ¥3,400 (US$32) per ton of CO_2, some of which will be passed on to consumers. Receiving a strong opposition from the industry sectors, however, the Ministry conceded and reduced the proposed tax rate to ¥2,400 (US$21).

The Petroleum Association of Japan (PAJ), an influential interest group consisting of major oil companies, together with Nippon Keidanren is the center of the resistance. The Cabinet has not approved the carbon tax proposal due to strong resistance from the industry sectors. It is estimated, under the proposed tax scheme, that the consumers will pay ¥1.5 ($0.014) extra per liter of gasoline and that the annual burden on households will be in the range of ¥2,100 (US$18) and ¥3,000 (US$28). The Ministry of the Environment estimates that the tax scheme will generate a new income of ¥37 billion (US$320 million) a year for the government (Green Car Congress, 2005). These estimates were discussed at the Central Environmental Council which is an advisory body of the MoE on the global environmental issues including climate change.

Particularly noteworthy, resistance to the carbon tax scheme is also coming from within the government itself. The Ministry of Economy, Trade and Industry (METI), being responsible for the economic and energy aspects of climate change policy, disagrees with the Ministry of the Environment with respect to the introduction of the carbon tax scheme. The METI discussed this as follows:

> The introduction of an environmental tax is presently facing opposition from the industry sectors on the ground that the effects of GHG emissions reduction on the domestic and transportation sectors are unclear. The GHG emissions from these sectors are remarkably increasing. In addition, an environmental tax may bring adverse effects on international competitiveness of the Japanese industry sectors competing with the U.S. and China in the international market. It may also lead to transferring production sites abroad resulting in an increase of GHG emissions. At present, an evaluation of an environmental tax as an economic instrument is taking place in Japan. (Ministry of Economy Trade and Industry, 2004).[46]

As the agency to design Japanese industrial policy, the METI pays attention to a possible loss in international competitiveness. On the other hand, the MoE places its attention on Porter's hypothesis that the companies adopting environmental regulations in the earlier stage may obtain competitive advantages in the international market against their competitors (Ministry of the Environment, 2004).

In the early stage of discussion, it was estimated that when the carbon tax scheme was to be imposed on the prices of coal and coke, the steel industry sector would have to bear an additional ¥160 billion (US$140) annually. The steel industry sector expressed its strong objection against such a scheme. The MoE accepted its objection in the latest proposal and listed coal and coke use for the steel production as exempted items from the carbon tax scheme. It is clear that an introduction of the carbon tax scheme is emerging as an essential source of regulatory pressures for the industry sectors in Japan. The companies in the energy-intensive sectors are formulating their strategies against such a mandatory scheme.

6.2.2.3 Domestic emissions trading scheme

Japan's MoE has been also proposing to introduce a domestic emission trading scheme in Japan. As stated earlier, the EU (and Norway) has already introduced a cap and trade scheme starting from 2005. Canada is planning to introduce its scheme from 2008. While the Ministry's proposal is to have a mandatory cap and trade scheme, the details of the proposal are not determined. Currently, there is an academic and policy debate about which industry sectors are to be covered under the scheme and whether the coverage would be geared to the "upstream" or "downstream" industry sectors.[47] Interestingly enough, the majority of Japanese economists are presently in favor of capping on the upstream industry sectors with respect to the GHG emissions (Niizawa et al., 2003). This proposed mechanism is in sharp contrasted to the EU ETS which caps the downstream industry sectors. The WWF (World Wide Fund for Nature) also supports the downstream approach in Japan (Matthes, 2004).

Whether it is a downstream or upstream approach, there is strong resistance from the Japanese industry sectors to the introduction of a domestic emissions trading scheme. Nippon Keidanren, together with the Japanese Chemical Industry Association and the Japan Iron and Steel Federation released an official statement against the scheme. They maintain that the Japanese industry sectors have made good progress in reducing their GHG emissions releases under Nippon Keidanren's Voluntary Action Plan. The METI shares a similar view as follows:

---

[46] Some words and phrases were replaced to correct grammatical errors and/or to change styles to the extent that it will not affect the contents of the original sentences.

[47] The upstream and downstream industry sectors are determined by the distribution flow. An example of the upstream industry sectors is with regard to fuel importers. The steel industry sector is an example of the downstream industry sector that consumes fuel at the end of the distribution flow.

> It has been discussed that we shall introduce a cap-and-trade emission trading scheme in Japan. However, there is a question whether the government can allocate the emissions allowances fairly and objectively in advance. On the other hand, the industry sectors are making progress in reduction GHG emissions under the voluntary action plan. It is important for us to consider whether the emissions trading scheme is an efficient economic instrument in comparison to other measures under way (Ministry of Economy Trade and Industry, 2004).[48]

In 2005, the MoE introduced a voluntary emissions trading scheme among 30 companies. There are no companies, however, participating from the energy-intensive sector. Whether or not a cap and trade emissions trading scheme will be implemented is unclear in Japan.

6.2.2.4 Government support for CDM and JI

MoE's proposals to introduce a carbon tax and a domestic emissions trading scheme have been receiving a strong objection from the industry sectors. On the other hand, there are other governmental initiatives gaining support in Japan. One of the initiatives is to purchase carbon credits through implementation of CDM and JI projects. In 2004, two government-owned banks, the Development Bank of Japan (DBJ) and the Japan Bank for International Cooperation (JBIC) formed the Japan GHG Reduction Fund (JGRF) with an initial fund of U.S. $140 million. There are 30 Japanese large firms investing in the fund. The fund was formed to purchase carbon credits generated from CDM and JI projects, namely the CERs and the ERUs. Table 23 lists the participating companies:

Table 23: Participating companies in the Japan GHG Reduction Fund (JGRF)

Sectors	**Firms**
Electric utility and gas sector	Chubu Electric Power Co.,Inc., Tohoku Electric Power Co.,Inc., Tokyo Electric Power Co.,Inc., The Chugoku Electric Power Co.,Inc., Electric Power Development Co.,Ltd.(J-Power), Hokkaido Electric Power Co.,Inc., Hokuriku Electric Company, Kansai Electric Power Co.,Ltd., Kyushu Electric Co.,Inc., Shikoku Electric Power Co.,Inc., The Okinawa Electric Power Co.,Inc., Tokyo Gas Co.,Ltd.
Other energy-intensive sector	Nippon Oil Corp., Idemitsu Kosan Co. Ltd., Japan Energy Corp., Kyushu Oil Corp., The Japan Iron and Steel Federation, Taiheiyo Cement Corp.,
Manufacturing sector	Sony Corp., Toshiba Corp., Sharp Corp., Fuji Xerox Co., Ltd., Toyota Motor Corp., Terumo Corp.
Trading sector	Mitsubishi Corp., Mitsui & Co., Ltd., Sumitomo Corp., Itochu Corp., Marubeni Corp., Sojitz Corp.
Engineering sector	JGC Corp.

The companies participate in the fund for various reasons. The trading firms such as Mitsubishi, Mitsui & Co., and Sumitomo are mainly interested in buying CERs and ERUs and selling them at higher prices to the companies in

[48] Some words and phrases were replaced to correct grammatical errors and/or change styles to the extent that it will not affect the meaning of the original sentences.

the manufacturing and energy-intensive industry sectors in Japan. Some manufacturing firms such as Sony, Toshiba, Fuji Xerox, Toyota Motor and Terumo are keen to count the carbon credits as part of their carbon neutral initiative. It can be said that their investment into the fund is associated with their CSR strategies. The motive of the companies in the energy-intensive sectors is linked to the Nippon Keidanren's Voluntary Action Plan. There are many companies participating in the fund from the electric utility, gas, oil, iron and steel and cement sectors. They consider counting the carbon credits as part of their GHG emissions reduction commitments under the voluntary plan.[49]

It is clear that CDM and JI are one of a few policy instruments that the government and the industry sectors both agreed to implement in Japan. As stated, the Japanese government relies on obtaining carbon credits equivalent to 1.6% of country's GHG emissions release through the CDM and JI under its Kyoto Target Achievement Plan. In this situation, Japanese companies are more willing to conduct CDM and JI projects. As seen in Table 24, Japan is emerging as the largest buyer of the CERs and ERUs in the carbon credit trading market (International Emissions Trading Association and the World Bank, 2006).

Table 24: Ranking of CERs and ERUs buyers in 2004 and 2005[50]

January 2005 to March 2006 Overall volume: 453.5 million tCO_2e			January 2004 to December 2004 Overall volume: 110.0 million tCO_2e		
Rankings	Countries	%	Ranking	Countries	%
1	Japan	38%	1	Japan	36%
2	UK	15%	2	The Netherlands	19%
3	Italy	11%	3	Unspecified	13%
4	Other Europe	9%	4	UK	9%
5	The Netherlands	8%	5	Other Europe	7%
6	Europe-Baltic sea	8%	6	Europe-Baltic sea	6%
7	Spain	5%	7	Canada	4%

(Source: International Emissions Trading Association and the World Bank, 2006)

6.2.2.5 Asian Pacific Partnership on Clean Development and Climate

The Japanese government announced that the country participates in the Asia-Pacific Partnership on Clean Development and Climate. The Partnership is a multilateral non-treaty agreement among Australia, China, India, Japan, South Korea, and the United States. It was announced in 2005 at the Association of South East Asian Nations (ASEAN) Regional Forum meeting. The countries agreed to co-operate on the development and transfer of technologies to reduce GHG emissions on a voluntary basis. Under the agreement, they established eight task forces including (1) cleaner fossil energy; (2) renewable energy and distributed generation; (3) power generation and transmission; (4) steel; (5) aluminum; (6) cement; (7) coal mining; and (8) buildings and appliances.

---

[49] In 2005, the METI started another initiative called the "Upfront Payment Scheme" with an annual budget of US$ 54-76 million. The scheme provides financial assistance to the project developers in the developing countries to cover up to 50% of the total project cost. This cost is borne in return of a future delivery of the carbon credits. The fund requires an involvement of Japanese firms in the arrangement.

[50] According to the source, purchases by the World Bank-managed funds have been attributed to the fund participants' countries pro rata. The Europe-Baltic Sea refers to Finland, Sweden, Norway, Germany, Denmark and Iceland. Other Europe refers to France, Portugal, Switzerland, Austria, Belgium, Luxembourg, and Greece + Italy and Spain. Other European purchases refer to buyers based in Europe. UNSP refers to purchases that are not possible to be verified with respect to the origins of the buyers.

There is a worldwide criticism against the agreement for the non-mandatory nature. It is also criticized for its inconsistent nature with the Kyoto Protocol. For the Japanese government, however, it is an endeavor to establish a policy framework to include countries without the GHG emissions reduction target under the Protocol. The Japanese industry sector generally welcomes the non-mandatory nature of the agreement.

Particularly noteworthy under the Partnership is that the Japanese steel industry sector chairs the Steel Task Force. The task force established the following objectives:

- Develop sector relevant benchmark and performance indicators.
- Facilitate the deployment of best practice steel technologies.
- Increase collaboration between relevant Partnership country government, research and industry steel-related institutions.
- Develop processes to reduce energy usage, air pollution and greenhouse gas emissions from steel production.
- Increase recycling across the Partnership.

The Japanese steel industry sector considers that this agreement can be a potential framework for the post-Kyoto regime. Their view on the post-Kyoto regime is elaborated in the section 6.3.

6.3 First level of analysis: Japanese corporate climate change strategy and management

This section presents an analysis of Japanese corporate climate change strategy and management. The thesis author collected information and data through extensive literature reviews including academic journals, industry journals, annual reports, sustainability reports, newspapers, company's websites and other. Based on the research method indicated in Section 3.3, the thesis author also conducted open-ending interviews with the two largest steel companies in Japan, Nippon Steel and JFE. He also had an interview with the Japan Iron and Steel Federation (JISF). Some information was collected through a site visit to Nippon Steel's Kimitsu steel plant. This section first presents an overview of the companies as well as of the JISF.

6.3.1 Company overviews

6.3.1.1 Nippon Steel

Nippon Steel is the 3rd largest steel company in the world with four blast furnace plants including Yahata, Nagoya, Kimitsu and Ooita. In 2004, the company produced 34.4 Mt of crude steel production in 2004 representing 27.4% of the Japanese market, an increase from 27.2% in 2003 and 25.6% in 2002 (International Iron and Steel Institute, 2005). Nippon Steel has experienced steady business growth due to increases in exports to China and other countries in Asia.

In the highly fragmented market, Nippon Steel has a strategy to advance an alliance with other major steel makers. The company formed an alliance with POSCO to transfer its direct-melting gasification technology to POSCO. It formed another strategic alliance with Arcelor to produce steel sheets for automobiles. It works with Kobe Steel to acquire equity stakes in East Asia United Steel, which will share semi-finished products. Bao Steel-Nippon Steel/Arcelor Automobile Steel Sheets is a joint venture in China among Nippon Steel, Arcelor, and Bao Steel that began in 2004 (However, the prospect of this joint venture is uncertain after Arcelor and Mittal merged in 2006). The company also formed the Nippon Steel and Sumikin Stainless Steel Corporation in 2003, with Sumitomo Metal Industries. Integration of the two company's stainless steel businesses has created the largest stainless steel manufacturer in Japan.

6.3.1.2 JFE

JFE is the 4th largest steel company in the world with three blast furnace plants including East Japan (Keihin and Chiba), West Japan (Fukuyama and Kurashiki) and Chita. The company produced 31.6 Mt of crude steel production in 2004 (International Iron and Steel Institute, 2005). In 2002, it became a holding company for Kawasaki Steel and NKK. JFE also takes advantage of the growth of the Chinese market. The company established a joint venture with Guangzhou Iron & Steel Enterprises Holdings in 2003. It also formed a strategic alliance with European steel producers including Corus and Thyssen Krupp.

6.3.1.3 Japan Iron and Steel Federation

JISF is a business association consisting of all steel producers and exporters in Japan. JISF conducts research, compiles statistics on the steel market and addresses new technologies for steel production. Mostly importantly, the organization represents the interests and concerns among the steel companies and provides its position papers on the public policy issues including climate change. It also operates as the focal point among the steel companies for the implementation of Keidanren's voluntary plan for GHG emissions reduction as well as for the participation into the Japan GHG Reduction Fund (JGRF).

6.3.2 Analysis

6.3.2.1 Policy statement

There are a number of policy statements by the Japanese steel companies on global climate change. The Japanese steel companies as well as the JISF developed position papers on climate change policy instruments such as the carbon tax, emissions trading and CDM/JI. The following statements made by Nippon Steel and JFE reflect their stance on climate change issues:

> Nippon Steel has already achieved the highest level of energy efficiency in the world for manufacturing the raw materials of steel which are indispensable for the ongoing development of society, and is now striving to obtain further efficiency improvements aimed at preventing global warming. We are also making efforts to reduce CO_2 emissions in collaboration with society by supplying highly functional materials, and are also striving to make our civilian and transportation departments more efficient. In addition, we are internationally promoting the utilization of energy conservation technologies (Kyoto Mechanisms) for the reduction of CO_2 on a global scale and also the global development of breakthrough technologies (development of hydrogen energy, CO_2 separation and storage) from a long-term viewpoint (Nippon Steel Corporation, 2005c).
>
> JFE Steel fully recognizes the importance of global warming and is committed to solving this urgent problem by developing and introducing new energy saving technologies and by developing the next-generation of steel manufacturing technologies. At the same time, JFE Steel is contributing to preventing global warming both in industrial sector and in the consumer/transportation sectors with environment-friendly steel products and new energy saving technologies (JFE Holdings, 2005).

There are two important messages in the policy statements. One message is that they reached a high level of energy efficiency in their steel production process. They maintain that they will continue to improve the energy efficiency of their systems. The second message is that they need to develop new technologies to reduce GHG emissions in the long term. JFE refers to them as the next-generation steel manufacturing technologies.

The reason why they discuss the transportation and household sectors is that there is a sentiment in the Japanese steel industry sector that although they are successfully reducing GHG emissions in the industry sector, the emissions from the transportation and household sectors are increasing.[51] From their viewpoint, they are not directly responsible for the drastic increase of GHG emissions in those sectors. Several interviewed managers maintained that while there is some room for improvement to reduce GHG emissions released from the combustion processes, it is becoming impossible to reduce GHG emissions release from the chemical reaction in the blast furnace process. They maintain that the government and the public attention to GHG emissions reduction should be addressed to the transportation and household sectors. Several interviewed managers maintained that "the public awareness of global climate change is low in Japan. It is important to recognize that the society, as a whole, is responsible for reducing the GHG emissions and transforming from the carbon to hydrogen society."

---

[51] GHG emissions from the transportation sector increased by 20.4%, while GHG emissions from the industry sector decreased by 1.7% in 2002 relative to 1990 level.

6.3.2.2 Organizational structure

In the last 10 years, Nippon Steel and JFE have received regulatory pressures to handle climate change issues both at the international and domestic levels. In response to such pressures, they have made continuous changes in the organizational structure. Global climate change has begun to arise as an important corporate agenda for the Japanese steel industry sector after the Earth Summit in 1991. Prior to this event, the main environmental tasks for the steel companies were only related to the pollution prevention issues. According to a manager of Nippon Steel, the company re-structured the Environmental Control Department into the Global Environmental Affairs Department in 1995 to cope with global environmental agenda. In the same year, NKK, one of JFE's former core companies, established the Environmental Department. Since then, climate change is recognized in the Japanese steel industry sector as an environmental issue with the highest priority to cope with.

In the case of Nippon Steel, a vice president in charge of environmental affairs, Mr. Hideaki Sekizawa, has an ultimate responsibility for climate change issues. The president of the company, Mr. Akio Mimura, serves as a vice president of environmental affairs of Nippon Keidanren. He has been extremely influential in formulating Nippon Keidanren's climate change strategy as well as in shaping the steel industry sector's views on regulatory schemes such as carbon tax and emissions trading scheme. In the case of JFE, the president of the company chairs the company-wide Environmental Committee. The Environmental Management Committee is established for implementing environmental management at the production sites. The Environmental Committee formulates the company's climate change strategy, while the Environmental Management Committee handles the implementation of the strategy.

6.3.2.3 Information disclosure

Nippon Steel and JFE released information on their climate change strategy through an environmental report. They have published reports annually for the last several years. The companies now also publish a 'sustainability' report. They have begun to integrate social issues such as their relationships with stakeholders into their overall strategies and into their reports, as well. The environmental issues remain, however, the core of their reports.

Nippon Steel is one of a few steel companies answering a questionnaire sent out by the Carbon Disclosure Project (CDP). The other companies responding to the questionnaire are Arcelor, Corus Group, POSCO and US Steel. The CDP started in 2002 and has requested the information from the FT 500 companies on corporate climate change strategy. The information request was sent in the name of signed institutional investors. In 2006, the company coverage was expanded to 2,180 companies. Approximately 950 companies responded to the questionnaire in 2006. Nippon Steel was selected as one of the companies in CDP's Climate Leaders Index. The index was comprised of the companies that are "best in class" with respect to their responses to CDP's questionnaire.

While Nippon Steel and JFE disclosed thoroughly the information on their climate change strategies, they were hesitant to disclose data on the volume of GHG emissions released. There is a deep concern in the Japanese steel industry sector that the GHG emissions data may be used as a source of information for a mandatory regulatory scheme in the future. Under the Nippon Keidanren Voluntary Action Plan, the Japanese steel industry sector established their goal based on energy consumption reduction.[52]

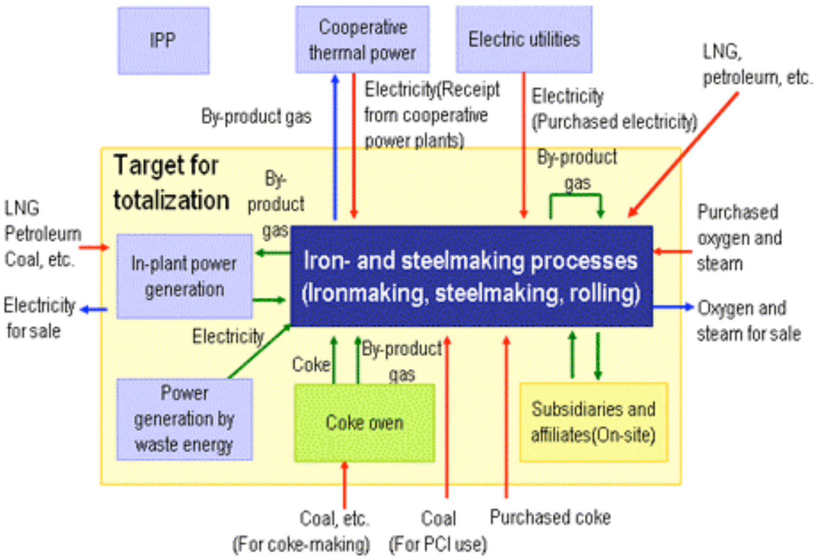
[52] As illustrated earlier, the JISF established a goal to reduce energy consumption by 10% by 2010 relative to the 1990 level, under the voluntary scheme.

6.3.2.4 Measurement

The Japanese steel industry sector established their target under Nippon Keidanren's Voluntary Action Plan based on the improvement of energy consumption. Nippon Steel maintains that the company reduced their energy consumption by 21.8% in 1990 and 28.9% in 2003 relative to the year of the oil crisis in 1973 (Nippon Steel Corporation, 2005a). However, there is no clear, third party auditing process to verify the improvement. The company does not disclose the information or data on the measurement of energy consumption.

There are some attempts to increase accountability of the measurement under the voluntary action plan. For example, JISF provided a definition of the energy boundary of the steel plant. As explained in Section 4.4.1.2, the energy use of the steel plant can vary greatly depending on the boundary. For example, whether or not including a supply of waste heat to a power generation unit located in the power plant or energy use in the coke oven plant within the boundary make a large difference in the total volume of energy consumption of the steel plant. The Japanese steel companies calculate their energy consumption based on the definition of the energy boundary by JISF illustrated in Figure 13:

Figure 13: Energy boundary defined by JISF



(Source: Japan Iron and Steel Federation, 2006)

6.3.2.5 Internal and external financial accounting

The Japanese steel industry sector has not yet integrated the costs and revenues associated with climate change initiatives in their external financial accounting. There are no climate change related costs and revenues described in their annual report. While there are some external pressures for the companies to incorporate them in their balance sheet (such as the CDP), the companies are not considering it seriously. A manager of JISF stated that environmental accounting has been only considered at the theoretical level.

It appears that a discussion on the "carbon" accounting has only begun a few years ago at the international level. Several major accounting organizations began to consider a specific guidance on accounting for carbon assets and liabilities and disclosure protocol. In 2005, the Canadian Institute for Chartered Accountants releases a discussion brief titled “MD&A Disclosure about the Financial Impact of Climate Change and Other Environmental Issues” (Canadian Institute for Chartered Accountants, 2005).

There are some efforts within the companies to calculate the climate change related costs. JFE describes in its sustainability report that it made ¥9.0 billion (US$7 million) capital investment and ¥14.4 billion (US$ 12 million) expenses as cost for “prevention of global warming” (JFE Holdings, 2005) in 2004. Nippon Steel reports that it made ¥84 billion (US$60 million) capital investment in energy-saving measures in 2004. This investment is identified as “global warming prevention costs” (Nippon Steel Corporation, 2005c). On the other hand, Nippon Steel maintains that “environmental conservation activities have effects in every part of the supply chains beyond our corporate boundaries and consequently we do not abstract some of them and convert into money as economical effect” (Nippon Steel Corporation, 2005a). Cost saving through improvement of energy efficiency as well as utilization of by-products is not integrated into their accounting system.

6.3.2.6 Product development

As the pressures among the automobile users increase to improve fuel efficiency of automobiles, the automobile companies began to consider using alternative lighter materials such as aluminum, plastics and other composite materials. They began to substitute plastics and aluminum for steel. The improvement of energy efficiency started to become increasingly part of strategic business considerations for the steel companies for securing the market share of their products (Innovest Strategic Value Advisors, 2005).

In response to this change in the market trend, the Japanese steel industry sector developed the Ultra Light Steel Auto Body (ULSAB). The ULSAB creates a lighter auto body resulting in the improvement of energy efficiency and reductions of GHG emissions. Nippon Steel managers stated in an interview that “the use of steel in auto bodies does not mean a heavy automobile. The use of the ULSAB can generate the lightest automobiles leading to fuel efficiency improvement.” The Japanese steel industry sector also contends that the use of steel provides better safety than plastics and aluminum. Nippon Steel reports that over 40% of automobiles are manufactured with the ULSAB in 2005. The use of the ULSAB contributes to the weight reductions of a vehicle by 7%, on average (Okazaki et al., 2004).

However, the production of light steel requires more energy than standard flat steel products. According to the interviewed managers, more energy is required especially in the continuous casting and hot rolling processes. Several interviewed managers stated that “it is necessary to consider the energy-efficiency performance of the ultra light steel from a more holistic perspective such as via the use of Life Cycle Analysis (LCA).”

6.3.2.7 Technological innovation

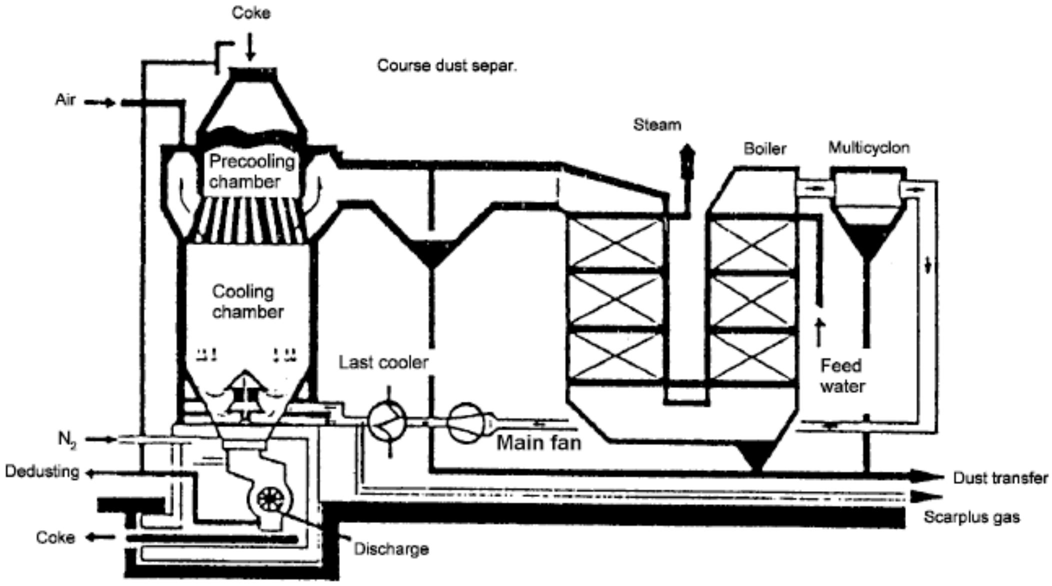
The Japanese steel industry sector takes a variety of technological measures to reduce GHG emissions. It appears that there are three main technologies to which they pay a particular attention: 1) Coke Dry Quenching (CDQ), 2) CO_2 capture and storage 3) the hydrogen energy project. The CDQ is a common technology among the integrated steel plants in Japan. However, it is uncommonly used in some countries. The Japanese steel industry sector promotes this technology as a technology-transfer initiative as well as a CDM project candidate in the developing countries especially in China. The latter two technologies are discussed in the context of future technological innovations. The Japanese steel industry sector has a strong strategic effort to conduct research and development on these technologies. The initiatives on the technologies are summaries as follows:

6.3.2.7.1 Coke Dry Quenching

The CDQ is a large waste-heat recovery system to quench red hot coke with nitrogen rather than water. Before the blast furnace process, it is necessary to cool down the red hot coke. According to the common approach, water is used for cooling and there is no recovery of thermal energy. According to the CDQ approach, nitrogen is used for cooling and high-pressure steam is generated through heat exchange with the hot nitrogen gas for producing electricity.

The CDQ was originally developed in Russian at the beginning of the 1960s (the so-called Giprokoks process). It was intended for application in the regions that have severe cold where wet quenching of coke is difficult. Moreover, the plants, in those regions, need considerable quantities of energy for heating purposes. Later on, the CDQ was applied in Japan and underwent further systematic development since the 1970s (European Commission, 2001). In the largest, integrated steel plant in Japan (Kimitsu work of Nippon Steel), there are three turbines with the CDQ generating 120MW. Figure 14 illustrates the CDQ:

Figure 14: CDQ technology diagram



(Source: European Integrated Pollution Prevention and Control Bureau, 2005) [53]

In Japan, the CDQ is under operation at 85% of the integrated steel plants. On the other hand, the CDQ is not utilized in most of the developing countries. As Table 25 indicates, the CDQ is not commonly used at the steel plants in the developed countries, either. (European steel companies show little interests in the CDQ. For the reasons, see Section 7.3.2.7.)

Table 25: Diffusion rates of energy efficiency improvement technologies among countries

	CDQ	TRT	Waste gas recovery from BOF
Japan	85%	100%	100%
South Korea	50%	100%	25%
United States	0%	2%	11%
United Kingdom	0%	9%	18%
Germany	33%	24%	0%

(Source: Japan Iron and Steel Federation, 2005)

Together with the CDQ, the above table illustrates the diffusion rates of other energy efficiency improvement measures including the TRT (Top Pressure Recovery Turbine) and waste gas recovery from blast furnace oxygen. The Japanese steel industry sector considers those measures can be implemented as a CDM in China. (For the interests of the Japanese steel industry sector in the CDM, see Section 6.4.3.)

6.3.2.7.2 CO_2 Capture and Storage

The Japanese steel industry sector is involved in the research and development projects for the CO2 CCS

[53] European Integrated Pollution Prevention and Control Bureau (2005) BREF: Production of Iron and Steel. Seville, European Commission. This document is available at http://eippcb.jrc.es/.

technology. CCS is a technology to capture CO_2 from large point sources such as power generation plants and storing it in underground geological formations. The technology is fairly developed but not utilized thus far. Nippon Steel participates in a national CO_2 project facilitated by the Research Institute of Innovative Technology for the Earth (RITE). They have also been participating in a project to develop CO_2 separation and storage technology using low-grade heat since 2004. In Japan, there is a great level of interest in the CCS among different industry sectors including the chemical, oil refinery and power generation. The CCS is recognized among the Japanese industry sectors as the only feasible "breakthrough" technology thus far to reduce GHG emissions. But you have not clarified what exactly the new carbon dioxide capture technology is. What is it and how does it work?

6.3.2.7.3 Hydrogen energy project

Nippon Steel is working on a five-year project to develop a technology to produce hydrogen from coke oven gas by combining heat from the steel making process, ceramic films for oxygen separation and catalysts to trigger a reaction for hydrogen separation. The company is implementing a demonstration project to produce liquefied hydrogen for use by fuel cell powered vehicles at Kimitsu. It reports that the company is committed to creation of a hydrogen-based society by tapping its engineering capabilities to mastermind the entire range of the hydrogen supply system (Nippon Steel Corporation, 2005c).

6.3.2.8 Integrated chain management/life cycle assessment

Nippon Steel and JFE integrate climate change issues in their supply chain management. Nippon Steel maintains that as part of its efforts to reduce GHG emissions, the company endeavors to improve loading ratio and optimize transportation means. It began to shift the mode of steel transportation from truck to railway in some cases. The company is in a dialogue with the main raw material supplier, Rio Tinto to reduce GHG emissions in the transportation of raw materials. Initiatives include switching to larger ships, conveyance sharing and selective use of transportation modes (Nippon Steel Corporation, 2006).

There are also some efforts to consider the scale of GHG emissions in the supply chain from the LCA viewpoint. Nippon Steel partakes in the LCA Energy Evaluation Research Committee facilitated by the METI. Nippon Steel reports that GHG emissions reduction by the use of the "high functional" or lighter steel for ships, rail vehicles, constructions, electric transformers, and power generation boilers was estimated to be 7.4 million tons of CO_2 per year in 2003 (Nippon Steel Corporation, 2006).

6.3.2.9 Partnership/membership

Nippon Steel and JFE both participate in the CO_2 Breakthrough Program established by the IISI (International Iron and Steel Institute). The IISI is a Brussels-based non-profit organization with a membership of 170 steel companies in the world. It serves as a forum to exchange information among the steel companies and as a research house to analyze the industry trends. The IISI launched in 2003 the CO_2 Breakthrough Program to "explore the opportunities, strategies and goals available globally to radically reduce CO_2 emissions". This is a multi-year program consisting of three phases over several years to explore possible CO_2 emissions reduction technologies. The companies in the program are to share the information and data on the technologies.

Besides the participation in IISI's program, Nippon Steel and JFE have established channels to exchange information with individual steel companies and associations on GHG emissions reduction measures. Nippon Steel began to work with Arcelor on the climate change issues as part of their strategic alliance agreement in 2001.[54] JFE has made a similar information exchange arrangement with Corus and ThyssenKrupp. In 2005, the Japan Iron and Steel Federation (JISF) concluded an agreement with the China Iron and Steel Association (CISA) to exchange information on environmental protection and energy saving measures. As discussed in the following section, this agreement is a basis for the Japanese steel industry sector to conduct CDM projects in China.

It is reasonable to say that Nippon Steel and JFE are proactively involved in the discussion at the regional and international levels to cope with global climate change. In addition, Nippon Steel participates in the IPCC discussion session as an industry expert. The company submitted a paper titled “Voluntary initiatives of Japan’s steel industry against global warming” to IPCC’s working group III (Okazaki et al., 2004). As mentioned above, Japan steel industry sector also chairs the steel task force in the Asia-Pacific Partnership on Clean Development and Climate.

[54] The future prospect of the alliance is, however, uncertain after the merger between Arcelor and Mittal Steel.

6.4 Second level of analysis: Japanese corporate responses to the climate change policy instruments

This section presents an analysis of Japanese corporate responses to the selected climate change policy instruments. The thesis author collected information and data through extensive literature reviews including academic journals, industry journals, annual reports, sustainability reports, newspapers, company's websites and others. As stated in the previous section, he conducted open-ending interviews with Nippon Steel and JFE as well as the JISF. Essential information was obtained through the face-to-face interviews.

6.4.1 Carbon tax

As described in Section 4.2.4.2.2.2, there is a strong regulatory pressure from the Ministry of the Environment to the industry sectors to accept an introduction of carbon tax. The MoE continues proposing the carbon tax scheme to impose surcharge on processors and importers of fossil fuels. On the other hand, the Ministry of Economy, Trade and Industry disagree with MoE's proposal. There is no consistent view on the carbon tax scheme among government agencies. It is unclear whether and how carbon tax is introduced in Japan.

The Japanese steel industry sector is strongly opposed to the introduction of a carbon tax. The JISF made the following statement titled "Our view on the global warming policy instruments" issued on September 20th 2005:

> It is argued that an environmental tax provides a price incentive, generates additional financial resources and leads to an "announcement effect" to the public. It is highly questionable, however, whether an environmental tax leads to a price incentive. For example, the increase in oil price has not been affecting the oil demand. In fact, an environmental tax will likely result in negative economic impacts on the households as well as on small and medium-sized enterprises. Whether or not an introduction of an environmental tax will generate additional financial resources is also uncertain under the present situation where the economic impacts of the present climate change budget of the government are unclear. The announcement effect to the public can be better achieved through public awareness and educational programs on global warming (Japan Iron and Steel Federation, 2005).

The Japanese steel industry sector has been successful in convincing the government to remove coal and coke use for the steel production from the items under the proposed carbon tax scheme. Interviewed managers expressed their strong objection against a carbon tax. They maintain that an introduction of a carbon tax will result in increases of electricity prices. Based on their argument, when increases of electricity prices become additional costs to the steel production, The Japanese steel companies have no option but to include those increases in their price of steel. According to them, consequently, they will lose in international competitiveness of their products. This point is further elaborated in the section 6.4.2.

6.4.2 National emissions trading scheme

As described in Section 6.2.2.3, the MoE proposed to introduce a "cap-and-trade" based emissions trading scheme in Japan. There was strong resistance, however, from the industry sectors to the introduction of the emissions trading scheme. As seen in Section 6.2.2.3, Nippon Keidanren released an official announcement against the scheme. The JISF made a separate statement as follows:

> Japanese industry sectors achieved a high level of energy efficiency through a series of energy saving measures since the oil shock. Nevertheless, there is an attempt to introduce a series of regulatory

> schemes to control GHG emissions release including a carbon tax and a cap-and-trade based emissions trading scheme. The introduction of these schemes will result in a serious loss of international competitiveness with neighboring countries that do not have such mandatory schemes. Furthermore, it may cause a loss of employment in Japan. From the perspective of global warming mitigation, in fact, these schemes may result in adverse effects by increasing GHG emissions in the neighboring countries especially China (Japan Iron and Steel Federation, 2005).

The statement indicates that the opposition against an introduction of the emissions trading scheme is based on two reasons. The first reason is a loss of international competitiveness. The second reason is a possibility of increasing GHG emissions release in the neighboring non-Annex I countries. The following sections elaborate upon these two points, separately.

6.4.2.1 International competitiveness

The IEA study discussed in Section 2.1.4 indicates that introduction of emissions trading scheme unlikely result in significant cost increase in the steel industry sector (Reinaud, 2005). The study also concludes that considering the price electricity of steel products, the demand reduction from the price increase of steel production remains low. Taking into account the international border tariff and transportation cost, the study simulates the price differences between local steel products and foreign products. The study suggests that since the price of local steel products is more attractive than foreign products, the sales of local products are unlikely affected by foreign products.

Some steel industry experts indicate that additional costs associated with an introduction of a cap-and-trade emissions trading scheme unlikely affect the business bottom line of the steel industry sector. Firstly, there is a wide range of steel products with respect to quality. Steel industry experts maintain that the steel producers in the emerging markets are still limited in capacity of producing high quality flat steel requested by the key industries such as automobiles. Therefore, the high quality steel produced in the developed countries cannot be replaced by foreign low quality steel. Second, the operation and maintenance of a large-scale steel production process requires a high level of technology and craftsmanship skills that are impossible to acquire in the short period of time. Steel industry experts argue that it requires several years until the steel producers in the developing countries obtain such technologies and skills. Therefore, the steel productions in the developing countries do not address an immediate threat to the steel makers in the developed countries in the international market.

In the case of the Japanese steel industry sector, steel industry exports point out another point as a reason that foreign steel productions are not threat to it. They emphasize the trust-based relationship as well as the long-term purchasing agreements that the Japanese steel companies have built with their customers. According to them, the relationship will not be spoiled with a marginal price increase. According to them, the automobile industry, for example, values a stable supply of high quality steel more than a marginal price increase.

The Japanese steel companies present contrary views to the above-mentioned analysis by the IEA. They consider that an introduction of cap-and-trade based emissions trading becomes additional cost to their production and result in loss of international competitiveness. A JFE manager stated that if the additional cost exceeds ¥2,000 (US$17) per ton of steel production, it becomes necessary for the company to pass some of the costs to their customers. According to the view of the company, the loss of international competitiveness may occur both in the domestic and international markets. As for the domestic market, if they increase the price of steel products, domestic customers may begin to purchase foreign products. In fact, the volume of steel imports from South Korea is increasing in Japan. A JFE manager pointed out that there is no significant difference any longer in quality between Korean and Japanese steel products. According to a Nippon Steel manager, there is a possibility that Chinese steel producers catch up with Japanese steel producers with respect to the level of the steel production technologies in the next five years. He stated that the quality of Chinese steel products is already acceptable for Japanese consumers except the high quality steel for the automobile industry. He added that the business culture in Japan to respect long-term trusted based relationship is no longer existent. Japanese customers simply select lower-rated products today if the quality of the products satisfies their needs.

As for the international market, the Japanese steel companies maintain that if they increase the price of their steel products in other Asian markets such as the Southeast Asian market, the customers in the markets may begin to purchase steel products from South Korea and China.[55] A JISF manager stated that there is already a severe market competition between Japanese and Korean steel makers in those markets. Several interviewed managers emphasized a difference between Japanese and European steel makers with respect to their customer locations. Whereas the majority of European steel products are consumed within Europe, the majority of Japanese steel products are exported to the foreign countries.[56] Since all EU countries have the emissions reduction targets under the Kyoto Protocol, European steel companies can increase their steel price in the domestic market without considering market competition against other EU steel markets in the region. On the other hand, Japanese steel makers are forced to compete in the Asian market against Korean and Chinese steel makers that are free from any obligations under the Kyoto Protocol.

6.4.2.2 Carbon leakage

The second reason for the Japanese steel industry sector to oppose against an emissions trading scheme is the possibility of increasing GHG emissions release in the neighboring non-Annex I countries. This is so called “carbon leakage” among climate change policymakers. By definition, carbon leakage refers to the indirect impacts of climate change policy, specifically, the replacement of GHG emissions from one source to another source. The replacement from one Annex I country to another Annex I country is acceptable since the total volume of GHG emissions between the countries are capped under the Kyoto Protocol. However, the replacement from an Annex I country to a non-Annex I country is problematic since there are no-cap on the GHG emissions released from the non-Annex I countries under the Protocol. Carbon leakage takes place in the steel industry sector when, for example, a steel production site is moved from Japan to China. In Japan, the GHG emissions from a steel plant are counted as part of the country’s total GHG emissions release. However, this is not case with China. Transfer of a steel production site from Japan to China results in increase of GHG emissions release. This is due to the fact that on per unit of steel produced in China, more GHG are released because they are using less efficient technologies than are used in Japan.

6.4.2.3 European Union Emissions Trading Scheme

It appears through several interviews that the Japanese steel companies have a critical view on the EU ETS. A Nippon Steel manager mentioned that although the EU ETS is a cap-and-trade system, European steel companies are granted sufficient allowances to the extent that they need no GHG emissions reduction efforts to achieve the cap. The manager added that the GHG emissions reduction target that the Japanese steel companies establish under the Nippon Keidanren Voluntary Action Plan is much harder to achieve than the target for European steel

---

[55] As indicated in Section, 4.1.2.1, those countries in Asia importing steel include Taiwan, Thailand, Vietnam, the Philippines, Indonesia and Singapore.

[56] As indicated in Section 4.1.2.1, the volume of steel that the EU traded within the region reached 77.9 million metric tons in 2003. Japan exports 6.4 and 22.3 million metric tons of steel to China and other Asian countries in 2003 respectively.

companies under the EU ETS.

Several interviewed managers stated that European steel plants are building new steel plants outside of Europe such as Brazil and the United States in order to avoid the costs associated with the Kyoto Protocol and the EU ETS. They maintained that this leads to carbon leakage. They emphasized that in the case of the Japanese steel industry, the entire steel production is conducted in the country and the GHG emissions release from the production is counted as their domestic emissions.

6.4.3 Clean Development Mechanism and Joint Implementation

The Japanese steel industry sector supports an implementation of CDM and JI projects. For several years, The Japanese steel companies have conducted a series of feasibility studies on CDM and JI projects commissioned by the NEDO (New Energy and Industrial Technology Development Organization) in Japan. The feasibility studies have been done in a various steel production locations including China, Brazil, Russia, Indonesia, Thailand, Ukraine and other countries (The list of the feasibility studies is contained in the sustainability reports of Nippon Steel and JFE). They were commissioned by the NEDO to build several model facilities for improvement of energy efficiency in China, India, Malaysia and Thailand. The Japanese steel companies have obtained their CDM expertise through the opportunities facilitated by the NEDO.

The main interest of the Japanese steel industry sector in CDM is to obtain the credits in the form of CER (Certified Emissions Reduction) and count them as part of their emissions reduction target under Nippon Keidanren's voluntary scheme. JISF announced the following statement regarding CDM:

> It is our request to the Japanese government to establish a strategy to make use of the Kyoto mechanism and work with the CDM Executive Board in order to promote more energy efficiency improvement projects as a CDM activity. We seek further support from the government on the development of CDM projects (Japan Iron and Steel Federation, 2005).

The views of individual steel companies are along this line. For example, Nippon Steel states "it is important for Japan to make use of the Kyoto mechanism in order to achieve our target under the Kyoto Protocol. We believe that an implementation of the Kyoto mechanism including CDM and JI contribute to the prevention of global warming" (Nippon Steel Corporation, 2006).

Several interviewed managers stated that Japanese steel companies are more interested in conducting CDM than JI. In fact, JI has not been their scope of consideration for project implementation. There are several reasons for the absence of their interests in JI. The first reason is a lack of their experience in the JI countries such as Russian and Ukraine. They perceive higher investment risk in these countries. They consider that there are higher political and other investment risks in Russia and Ukraine than Asian and South American countries. The second reason is higher level of uncertainties relating to the UNFCCC procedures for the JI project implementation. Presently, the UNFCCC procedures for the CDM project implementation are established in more robust and accountable fashion.[57] However, the UNFCCC procedures for the JI are still unclear. The third reason is unpreparedness of the

[57] The favorable trend for CDM projects is reflected in the larger trade volume of the CERs relative to the ERUs. According to the State and Trends of the Carbon Market 2006 report published by the International Emissions Trade Association and World Bank, the traded volume of the CERs in 2005 was 346.15 million CO_2e tons, while the traded volume of the ERUs was 17,78 million CO_2e tons. See International Emissions Trading Association and the World Bank (2006) State and Trends of The Carbon Market 2006. Washington DC.

governments to host JI projects. The JI host governments have not provided a clear guidance for the project approval procedure. In addition, the support of the JI host governments for the project implementation is relatively weak. The support of the CDM host government is greater, while the degree and form of the support vary among the CDM host countries.

There are several initiatives on CDM among Japanese steel companies. First, Japanese steel companies through the JISF jointly invested US$5 million in two carbon funds respectively: the Japan GHG Reduction Fund (JGRF) and the World Bank Bio Carbon Fund. As seen above, the JGRF is a fund established by the DBJ and the JBIC. Japanese steel companies are acquiring carbon credits through these funds. Second, Nippon Steel, together with Mitsubishi Corporation, invested in a HFC-23 decomposition project in China to capture and incinerate HFC23. HFC is a by-product of HCFC22 which is a refrigerant frequently used in the chemical products. This project is estimated to reduce 10 millions tons CO_2e per year and considered to be one of the largest CDM projects ever conducted with respect to the volume of generated CERs.[58]

Third, Japanese steel companies promote energy efficiency improvement projects as a CDM activity in the steel industry sector in the developing countries.[59] At present, they are focusing on CDQ and TRT projects in China. As explained above, the CDQ is a large waste-heat recovery system to quench red hot coke with nitrogen for electricity generation. TRT is a system to recover exhaust pressure and heat from the blast furnace for electricity generation. Nippon Steel is working on two potential CDQ projects in China to conduct them as CDM activities (Okazaki, 2006).[60] The company considers that those projects contribute to technology transfer to the developing countries. According to the company, it investigates a replicability of the result of the projects in the other countries such as Brazil and India.

There is a debate whether or not an acceleration of technology transfer to China leads to a future threat in the international market for the Japanese steel industry sector. As mentioned earlier, there is a prospect that Chinese steel markers turn into a major exporter when the steel demand in the local market is met around 2008. With this respect, a JFE manager stated that technology transfer takes place in any case, if not Japanese companies, European companies come to China and provide technologies. Increasing Chinese technological capability and future threat in the market are not a main concern for the Japanese steel industry sector to conduct CDM.

As mentioned above, the primary interest of the Japanese steel industry sector in CDM is to obtain carbon credits and count as part of their emissions reduction target under Nippon Keidanren's voluntary scheme. However, it also recognizes CDM as a mechanism to boost their sales of technology to the other countries. A JFE manager mentioned that the environmental department is closely working with their in-house international marketing team to identify possible project sites for CDQ and TRT. It is important to note that the Japanese steel companies own the CDQ and TRT technologies and their patents. Both Nippon Steel and JFE successfully sell CDQ and TRT to Korean and Chinese steel makers. As of 2005, Nippon Steel sold nearly 50 CDQ to the other companies including

---

[58] For the project details, see http://cdm.unfccc.int/Projects/DB/DNV-CUK1136817489.89/view.html.

[59] As of March 2005, there are six steel industry-related new baseline and monitoring methodologies are presented at the CDM Executive Board. These methodologies are NM0002, NM00029, NM0031, NM0049, NM0059 and NM0064. While none of the methodologies are approved by the Executive Board, there is a possibility for approval once a revision of the methodologies is made.

[60] Okazaki explains that Nippon Steel is developing Project Design Documents (PDD) to develop these two projects as CDM activities. The company is working on the PDDs based on the consolidated methodology for waste gas and/or heat for power generation (ACM 0004). The description of ACM 0004 is available at http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html. The company reports that it attempts to develop another consolidated methodology applicable for broader energy efficiency improvement projects in the energy-intensive industry.

POSCO in South Korea. As indicated above, while the majority of the integrated steel plants in Japan are equipped with CDQ and TRT, there are few steel plants in China with the waste-heat recovery systems. The JISF and the CISA decided to explore a possibility of promoting the CDQ and other energy efficiency improvement projects as CDM activities in China jointly (Okazaki, 2006).

6.4.4 Post-Kyoto policy instruments

The discussion on the post-Kyoto policy instruments started to take place a few years ago among the Japanese industry sectors. The discussion began by questioning about the Kyoto Protocol. The Japanese industry sectors still oppose the cap-based approach adopted in the Protocol. According to their view, the Japanese 6% emissions reduction target agreed in the Protocol is the hardest to achieve among the countries. They maintain that the target was established arbitrarily and unilaterally through a one night political negotiation without any considerations of possible economic consequences. The Japanese industry sectors are also opposing against a continuation of the cap-based Kyoto approach in the post Kyoto period. The following is a statement made by Nippon Keidanren:

> In order to reach a successful agreement in the international negotiation, it is inevitable to consider both equity and economic incentive. The emissions reduction targets established under the Kyoto Protocol was nothing more than an outcome of political negotiations. It left us a question about its equitability. The continuation of the Kyoto approach will not only demean a credibility of the framework of the climate change negotiation but also creates an obstacle for a wider participation in the framework. It is essential, therefore, not to limit the scope of agreement to an absolute value-based scheme adopted by the Kyoto Protocol but to consider a diverse scheme reflecting different circumstances of each country and region. For example, setting a target based on energy efficiency and GHG emissions performance per unit production will cover the shortcoming of the absolute value-based scheme... Emissions reduction target shall not be unilaterally determined through political negotiations. Instead, the GHG emissions reduction targets shall be established in the form of “pledge” of each country with a declaration of an ambitious emission reduction target reflecting the different circumstances of each country. It is necessary to review a progress toward the goal regularly. Penalty and sanction shall not be conducted, however, against those countries that are unable to meet the target. Instead, the out-performing countries shall provide support to the under-performing countries (Nippon Keidanren, 2005a).

The Japanese steel industry sector vocally express their views on the post Kyoto policy instruments through publications, conferences and government workshops and the media. The position of the Japanese steel companies on the post Kyoto policy instruments has threefold. First, the Japanese steel companies are in favor of a sectoral approach in the post Kyoto period. They are against the country-based approach adopted by the Kyoto Protocol. They are also against the absolute value-based approach. In consistent with the above Nippon Keidanren statement, the Japanese steel companies are in favor of the unit performance-based approach. In addition, in their view, the sectoral approach has to be conducted on the voluntary basis (Okazaki, 2006).

Second, the Japanese steel industry sector maintains that expert’s identification of the “best available technologies” (BAT) with lower GHG emissions releases can be a basis for the sectoral approach.[61] It proposes to

[61] As indicated in footnote 8, the concept of Best Available Technologies or Techniques (BAT) indicates the latest stage of development of processes, facilities, or methods of operations. The concept is lay down by the European Commission in the IPPC (Integrated Pollution Prevention and Control) Directive 96/61/EC. The Directive requests the EC to organize an exchange of information among member states and the concerned industry sectors on BAT. The steel industry sector is one of its focal

establish a joint program to improve a diffusion rate of the BAT and monitor a progress through international cooperation. The Japanese steel industry sector estimates that if the technologies such as CDQ and TRT are introduced in the other countries at the Japanese diffusion rate, nearly 300 million tons of CO_2 emission is reduced annually in the world (Watanabe, 2006). From their viewpoint, the diffusion rate shall be only used as a reference to monitor the progress and shall not be used as an index leading to a compulsory measure.

Third, the Japanese steel industry sector considers that IISI's CO_2 Breakthrough Program can be an important focal point for technological innovation in GHG emissions reduction. As indicated above, the CO_2 Breakthrough Program is a multi-year program involving all major steel companies around the world. The Japanese steel industry sector expects that this international program become the main technological platform in the global steel industry sector leading to the technological transition to the hydrogen energy society.

It also recognizes the Asia-Pacific Partnership on Clean Development and Climate as another important policy platform in the post Kyoto period. An involvement of the countries without the GHG emissions reduction targets is crucial for the steel industry sector from the viewpoint of international competitiveness. The Japanese steel industry sector therefore encourages the steel industry sectors in other countries especially in China, India and United States to join the policy platform.

Summary of Chapter 6

This chapter examined the Japanese institutional dimensions and corporate climate change strategy of two Japanese steel companies: Nippon Steel and JFE. It was recognized that the Keidanren Voluntary Action Plan on the Environment is becoming a focal point for GHG emissions in the industry sectors in Japan. The next chapter investigated the European institutional dimensions as well as corporate climate change strategy of two European steel companies: Arcelor and Corus Group.

---

industries to investigate BAT. The more information on the BAT is available at http://eippcb.jrc.es/.

Chapter 7: European firms

7.1 Overview of European steel industry sector

The EU as a whole is the second largest steel producing region after China in the world with the total production of crude steel of 187 million tons in 2004 (European Parliament, 2005). This figure represents 18-19% of the world's production (European Commission, 2006). The BOF and EAF are respectively responsible for 61% and 39% of the total steel production (Eurofer, 2006). Steel companies account for approximately 1.5% of employment in the manufacturing sector in the EU (European Parliament, 2005). As illustrated above, a majority of steel produced in the EU is consumed within the region. This makes a sharp contrast to Japan exporting a majority of steel to other countries (especially in Asia). However, there is some level of trade between the EU and non-EU countries in Europe. The EU countries exported 13.5 million metric tons of steel to the non-EU countries in Europe, while they imported 15.1 million metric tons of steel from them in 2003 (International Iron and Steel Institute, 2005).

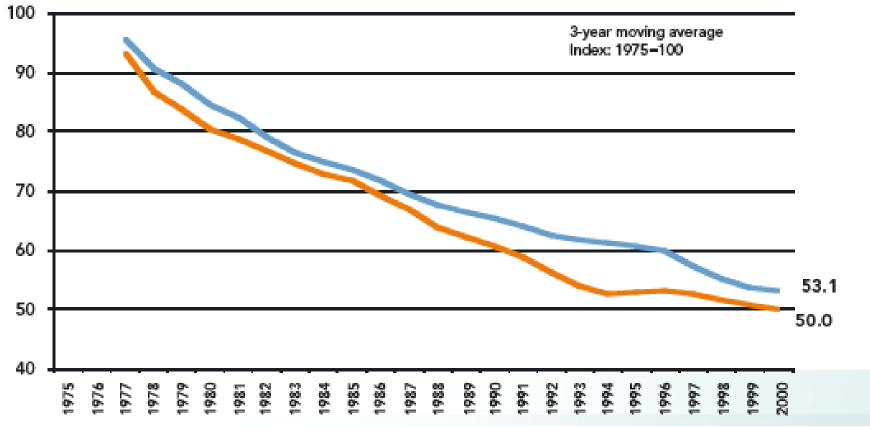
There are several major steel companies in the EU with BOF operation. Arcelor-Mittal is the largest steel company both in the EU and in the world. Arcelor-Mittal was formed after the merger of Arcelor and Mittal Steel in June 2006. While Arcelor was the largest steel company with 46.9 Mt. of crude steel production, Mittal Steel was the second largest steel company with 35.3Mt. in 2004. Arcelor-Mittal is three times as large as its closest rival, Nippon Steel. Corus Group is the 8th largest steel company in the world with 19.0 Mt. of crude steel production in 2004. The main operations of the company are located in the UK and the Netherlands. ThyssenKrupp is the 10th largest steel company based in Germany with 17.6 Mt. of crude steel production in 2004. The company is followed by Riva Acciao based in Italy with 16.7 Mt. of crude steel production in 2004.[62]

The GHG emissions release from the steel industry sector represents a large portion of the region's total GHG emission production. It accounts for nearly 6% of the region's total CO_2 emissions and 30% of the total CO_2 emissions from the industry sector (Eurofer). While there are some variances among the member state countries, the GHG emissions from the steel industry sector in the major countries in the region including the UK, France, Germany and Italy are significant. As indicated above, in the Netherlands, it reached 9.8 million tons on average per year between 2000 and 2002. The steel industry sector is the fourth largest CO_2 emitter in the country after the electricity generation, chemical and oil refinery sectors.

On the other hand, European steel companies have reduced significantly the energy use and CO_2 emissions in the last 30 years. They have achieved them largely through reduction of coke consumption in the blast furnace and increased use of scrap steel. European steel companies are one of the sector leaders with respect to the improvement of energy consumption and reduction of CO_2 emissions release. Figure 15 indicates the improvement trends in the last 30 years:

[62] The figures mentioned in this paragraph are cited from the IISI publication: International Iron and Steel Institute (2005) World Steel in Figures 2005. Brussels.

Figure 15: The improvement trends of energy consumptions and CO_2 emissions in the last 30 years



(Note: The above and below lines indicate the levels of energy consumption and CO_2 emissions respectively.) (European Commission, 2006)

Among the European steel companies, this research focuses on two steel companies in the region: Arcelor and Corus Group (It is important to note here again that both of them have experienced a merger with another steel company as of February 2007. The merger between Arcelor and Mittal Steel took place in June 2006. The merger between Corus Group and Tata Group is under way. This analysis is based on the information collected before those two mergers. Therefore, there may be change in corporate strategy after the mergers). As noted above, Arcelor and Corus Group are ones of the largest steel companies in the EU. It is recognized, however, that there are a great degree of differences among European steel companies as to their business strategy and management, business models, cost structures and quantity and quality of produced steel as well as their corporate strategy on climate change. Especially, there are distinct differences between the northern and southern EU steel producers in some of these areas. It is noted that the analysis of the two steel producers headquartered in the northern Europe may not be applicable to the steel companies in the southern Europe. It is admitted that focusing on the two steel companies lead to a failure in addressing the differences and diversities among steel companies in the EU.

With respect to the analysis of the European institutional dimensions, the thesis author heeded a particular attention to the policy development at the EU level. As Boyd and other scholars argue, the European Commission plays an important role in formulating policy guidance among the member states in the EU. The Commission has a strong influence on the policy implementation among the member states. It is especially the case in the climate change policy arena. Its roles in the coordination of the economic policy instruments including carbon tax and emissions trading scheme are an example (Boyd, 2002, Doh and Guay, 2006). At the member state level, particular attention was paid to the Netherlands. The country addresses an interesting case with respect to the institutionalization of climate change policy into the social and economic areas in the country.[63] The thesis author examined the institutional aspect of the Netherlands in some detail including its societal concerns about climate change as well as regulatory cultures and schemes. He also examined the cases of other EU countries in a brief manner.

---

[63] It is recognized that some aspects of the Dutch case may be unique aspect among the EU countries. Therefore, the institutional context at the national level is the Dutch-specific. It is hardly possible to generalize the institutional contexts at the national level among the EU member states.

7.2 European institutional dimensions

7.2.1 Divergent factor: Societal concerns about climate change

The EU region is generally perceived as environmental conscious and progressive in the implementation of environmental policy. As indicated above, a public opinion survey conducted in 2006 demonstrates that the rates of the people who answered climate change as a serious problem reach 73% in Germany, 70% in France and 70% in the UK. These rates are relatively higher than the developed countries in other region (GlobeScan, 2006).

In contrast to the case of Japan, there is a great degree of NGOs presence at various levels of policy discussion on climate change in the EU. The NGOs such as WWF (World Wide Fund for Nature), Friends of the Earth and Greenpeace have continuously participated in the policy discussion both at the EU and national levels since an early phase of the climate change negotiation. According to Giorgetti following the policy development of the UNFCCC negotiations, “the most influential and active Environmental Non-governmental Organizations (ENGOs) were advocacy groups representing both “mainstream” (World Wide Fund for Nature (WWF) and Environmental Defense Fund (EDF)) and “deep ecologist” (Greenpeace and Sierra Group) ideologies, from both international (Greenpeace) and national (Ozone Action and EDF) perspectives” (Giorgetti, 1999). According to Gough and Shackley, “some NGO representatives have also become highly expert in issues of climate change policy and science, and as such they have contributed their expert judgment, somewhat separately from their political judgment as an NGO. Such partnership has enabled NGOs to belong to the *epistemic community* that has built up around a consensus that anthropogenic climate change is a significant risk that has to be managed” (Gough and Shackley, 2001).

It is important to note that there is a great variety among NGOs with respect to their roles, interests and natures of an involvement in climate change. Some NGOs such as Greenpeace and Friends of the Earth are primarily interested in lobbying and campaigning against governments and companies. Some NGOs such as WWF, Worldwatch Institute, Wuppertal Institute for Climate, Energy and the Environment and Foundation for International Environmental Law and Development (FIELD) are interested in developing policy recommendations on specific climate change issues. Based on their expertise, they produce research and policy papers to distribute among policymakers on climate change.

There is an ample body of literatures examining the different roles of the NGOs. Some of them attempt to evaluate their effectiveness in influencing their beliefs and thoughts on governments and companies. The results of their evaluations are not positive, however. There are several issues that scholars identify as a hindrance to their operations in the literatures.

One issue relates to the fact that there are disagreements among the NGOs as to what actions to be taken to address climate change (Giorgetti, 1999). With respect to EU’s climate change policy, Greenpeace and Friends of the Earth criticize the European Commission for not setting clear GHG emission reduction targets for the post 2012 period. On the other hand, the WWF is supportive of European Commission’s initiatives in the international climate negotiations (EurActiv, 2005). Another issue is their limited resources to work on climate change. Their financial constraint has been a major hindrance in exercising their advocacy activities. According to Rootes, while the NGO community has grown since its establishment in the 1970s, it has been declining in recent years. Greenpeace, for example, closed their national offices and consolidated their branches in response to a decline in its global income (Rootes, 2002). Michaelowa pessimistically points out the fact that the cumulated staff of the environmental NGOs in Brussels is not even equal to the staff of a single industry lobbying organization (Michaelowa, 1998). Overall, NGOs are understaffed to perform their activities to influence their thoughts on the governments and companies. Unfortunately, their influences are very limited in the climate change arena.

The following section examines an integration of climate change into the society in the Netherlands. In particular, it attempts to observe an influence of the NGOs community upon the national climate change policy.

7.2.2 Integration of climate change in the society: The case of the Netherlands

The Netherlands is generally recognized as one of the most environmentally progressive countries in the EU. The geography and demography of the country are associated with its high level of environmental concerns and its ability to cope with them. The country is four times as populous as other EU nations on average. Almost one-third of the country is reclaimed land lying below the sea level. It is not surprising that the Dutch society take seriously a possible rise of the sea level due to global warming.

The Netherlands follows a pattern of other developed countries in the EU that began to face serious environmental problems in 1960s. At first, the government took regulatory measures against noise, water and air pollutions. In 1972, it published the first comprehensive statement on the environmental protection titled “Memorandum on Urgent Environmental Issues”. In the 1980s, there was a strategic shift in coping with environmental problems from the command-and-control measures to more integrated policy measures including economic incentive plans. In 1982, the institutional capacity of the government to cope with the environmental problems was increased when the Ministry of Housing, Spatial Planning and the Environment (VROM) replaced the earlier Ministry of Health and Environment. The scientists at the National Institute for Public Health and Environmental Protection conducted a survey around this time on environmental conditions and future trends in the country. Their report titled “Concern for Tomorrow” became the catalyst for a major change in its approach to environmental problems calling for the country’s first National Environmental Policy Plan (NEPP) or Green Plan in 1989 (Resource Renewal Institute, 2006).[64]

There has been a remarkable NGOs presence since the 1980s in the Netherlands. According to a research project conducted by Johns Hopkins University, the Netherlands has the highest ranking in terms of the size of the non-profit sector followed by Ireland and Belgium (Salamon et al., 2000). The rate of the non-profit employment is 12.6% out of the total non-agricultural employment. This rate is considerably high in comparison to 11.5% of Ireland, 10.5% of Belgium, 7.8% of the United States, 6.2% of the UK and 3.5% of Japan. Noteworthy, the ENGOs have more than 2 million members in the Netherlands out of its 16 million population (Lise and Lise, 2002).

There is a research that examined ENGO’s influence on public awareness of the climate change issue in the Netherlands. The research was conducted by Lise and Lise at Free University of Amsterdam. They conducted extensive interviews with ENGOs, governments and other organizations to investigate their views on the roles of NGOs in climate change. They concluded that “environmental NGOs in the Netherlands may not always be active and systematic, as it is generally perceived, in raising public awareness and putting pressure on the Dutch government for implementing the targeted measures at the national level” (Lise and Lise, 2002). They argue that it was the government (not NGOs) that has played an important role in the Netherlands of raising public awareness about climate change. The following is their observation:

> The climate change issue was initially brought by the Dutch scientific community in the Netherlands.

[64] The facts about the history of the Dutch environmental policies were drawn from Resource Renewal Institute’s Green Planning Archives, The Netherlands Environmental Policy Profile (Resource Renewable Institute, 2006).

> Especially, around the early and mid-1980s various scientific efforts took place for the purpose of understanding the problem more clearly. During the period many ENGOs were more concerned with other issues such as acid rain and the nuclear energy debate rather than climate change. In fact, the ENGOs wanted to keep the climate problem as low profile as possible, as they tried to avoid any argument in favor of carbon frees nuclear energy. The climate change issue began to enter the environmental political agenda of the Dutch government in the late 1980s. In 1989, with the publication of the National Environmental Policy Plan (NEPP), the climate change issue was officially put on the political agenda of the government. During the late-1980s, the Dutch government adopted an ambiguous and progressive stance with respect to climate change. Public campaigns addressing citizens on climate change was initially launched by the Dutch government in the Netherlands. This involvement has been systematic in the Netherlands since 1990 (Lise and Lise, 2002).

The results of Lise and Lise's research on the Netherlands coincide with the results of other scholar's research indicating a lack of NGOs influence on governments and companies in the EU in the area of climate change. Nevertheless, NGO's presence in the EU is remarkably higher than other countries. They are warning the potential risks of global warming and participating in the policy dialogues at various levels. It is not deniable that their operations are directly or indirectly influencing the formulation of climate change policies and strategies among governments and companies.

7.2.3 Divergent factor: Regulatory culture and schemes

The EU is consistently one of the most progressive negotiators in the climate change negotiation.[65] The GHG emissions reduction target under the Kyoto Protocol is 8% in the period of 2008 and 2012 relative to 1990. Prior to the ratification of the Protocol, there was a negotiation on the "burden-sharing" agreement among the 15 member states. The member states agreed to establish the following uneven targets among them in 1998.[66]

[65] Axel Michaelowa, an expert on the climate change negotiation, also presents a similar view in his publication. Michaelowa states "the position of the EU for the Kyoto negotiation was…considerably strengthened and it proposed a 15% reduction for all industrialized countries by 2010 with an intermediate target of 7.5% by 2005 while the U.S. only proposed stabilization and Japan a reduction of 2-5%. The overall reduction target of 5.2% achieved at Kyoto would not have been reached without the strong EU position" (Michaelowa, 1998).

[66] Before the COP 3 that took place in Kyoto in 1997, the EU had a difficulty to harmonize policies and measures among the member state governments. Michaelowa states, however, that "a breakthrough was achieved by the Dutch presidency that was able to negotiate an explicit burden sharing on the base of a proposal of university researchers" (Michaelowa, 1998). This proposal was based on the approach called the "Tryptych" approach proposed by the climate change researchers at University of Utrecht.

Table 26: Emissions reduction targets of the EU member states under the burden share agreement

Member states	Emissions reduction targets relative to 1990
Austria	-13%
Belgium	-7.5%
Denmark	-21%
Finland	0%
France	0%
Germany	-21%
Greece	+25%
Ireland	+13%
Italy	-6.5%
Luxembourg	-28%
The Netherlands	-6%
Portugal	+27%
Spain	+15%
Sweden	+4%
United Kingdom	-12.5%
European Community as a whole	**-8%**

(European Commission, 2002)

The EU as a whole is expected to achieve the emissions reduction target during the commitment period of 2008 and 2012. According to the report published by David Suzuki Foundation titled as "Who's meeting their Kyoto targets?", the large member states including the UK, Germany and France are on a right track to meet their emissions reduction targets under the Protocol. The UK has surpassed its target by 12.5%. It is expected to reduce GHG emissions by 23-25% by 2010. Germany has reduced GHG emissions by 18.5%. Its 21% emissions reduction target is within its reach without the use of the Kyoto mechanism. France has met its emissions reduction target to reduce by 2%. On the other hand, there are several countries lagging behind. Those countries are Denmark, Spain, Portugal, Italy and Ireland (David Suzuki Foundation, 2006). (The numbers relating to the emissions reduction targets are cited from the report published by David Suzuki Foundation.)

At the EU level, there are several regulatory pressures to the companies in the energy-intensive industry sectors. At present, the center of the pressures is the EU ETS. In March 2002, the ministries of the member states agreed to adopt the Commission's proposal to ratify the Kyoto Protocol at the Environmental Council. Prior to the ratification, the European Commission began to discuss a possible introduction of an emissions trading scheme. In October 2001, the Commission submitted its proposal for a framework directive on emissions trading scheme. As described below, the emissions trading scheme is under implementation.

In 2006, national governments submitted the 2nd National Allocation Plans (NAPs) to the EC which assign the amount of emission allowances (EUAs) to each plant installation covered under the EU ETS. The political bargaining among the EU, national governments and companies has been active with respect to the volume of the EUAs. The energy-intensive industry sectors including the steel industry sector have been expressing their concerns about negative impacts of the EU ETS on their business operations. In fact, Arcelor sued the European Union to terminate the EU ETS at the European Court of Justice in 2004. The interest group representing

European steel companies, Eurofer maintains that the EU ETS result in a loss of international of the European steel companies and increase of the GHG emissions in the developing countries.

Another regulatory pressure at the EU level is associated with a discussion on the post-Kyoto regime. An intensive discussion on the post-Kyoto regime has begun among the member states. For example, the EU Council of Ministries suggested ambiguous GHG emissions reduction targets in the post Kyoto period (15-20% by 2020 and 60-80% by 2050). The ministries requested the Commission to study the costs and benefits of future actions (or inactions) as well as the competitiveness aspects of the future EU strategy (EurActiv, 2005).

At the national level, there were regulatory pressures to the energy-intensive industry sectors, even prior to the ratification of the Kyoto Protocol, to reduce GHG emissions. There has been a strong pressure to introduce carbon tax. That has been also a pressure to establish a voluntary agreement for the industry sectors to reduce GHG emissions among the member states. On the other hand, the characteristics of each pressure differ greatly among them. The following sections discuss the essential differences in the characteristics of the regulatory pressures in the EU.

7.2.3.1 Voluntary agreements between the government and industry

European countries have been implementing voluntary agreements as a policy measure in the environmental arena since the 1980s. Scholars contend that the European countries have taken a learning-by-doing approach in the implementation of the VEAs and have integrated lessons in the arrangements. The VEAs are widely recognized as an effective policy measure in achieving a certain environmental goal. Having being facilitated in the area of waste management in the beginning of 1980s, the VEAs started to be introduced in other environmental area including climate change.

It is important to note that there are a great variety among the VEAs with respect to their regulatory contexts (whether it is legally-binding or purely voluntary), definitions of targets, linkages to incentive policies, auditing/reporting schemes and other aspects of the agreements. Table 27 illustrates some key differences among voluntary environmental agreements on climate change:

Table 27: Comparative features of national VEAs related to climate change in the EU

Country	Program	Start	Type [legal character]	Link to public incentive policy	Audit & Reporting
The Netherlands	LTAs 1	1992	NEA (Covenants) [civil action allowed]	Permits/Licenses (Plus) future energy taxes	Individual firms report to authority; Audit by Third party
	Benchmark Agreement & LTAs 2	2001			
Denmark	Energy Efficiency	1996	PVEP [legally binding]	Carbon tax	Third-party auditing & reporting to Energy Agency
UK	Climate change	April 2001	NEA [judiciary action allowed]	Climate Change Levy	Official auditing & reporting
Germany	Climate change	1995	UVEP	None (except in regional accords)	Sectoral reports only
		Nov. 2000	NEA		Third-party (RWI) monitoring
France	Climate change	2001	NEA [binding only when linked to subsidies]	Environment tax (2001 proposal deferred)	Branch associations' reports only

(Notes: NEA, PVEP, UVEP stand for negotiated environmental agreement, public voluntary environmental program and unilateral voluntary environmental codes and action plans.) (Usui, 2003)

While the term "voluntary" is typically defined as being "not forced by law nor persuaded by financial incentives", some VEAs contain legally binding features (Jacobs, 1991). The Dutch covenants on energy efficiency benchmarking, for example, a violation of the covenants can be suited under civil law. In addition, when companies meet their targets under the covenants, there is an incentive scheme to reduce future energy taxes. Unlike the Japanese voluntary scheme (Nippon Keidanren's Voluntary Action Plan), these conditions of the agreement are negotiated and agreed between the government and industry. With this respect, it is possible to perceive a majority of the voluntary environmental agreements in the EU falls as the type 2 under the OECD classification indicated in Section 1.2.2.3: *negotiated* voluntary environmental agreements (NEAs) between industry and public authorities. NEAs have more or less explicit links to public incentive policies. Usui provides his insight in a comparison among European VEAs as follows:

> The Dutch NEA and the Danish PVEP are relatively better structured with elaborate procedures than the French NEA and the German UVEP (later becoming NEA). In the Netherlands, nearly nine-tenths of the covenants are enforceable under civil law in principle, although no actual litigation has been reported yet. Denmark's environmental law has provisions for making legally binding industry-government agreements, although actually only a few existing covenants explicitly assume that status. The French and German schemes are generally legally non-binding, with no established measures for non-compliance, except in the regional accords specifically linked to subsidies and other incentive schemes. Around 1985, France witnessed a bitter debate questioning the legality of relegating those matters traditionally handled by regulatory authorities to "voluntary" agreements (Usui, 2003).

The Netherlands has employed EVAs to improve energy efficiency and to reduce GHG emissions in the industry sector. The Dutch EVAs have attracted scholar's attention for their uniqueness. One of the programs is called the Long-Term Agreements (LTAs). The LTAs have been signed between the government and industry sectors since 1992. Total of 29 LTAs had been contracted with industrial sectors and 14 LTAs with non-industrial ones by 1999. The "first-generation" LTAs have a participation of approximately 1,250 companies accounting for 90% of industrial energy consumption. It was agreed to improve energy efficiency by 20% from 1989 to 2000. The steel industry sector improved their energy efficiency level by 15% during the period. Although the LTAs fall into the category of EVAs, they are legal contracts between the government and industry sectors. The participating companies outline a broad area of actions to improve energy efficiency such as energy management, combined heat and power, improvement in power generation, heat integration and process modernization. In exchange, the government assures a protection from new regulations and taxes. (Newman, 2005, Nuijen and Booij, 2002).

In 2001, the new "second generation" Long Term Agreements on Energy Efficiency (LTA 2) were established with medium-sized and small businesses. In addition, the Energy Efficiency Benchmarking Covenant was signed with the energy-intensive sectors including the steel industry sector. Under the benchmarking covenant, companies pledge to become among "the best in the world" in terms of energy efficiency. The companies' goal is to be ranked in the top 10% of energy efficiency by 2012 in comparison with comparable foreign facilities. The covenant requires companies to improve systematically their energy efficiency rate and monitor their energy use. In return, the government agrees not to impose additional specific measures for energy conservation or GHG emissions reduction upon the participating companies. The companies acting under the covenants may also offset some taxes (Newman, 2005, Nuijen and Booij, 2002).

7.2.3.2 Carbon tax

In the EU, many member states have introduced energy or carbon tax to discourage fossil fuel use and reduce GHG emissions. According to the OECD, the countries with energy or carbon tax are Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Italy, the Netherlands, Sweden and United Kingdom (Organisation for Economic Co-operation and Development, 2003). Some other European countries outside of the EU such as Norway and Switzerland also introduced carbon tax.

Table 28 illustrates some features energy and carbon tax in the major EU member countries and Norway. As seen in Table 28, there is a great degree of variety among the tax schemes as to taxed energy sources, taxed rate and industry exemptions. The right side of the table indicates a result of an analysis of possible economic impacts on the cost of the BOF production. Table 28 provides two different estimates. One is nominal costs excluding any exemptions and refunds that may be available to steel companies. The other is net costs reflecting exemptions and refund that are available for steel companies. As this table indicates, the next costs of tax for steel companies in the

EU remain low with an exception of Sweden.

Table 28: Summary of environmental taxes and their possible economic impacts on the cost of the BOF steel production

Country	Tax scheme	Taxed energy sources and rates	Industry exemptions, refunds and other considerations.	Estimated economic impacts on the cost of the BOF steel production (€/ton of finished steel)	
				Nominal	Net
Finland	Energy/CO_2 tax	Coal - 43.52 €/t Natural gas - 19.07 €/107 kcal Fuel oil (low sulphur) - 56.80 €/t	Energy sources not used as fuels are exempted. For fuels, an exemption of 85% of the portion of tax exceeding 3.7% of value added.	22	<4
Germany	Eco-tax	Natural gas - 3.81 €/107 kcal Fuel oil (light) - 4.09 €/kl Electricity - 0.0123 €/kWh	80% discount on fuel and electricity component for manufacturing industries, further exemptions for energy-intensive industry.	8	<2
Italy	Carbon tax	Coal - 2.63 €/t	Tax applies to fossil fuel combustion only (i.e. fossil fuels not used as energy sources are exempt).	1	0
The Netherlands	Environmental Protection tax and ECO tax	Natural gas - 13.44 €/107 kcal (1 - 10M m^3) - 8.92 €/107 kcal (>10M m^3) Electricity - 0.0065 €/kWh (0.05 - 10M kWh) - 0.0005 €/kWh (> 10 M kWh)	No exemptions, lower rates apply amounts greater than 10 million kWh and 1 million m^3 of natural gas (except when it is used to generate electricity).	6	2
Norway	CO_2 tax and consumption tax	Coal - 500 NOK/t (CO_2 tax) Fuel oil (heavy) - 510 NOK/kl (CO_2 tax) Electricity - 0.0967 NOK/kWh (consumption tax)	Some energy-intensive industries are exempt from the tax for competitiveness reasons. Process uses exempt.	No BOF steel plants in Norway	No BOF steel plants in Norway
Sweden	CO_2 tax	Coal - 1892 SEK/t Fuel oil (low sulphur) - 565.37 SEK/t	65% refunds are given for energy sources used as non-fuel inputs to manufacturing industries. Upper limit on payments.	87	<8
United Kingdom	Climate Change Levy	Coking coal - 11.70 £/t Natural gas - 0.0015 £/kWh Electricity – 0.0043 £/kWh	80% discount for facilities that have taken on Climate Change Commitments. Also non-fuel uses are exempt.	15	3

(Newman, 2005)

In the case of the Netherlands, Ecotax or Energy Regulatory Tax (REB: Regulerende Energie Belasting) was introduced in 1996 to tax on the final consumption of electricity and natural gas. The REB represented a partial shift in taxation from income tax to tax on environmentally damaging activities. The tax is limited to small and medium users only. The government considers that the voluntary agreements such as the Long Term Agreements and Benchmark Covenants are proven effective in inducing large energy consumers to reduce energy use and an introduction of unilateral tax scheme may result in their economic loss. As discussed below, there is a strong resistance to tax scheme among steel companies in the EU. European steel companies contend that an introduction of additional tax scheme, as well as the EU ETS, results in a loss of international competitiveness.

7.2.3.3 European Union Emissions Trading Scheme

The European Union decided to introduce an emissions trading scheme and adopted the EU Emissions Trading Directive (2003/87/EC) in July 2003. Subsequently, it adopted the "Linking Directive" in September 2004 to make it possible to trade CERs and ERUs generated through CDM and JI projects with EUAs in the EU ETS. The EU ETS began a pilot phase from 2005 to 2007, followed by the second phase from 2008 to 2012 which matches the commitment period under the Kyoto Protocol. In the pilot phase, the EU ETS covers only CO_2 emissions from the power generation, oil refineries, coke ovens, and the iron and steel, cement, lime, glass, ceramics, and pulp & paper sectors as well as from all combustion plants with a rated thermal input of more than 20MW capacity. The number of the installations covered by the EU ETS reaches approximately 12,000.

Table 29 illustrates key features of the EU ETS:

Table 29: Key features of the European Union Emissions Trading Scheme

Type of target	Absolute target (e.g. X tCO_2equivalent). One allowance in the EU ETS allows the owner to emit one ton of CO_2equivalent; its validity is limited to a specific period. During 2005-2007, mostly free allocation by Member states following common criteria.
Allocation mode	Up to 5% auctioning allowed during 2005-2007 Up to 10% auctioning allowed for 2008-2012.
Sectors included	CO_2 emissions from large combustion installations (>20MW rated thermal input) from all sectors (i.e. including power generation), plus emissions from oil refineries, coke ovens, and the iron and steel, cement, lime, glass, ceramics, and pulp & paper sectors (coverage of these sectors is subject to certain size criteria).
Coverage	Initially CO_2 only. After 2008, other gases may be included, provided adequate monitoring and reporting systems are available and provided there is no damage to environmental integrity or distortion to competition.
Banking	Banking allowances from the first to the second trading period is at the discretion of each Member State. As of 2012 onwards, it is a provision in the directive.
New entrants	Member States shall take into account the need to provide access to allowances for new entrants; how and how much is to be decided by each Member State.
Links with Kyoto units	The council of ministers and the European Parliament agreed (April 2004) on a text for the EU Linking Directive that will allow entities covered by the EU ETS to use emission units from the Kyoto Protocol's project-based mechanisms (i.e. Joint Implementation and the Clean Development Mechanism) towards meeting their emissions targets. The use of the mechanisms is to be supplemental to domestic action, in accordance with the relevant provisions of the Kyoto Protocol and the Marrakech Accords. The EU Directive does not include recognition of assigned amount units (i.e. governments overall emissions allocation under the Kyoto Protocol).
Links with other countries' schemes	The Directive includes the possibility of linking with third Parties with Kyoto commitments and that have ratified the Kyoto Protocol, based on agreements that provide for the mutual recognition of allowances between the EU ETS and other domestic GHG trading schemes.
Penalties	A non-compliance penalty tax of €40 per ton of excess CO_2 emissions in the first compliance period and of €100 in the second period, plus restoration of the GHG emitted without having surrendered allowances.

(Source, Reinaud 2005)

The majority of EUAs traded in the EU ETS is allocated through the NAPs published by the member states and later approved by the European Commission. The EU rules specify that at least 95% of allowances are to be allocated for free (through grandfathering) and only a small percentage of allowances may be auctioned in the pilot phase (2005-2007). In the second phase, the volume of emission allowances granted for free is to be at least 90%. It is important to note that the allocation of the emission allowances is a crucial task in the design of an emissions trading scheme, since it creates an asset equivalent to €38 billion transferable in the emissions trading market (1.88 billion tons of CO_2 annually at a price of € 20).

European steel companies received EUAs for the pilot phase through the national allocation plans from the member state governments. Table 30 illustrates a comparison of historic emissions and assigned emission allowances under the national allocation plans:

Table 30: Comparison of historic emissions and assigned CO_2 emission allowances under the national allocation plans

Country	Historic emissions (million tons CO_2/year)	Assigned CO_2 emission allowances (million tons CO_2/year)
Austria	8.95	11.313
Finland	5.8	6.66
France	28.33	27.57
Germany	48.7	48.4
Italy	27.6	29.12
Luxembourg	0.46	0.553
The Netherlands	9.8	10.3
Spain	10.79	11.23

(Notes: The figures of the historical emissions are based on the 2002 data or the average between 2000 and 2002. The figures of Italy do not include CO_2 emissions from the coke oven plants.)
(Source: Newman, 2005)

This table indicates that European steel companies by and large received sufficient emission allowances in the pilot phase. This is an interesting fact since, if the companies have enough allowances, companies do not need to purchase emission allowances from the market and therefore there will be no financial loss through the emissions trading scheme. In fact, they have a financial gain when they sell surplus allowances in the market. Nevertheless, European steel companies contend that the EU ETS is resulting in the serious economic loss. The reasons for their argument and the view of two European steel companies on the EU ETS are elaborated in detail in Section 7.4.3.

7.2.3.4 Government supports for CDM and JI

The Kyoto mechanism including CDM and JI was proposed for a possible inclusion into the Kyoto Protocol by the United States. The EU was initially skeptical about the use of the market-based mechanism favoring a climate change strategy based on the coordinated policies and measures (PAMs) and pushing for limitation on the use of the Kyoto mechanism (Bang et al., 2005). When the Kyoto Protocol was signed, in fact, the EU eagerly contended the use of the Kyoto mechanisms shall be “supplemental” to domestic GHG emissions reduction efforts. There has been a remarkable change in its view, however, since the signing of the Kyoto Protocol. For example, the Dutch government decided to meet half of its emissions reduction target through JI and CDM projects and established a series of carbon credit procurements programs and facilities including the Certified Emission Reduction Unit Procurement Tender (CERUPT) for CDM projects and the Emission Reduction Unit Procurement Tender (ERUPT) for JI projects. The other EU member state governments including Austria and Denmark followed the Dutch initiative and established their own carbon credit procurement programs. Table 31 is the list of the major procurement programs established by the EU member state governments.

Table 31: Major procurement programs established by the EU member state governments

Donor	Target amount (Mt)	Title	Target (Mt)	Total amount (US$)	Target
Dutch Government	100	ERUPT (SENTER Novem)	12	320.0M	JI, AAU
		CERUPT (SENTER Novem)	8	100.0M	CDM
		The Netherlands CDM Facility (at the World Bank)	21	90.5M	CDM
		The IFC-Netherlands Carbon Facility (at IFC)	10	56.2M	CDM
		The Netherlands EBRD Carbon Fund (at EBRD)	6	41.0M	JI
		CAF Netherlands Carbon Fund (at CAF)	10	58.1M	CDM
		RaboBank-Dutch Government CDM Facility	10	58.1M	CDM
Belgium Government	-	Belgium JI/CDM Tender	-	15.0M	CDM/JI
		Flemish Government JI/CDM Tender	-	85.0M	CDM/JI
Spanish Government	100	Spanish Carbon Fund (at World Bank)	34	219.0M	CDM, JI, AAU
Italian Government	60	Italian Carbon Fund (at World Bank)	10	80.0M	CDM, JI
Danish Government	19	Danish Carbon Fund (at World Bank)	5-6	35.2M	CDM, JI, AAU
		Danish Carbon Facility (Eco Securities, Standard Bank London)	1-2	9.5M	CDM, JI
Austrian Government	35	Austrian JI/CDM Program (Kommunalkredit)	-	310.0M	CDM, JI

(Source: Various sources)

7.2.3.5 Post-Kyoto policy instruments

At the eleventh COP in Montreal in December 2005, it was agreed to begin a negotiation to extend the Kyoto Protocol beyond 2012 inviting signatories such as the United States and Australia. Earlier in the year, the European Commission published a communication paper titled “Winning the battle against climate change” in which it outlined its strategy and policy after 2012 (EurActiv, 2005, European Commission, 2005). The followings are the core elements of the strategy:

- To persuade all major world emitters to commit to a binding scheme, including the United States and rapidly emerging economies such as China and India.

- To include more sectors in emissions reductions, including transport (aviation, maritime) as well as tackling the deforestation which increases global warming in some regions.
- To promote climate-friendly technologies
- To facilitate further market-based instruments such as the EU Emissions Trading Scheme
- To prepare adaptation policies in Europe and globally to deal with the inescapable impacts of climate change

While European Commission's publication did not specify a precise GHG emission reduction target in the post-Kyoto period, the leaders at the EU level began vocal about it. In March 2005, The EU Council of Ministers suggested ambitious GHG emissions reduction targets. As stated above, they proposed respectively 15-30% and 60-80% reductions by 2020 and 2050. The ministers also requested a global approach to the issue and invited the European Commission to study the costs and benefits of future action (or inaction). In addition, the summit of EU leaders endorsed the goal established by the ministers and agreed to state that GHG emissions reduction by 15-30% "should be considered" for 2020 (EurActiv, 2005).

7.3 First level of analysis: European corporate climate change strategy and management

This section presents an analysis of European corporate climate change strategy and management. The thesis author collected information and data through extensive literature reviews including academic journals, industry journals, annual reports, sustainability reports, newspapers, company's websites and other. Based on the research method indicated in Section 3.3, He also conducted open-ending interviews with Arcelor and Corus Group as well as steel industry experts in the EU.

It is important to note that when a reference is made as "European" steel companies below, it indicates steel companies in the EU 15 region only. It excludes steel companies in the EU accession countries such as Poland and Hungary. In addition, as mentioned above, this research is conducted based on the information provided by Arcelor and Corus Group. It is recognized that there are a great degree of differences among European steel companies as to their business strategy and management, business models, cost structures and quality and quality of produced steel as well as their corporate strategy on climate change. It is recognized that the focus on the two steel producers becomes a constraint in understanding the difference among the steel companies in the EU.[67] First, this section presents an overview of the two steel companies and the steel non-profit organization in the EU, Eurofer.

7.3.1 Company overviews

7.3.1.1 Corus Group

Corus Group is the third largest steel company in Europe. The company was formed from the merger of British Steel and Koninklijke Hoogovens in 1999. In addition to steel, it produces aluminum. The company has 5 BOF steelworks located in Llanwern, Port Talbot, Teesside and Scunthorpe in the UK, and in IJmuiden in the Netherlands. Aluminum is produced at three smelters located in Delfzijl in the Netherlands, Voerde in Germany and at a joint venture at Sept-Iles in Canada. It also produces steel by EAF technology at Rotherham and Stocksbridge

[67] It is also admitted that while we placed a special focus on the Netherlands in analyzing the institutional contexts, Corus Group has operations in other EU member countries and therefore tend to receive country-specific institutional pressures of the countries. The institutional contexts of the Netherlands are demonstrated in this research as a case study of the country-specific institutional contexts.

in the UK. Corus is organized into a structure that comprises four main operating divisions: Strip Products Division, Long Products Division, Distribution & Building Systems Division and Aluminum Division. As of December 2005, the company employed 47,300.

The merger between British Steel and Koninklijke Hoogovens took place in the middle of the long-lasting crisis of the British steel industry sector from the 1970s. In 1979, the industry employed 150,000 in the UK but in the early 1980s a combination of the global economic recession and the effects of a strong exchange rate caused thousands of job losses. In addition, the oil crisis in 1973 increased energy cost and triggered a trend among customers to substitute steel for alternative materials with a lower price such as plastics. In 2000, Corus Group had only 35,000 employees. Presently, Corus Group attempts to increase the share of their total output exported overseas.

7.3.1.2 Arcelor

Arcelor was the largest steel producer in the world until Mittal Steel took the first spot in 2004. The company produces approximately 50 million tons of annual crude steel production. It was established in 2001 following the merger of Luxembourg’s Arbed, France’s Usinor and Spain’s Aceralia. The merger increased geographic coverage and product diversity. The company employs 98,000 in 60 countries. It plans to produce steel in the emerging markets including Brazil and China where high automobile sales are generating a surging demand for steel. In Brazil, Arcelor formed Arcelor Brazil as a result of combining of Companhia Siderurgica Belgo Mineira and the other steel producers in 2005. Arcelor Brazil is now the largest steel producer in Latin America with an annual installed production capacity of 11 million tons of crude steel. In China, the company has a joint venture with Nippon Steel and Baosteel (Bao Steel-Nippon Steel/Arcelor) to develop automobile steel sheets in 2004. In the North America, the company announced the acquisition of Dofasco in January 2006. Dofasco was the largest steel producer in Canada with 4.4 million tons of annual crude steel production. Arcelor won an intense bidding against the Germany steel producer, ThyssenKrupp to acquire Dofasco.

In June 2006, the management board of Arcelor decided to accept a merger proposal from Mittal Steel. Mittal agreed to acquire Arcelor for $34 billion, creating Arcelor-Mittal, a steel company three times as large as Nippon Steel. Before the merger, three were sever political reactions to the proposal by Mittal. The French, Luxembourg and Spanish governments strongly opposed the takeover. On the other hand, the Belgian government declared its stance as neutral and invited both parties to deliver a business plan with the future investments in research in the Belgian steel plants. The French opposition was initially fierce and has been criticized in the media as double standards and economic nationalism in Europe. Indian commerce minister Kamal Nath warned that any attempt by France to block the deal would lead to a trade war between India and France.

7.3.1.3 Eurofer

Eurofer is the European Confederation of Iron and Steel Industries founded in 1976. The office is located in Brussels. It is a non-profit industrial organization with a membership of all major steel producers and exporters in Europe. The two main objectives of Eurofer are to promote cooperation among European steel companies and to represent the common interests of the member companies at the international institutions especially at the EU. Therefore, the organization is active in lobbying for the interest of the European steel industry sector. Eurofer publishes position papers on public policy issues that are discussed at the EU level including climate change. In particular, it serves as the focal point to address the concerns among European steel companies towards the climate change policy instruments such as the emissions trading scheme and carbon tax.

7.3.2 Analysis

7.3.2.1 Policy statement

The European steel companies (Arcelor and Corus Group) as well as the Eurofer frequently announce their initiatives on global climate change. They also express their positions through position papers on the climate change policy instruments at the EU as well as national levels such as the EU ETS and the post-Kyoto policy regime. The following statements issued by Arcelor and Corus Group reflect their stance on climate change issues:

> The production sites of the Arcelor Group are implementing a growing number of projects for improving the process for producing steel from iron ore, in order to reduce CO_2 emissions. Arcelor reduced its CO_2 emissions by 18% in absolute value and 23% per ton of crude steel between 1990 and 2004...In favor of decreasing GHG emissions and the principles of the Kyoto Protocol, Arcelor had denounced its terms of application in Europe, and in particular the directive on CO_2 Credits. This directive focuses the efforts required on industry alone and on each industrial sector differently. The allocation of CO_2 Credits per country, and even per region, runs counter to a worldwide approach to large sectors such as the steel industry (Arcelor, 2004).

> Through a series of incremental steps, Corus has made important reductions in energy consumption per ton of steel, which is closely related to CO_2 emissions. However, our calculations show that Corus blast furnaces operate close to the theoretical minimum for coke use. Without a radical new technology, further reductions in energy consumption and CO_2 emissions will continue to be small and incremental. Therefore, Corus, along with a number of industry and research partners is participating in a research and development project to investigate new steel production processes that would radically reduce CO_2 and other GHG emissions compared to current production methods. The project has an arbitrary and self-selected target of 50% reduction in atmospheric emissions of CO_2 from the iron ore route (Corus Group, 2005).

Their messages in the policy statements can be summarized in the three points. First, they reduced energy consumptions and GHG emissions to the theoretical minimum level. They maintain that it has been impossible to reduce GHG emissions on a large scale in the short term. Second, they emphasize an importance of conducting research on breakthrough technologies to reduce GHG emissions reduction in the long term. They consider the below-mentioned ULCOS project as the central platform as their research initiative. Third, they have a negative perception toward the EU ETS. As described in detail below, they consider that it harms their business bottom lines and leads to a loss of competitiveness in the international market.

7.3.2.2 Organizational structure

As it is the case with the Japanese steel companies, The European steel companies have begun to recognize global climate change as a key corporate agenda since the Earth Summit. In recent years, they are faced with a strong regulatory pressure to cope with the EU ETS at different levels within a company. European Commission's decision to launch the ETS in October 2003 has had a significant impact on the organizational structure of the steel companies in the EU. At the management level, it started to become necessary for them to establish an effective structure to formulate their ETS strategy and to address their concerns about towards it through a lobbying activity in Brussels. In addition, it has become inevitable to monitor the release of GHG emissions at the plant level. The level of the GHG emissions is capped at the plant installation level under the EU ETS. The preparation for the EU ETS has started to require a close communication between senior-level managers at the headquarter and steel plant managers. It has begun to become necessary for energy managers at the plants to understand the scheme and consider how to cope with it.

In the case of Arcelor, corporate strategy on climate change is formulated at the management board level. According to the company, the strategy is discussed every four to six months at the level. The Executive Vice President (EVP) of Sustainable Development, Mr. Jerôme Granboulan, formulates strategy and directly reports to the Chief Executive Officer. The Senior Vice President (SVP) of the Environment, Mr. Karl Buttiens reports to the EVP. The EVP of Research and Development, Mr. Jean-Louis Pierquin, is in charge of the technological initiatives on climate change such as the ULCOS and IISI's breakthrough program. The EVP of Finance, Mr. Phlippe Capron, is in charge of the financial aspects of the GHG emissions including registry, pooling and accounting of the emissions allowances under the EU ETS (Arcelor, 2006). In the case of Corus Group, the Chief Executive Officer has an ultimate responsibility for climate change issues. At the Executive Committee level, the Group Director of Technology and Services, Mr. Nelson Cunha is responsible for the issues. Specific climate change issues are the responsibility of the Director of the Environment, Dr. Paul Brooks (Corus Group, 2006).

These cases indicate that global climate change has arisen as a key agenda to handle at the board meeting level. It also appears that it has been increasingly becoming inevitable to involve the main business divisions such as finance division and research division. Traditionally, an involvement of these divisions was absent with respect to the environmental issues. The environmental department took care of the major part of the issues without any coordination with other divisions. At this point, an environmental consultant in Europe states that "previously, strategically important issues from the point of view of the finance department may not have included environment, health and safety. Increasingly, the environment is becoming a significant one" (Nicholls, 2005).

It appears that global climate change is arising as an issue for the European steel companies that requires both horizontal and vertical communications within the companies. The horizontal communications among business divisions are becoming necessary for the cross-divisional nature of the issue. As stated earlier, the vertical communications between senior-level officers and plant managers are also becoming crucial for the integration of management strategy into the plant-level initiatives.

7.3.2.3 Information disclosure

Arcelor and Corus Group disclose information on their strategy on climate change. Arcelor describes its strategy in the sustainable development section of the annual report. Corus Group publishes annually a corporate sustainability report. While the Germany steel company, ThyssenKrupp, does not publish a sustainability report, it describes its climate change initiatives and programs in separate documents. Climate change is recognized as a main corporate environmental agenda in the documents. As mentioned earlier, Arcelor and Corus respond to a questionnaire by the CDP. They describe their climate change initiatives and programs in their answer to the questionnaire.

7.3.2.4 Measurement

While Nippon Steel and JFE are hesitant to disclose data on GHG emissions release, it is mandatory now for the European steel companies to report it to the national governments under the EU ETS. The reporting is subject to the rules and instructions under the Monitoring and Reporting Guidelines issued by the European Commission. It is also necessary for them to obtain verification from an independent accredited verification body for the reporting contents. The national governments use the data for the allocations of the emission allowances under the National Allocation Plans (NAPs). For example, the Dutch government allocated 31,039,212 ktons of the emissions allowances to Corus Group' steel plant in Ijmuiden between 2005 and 2007.[68] The volume of the GHG emissions released from the large integrated steel plants is publicly available information in the EU now.

Arcelor decided to introduce an environmental data management system in 2002 to collect data from its 140 production sites. The SVP of the Environment of the company states that "equally important for a company with 140 production sites around the world has been the need to ensure it can collect enough data, often enough, to ensure it amounts to a true reflection of the company's environmental performance" (Nicholls, 2005). Of particularly importance is the ability of the system to benchmark facilities against each other. The SVP adds that "we have plenty of installations that are doing the same thing, so we have a chance to look at who is performing better".

7.3.2.5 Internal and external financial accounting

Arcelor and Corus have not yet integrated the costs and revenues associated with climate change initiatives into their external financial accounting. No climate change related costs and revenues are reported in their annual reports. The reason for the absence of the initiative is, as mentioned above, seems to be associated with the fact that the discussion on the external carbon accounting has only begun a few years ago.

On the other hand, the European steel companies have begun to integrate climate change related costs in their internal accounting. As indicated above, whether it is large or small, the EU ETS has financial impacts on the steel companies under the EU ETS It is becoming necessary for the European steel companies to compare the costs and benefits of in-plant energy efficiency improvement measures with the costs to purchase emissions allowances from the emissions trading market (For the economic logic behind this, see Section 2.1.2).

7.3.2.6 Product development

As is the case with Nippon Steel and JFE, Arceor and Corus Group have received pressure to increase fuel efficiency of automobiles from the European automobile makers and users. There is in competition with alternative materials that provide a lighter weight body for automobiles such as aluminum and plastics. The European steel companies responded in the same fashion as the Japanese steel companies to such a pressure by developing the ULSAB.

7.3.2.7 Technological innovation

As illustrated in the policy statement section (Section 7.3.2.1), the European steel companies emphasize that their energy consumption and GHG emissions release level has reached a theoretical minimum level. They maintain that technological breakthrough is necessary to make further GHG emissions reductions. As illustrated above, this is the argument similarly presented by the Japanese steel companies.

---

[68] The emission allowance data in the Netherlands is available in the document titled as "Bijlage 2 bij de artikelen 2 en 4 van het nationale toewijzingsbesluit broeikasgasemissierechten 2005 and 2007."It is noteworthy that the Corus' plant in Ijmuiden received by far the largest amount of the emissions allowances in the Netherlands. This indicates that the steel plant produces the largest quantity of the GHG emissions of all plants in the Netherlands. The plant that received the second largest volume (19,882,604 ktons of allowances) is Shell's refinery plant in Pernis in Rotterdam.

With a view of investigating technologies to reduce GHG emissions, Arcelor and Corus Group, together with other European steel companies established a research consortium called the ULCOS (Ultra Low CO_2 Steelmaking). The consortium comprises 48 European steel companies with an initial budget of €44 million partly funded by the European Commission. All major steel makers in the EU participate in the consortium including Arcelor, Corus Group and Theyssen Krupp. The ultimate goal of the consortium is to identify technologies to reduce GHG emissions release by 30% to 70%.

The consortium established a ten year project consisting of two phases. The first phase started in 2004 and continues until 2009. The objective of the first phase is to select two main routes for steelmaking that demonstrate technical and economical feasibility. The second phase follows the first phase from 2009 to 2015. The objectives of the second phase is to build and operate two industrial size pilot plants based on the outcome of the first project, to address technological problems, and to develop a reliable estimate of its operating and maintenance costs (European Commission, 2006). Presently, the ULCOS consortium is investigating eight technological routes, out of which two will be selected for an implementation of a pilot project in the second phase. The followings are the technological routes under investigation:

1 New blast furnace;
2. New smelting reduction;
3. Natural gas route to steel;
4. Hydrogen steel production;
5. Electrolysis steel production;
6. CO_2 capture and storage (CCS);
7. Use of biomass;
8. Use of electrical energy together with carbon.

As the project began only a few years ago, it is unclear what technological routes will be chosen for the second phase. It seems, however, that there is a strong focus on the development of CCS among European steel companies. Corus Group, for example, states that it conducted a mapping of CO_2 storage sites in the North Sea that could potentially be used for storage of carbon dioxide from its steel production sites including Scunthorpe, Teesside and IJmuiden (Corus Group, 2005). A manager of Corus Group stated in an interview that CCS is the most promising technology thus far, through which steel companies may reduce their GHG emissions by 50% in the future. With this respect, Japanese and European companies share the same view. As stated above, the Japanese steel companies, Nippon Steel and JFE also anticipate CCS to be a breakthrough technology for future GHG emissions reductions.

The European steel companies (Corus and Arcelor) also consider that the ULCOS initiatives may bring about possible technology transfer to the developing countries. Corus Group stated that “opportunities may also arise for the implementation of ULCOS technologies, both iron making and CCS, within the rapidly developing economies of China, India and Brazil” (Corus Group, 2005).

While Nippon Steel and JFE recognize CDQ as a promising technology to reduce GHG emissions, Arcelor and Corus Group show little interests in this technology except some German and Finnish steel companies. From their standpoint, With the current energy prices in the EU, “instrument/operational cost-environmental benefit consideration sets strong limitations on the applicability of CDQ” (Schoenberger, 2000). Interviewed managers in the EU stated that an introduction of CDQ in Europe is not as attractive as Japan or South Korea considering the lower price of electricity in Europe. Indifference of the European steel companies to CDQ is also associated with the fact that the Japanese steel companies developed the technology. The European steel companies were not involved in its development. A manager at Corus Group clearly stated in an interview that the company does not have an intention to investigate a possibility of CDQ at their plants.

7.3.2.8 Integrated chain management/life cycle assessment

There are some initiatives among European steel companies to integrate climate change issues in their supply chain management. Arcelor monitors the GHG emissions from the material procurements through the environmental data management system stated above (Arcelor, 2006). Arcelor and other European steel companies also investigate impacts of the GHG emissions in the context of LCA. Their initiatives in LCA center around the development of the life cycle inventory (LCI) database of the IISI. Arcelor states that “the current LCI methodology focuses on the production of steel but we are investigating an evolution of the methodology which would also consider the multiple recycling of steel and its end of life” (Arcelor, 2006).

7.3.2.9 Partnership/membership

Arcelor, Corus Group, Thyssen Krupp and other major steel companies in the EU participate in the CO_2 Breakthrough Program established by the IISI. As described above, the IISI is a Brussels-based organization serving as a forum to exchange information among the steel companies in the world. The CO_2 Breakthrough Program was established to “explore the opportunities, strategies and goals available globally to radically reduce CO_2 emissions”. The companies share the information and data on GHG emissions reduction technologies under the program. As illustrated above, the European steel companies have formulated the ULCOS consortium through Eurofer, separately from the IISI. While the CO_2 Breakthrough Program and ULCOS share the common goal to explore future technologies to reduce CO_2 emissions, the membership of the ULCOS consortium is limited to European companies.

Aside from the global and regional programs, the European steel companies have established bilateral relationships with individual steel companies outside of the EU to exchange information on GHG emissions reduction measures. Arcelor began to work with Nippon Steel on the climate change issues as part of their strategic alliance agreement in 2001. Corus and Theyssen Krupp have established a similar arrangement with JFE.

It is also noteworthy that environmental managers of European steel companies such as Arcelor, Corus Group and Theyssen Krupp are proactively involved in the discussion at the regional and international levels to cope with global climate change. They are vocal about their positions on the climate change policy instruments such as via the EU ETS in the climate change workshops and roundtables. They are also active in providing policy proposals on the post-Kyoto regime.

7.4 Second level of analysis: European corporate responses to the climate change policy instruments

This section presents an analysis of European corporate responses to the climate change policy instruments. The thesis author conducted research based on the method presented in Section 3.3. The thesis author collected information and data through extensive literature reviews including academic journals, industry journals, annual reports, sustainability reports, newspapers, company’s websites and other. He also conducted open-ending interviews with corporate managers at Arcelor and Corus Group as well as steel industry experts analyzing the economic impacts of climate change policy instruments, especially the EU ETS.

7.4.1 Voluntary agreement between the government and industry

As described in Section 4.2.5.2.2.1, many European countries have a tradition of implementing voluntary environmental agreements (VEAs). Presently, VEAs are introduced in the field of energy and climate change in many European countries. As discussed in the earlier section, although they are labeled as “voluntary”, many VEAs implemented in Europe have legally binding features and explicit linkage to public incentive policies. With this respect, the European VEAs are considered as *negotiated* voluntary environmental agreements (NEAs) according to the OECD classification of VEAs. The characteristics of the European NEAs make a sharp contract to the voluntary agreements in Japan and the United States which tend to be only unilateral announcements. The previous section illustrated the Dutch Long Term Agreements as well as Benchmark Covenants on Energy Efficiency as successful cases of agreements between the government and industry to cope with climate change. Implementation of VEAs is generally supported by European steel companies. The following is a statement announced by Eurofer:

> Eurofer supports the idea of voluntary or negotiated agreements at national level. Because of the investment time scales in the sector and because of the limits on improvements in energy efficiency, such agreements are best considered in a timeframe of a few decades. Currently, the steel industries in five Member States are covered by agreements, i.e. in Finland, France, Germany, Luxembourg, and The Netherlands. This implies coverage of about 50% of EU steel production. An agreement is close to completion in the United Kingdom, which would result in about 60% coverage (Eurofer, 2000).

7.4.2 Carbon tax

As described in Section 4.2.5.2.2.2, many EU member states have already introduced energy or carbon taxes to decrease fossil fuel use and to reduce GHG emissions. The steel companies in the EU, however, are generally receiving tax exemptions and refunds. The actual costs to comply with the tax schemes for the steel companies are not substantial.

At the European Commission level, there is a discussion to remove possibly the tax exemptions and refunds. Responding to this discussion, Eurofer published a position paper titled “Eurofer view on energy taxation”. It expressed its objection against such a possibility as follows:

> The use of a fiscal measure to promote a reduction in energy consumption and CO_2 emissions is misconceived. The imposition of additional taxation is not suitable for a reduction in energy consumption by industrial sectors whose production processes are necessarily energy-intensive; it will simply increase the unit cost of such production at the expense of the cash flow from which research and development and new energy efficient installations are financed...There already exists a significant imbalance between the EU and its major international competitors in the energy costs they face. It has been estimated that energy prices for industry in the USA for instance are 30-40 percent lower than those faced by European industry without any marked difference in specific energy consumption. Additional taxes in Europe would simply aggravate this imbalance and seriously undermine the competitive position of EU industry (Eurofer, 2004c).

It appears that Eurofer is expressing its objection to carbon tax for the same reason as the EU ETS. (See the below section on the EU ETS). Cost increases and loss of international competitiveness are the major sources of their concerns toward these schemes. In addition, European steel companies are expressing their concerns over a possible double burden with carbon tax and the EU ETS. They contend that the member state governments must remove the carbon tax if the European Commission decides to continue the EU ETS (Eurofer, 2004c).

7.4.3 European Union Emissions Trading Scheme

The EU adopted the EU Emissions Trading Directive (2003/87/EU) in July 2003. Since then, there has been a strong resistance to the EU ETS among the energy-intensive sectors including the steel industry sector. The followings are the statements announced by Eurofer, Arcelor and Corus Group:

> The implementation of the Emission Trading Directive is of major concern to the EU steel industry. Indeed, it is not obvious that the steel companies will be correctly rewarded for their early actions and the efforts that have been made to reach the asymptotic related greenhouse gases emissions. We fear that the full allowances needed to cover the steel process related emissions would not be allocated in a sufficient manner to allow the steel companies to grow or even to survive at their current production level. In the short term the potential is very high that they would lose business to non-EU competitors, who may not be subject to any CO_2 emissions limitations. The net result will therefore, be an increase of global CO_2 emissions, an increase of imports of finished products and therefore, reduction of employment in the EU (Eurofer).

> In favor of decreasing GHG emissions and the principles of the Kyoto Protocol, Arcelor has denounced its terms of application in Europe, and in particular the directive on CO_2 Credits. This directive focuses the efforts required on industry alone, and on each industrial sector differently. The allocation of CO_2 credits per country, and even per region, runs counter to a worldwide approach to large sectors such as the steel industry (Arcelor, 2004).

> The effect of EU ETS is to put an economic value on CO_2 emissions. The cost of carbon then has to be taken into account in commercial and technical decisions. Unfortunately, we operate in a global market and the majority of our competitors is not in the EU and is not subject to the same constraints and financial impacts. We are not able to pass on increases in costs since generally we are price takers not price makers (Corus Group, 2006).

The above statements indicate that there is a significant concern among European steel companies about a possible loss of competitiveness in the international market through an introduction of EU ETS. This is a noteworthy point since, as described in Section 5.2.1, some experts on the emissions trading scheme consider that the ETS only leads to minor economic impacts. For example, the IEA study maintains that an introduction of the emissions trading scheme is likely to result in significant cost increases in the steel industry sector (Reinaud, 2005). In addition, steel companies received sufficient or surplus emission allowances during the first period (2005-2007). Arcelor states that “for the period of 2005 and 2007, Arcelor has been granted a sufficient quantity of emission credits under various national application plans in relevant European countries to cover its anticipated steel production needs” (Arcelor, 2005). Corus Group’s manager also states that “we were in slight surplus for the year (2005) of Phase 1 of EU ETS, but expected to be roughly in balance for Phase 1 overall” (Corus Group, 2006).[69] In addition, as seen in Section 4.2.1, the majority of steel produced in the EU is consumed in the region. The EU is

[69] A steel company belonging to Arcelor Group stated in an interview that it has surplus allowances that it can sell to other parties. Corus Group stated in an interview that while the company has sufficient allowances in the UK, it is short in allowances in the Netherlands.

neither a larger steel importer nor exporter. European steel companies are not presently as exposed as Japanese steel companies to the international market.

It appears that there are mainly three reasons why the European steel companies still consider that the economic impacts of the EU ETS are significant. The first reason is an increase of electricity price. The energy-intensive industry sectors including the steel industry sector in the EU maintain that the electricity generation sector, which is also covered by the EU ETS, is passing through the opportunity cost of the EU ETS to the customer. In their view, the electricity generation sector is making so called, "windfall profit" by reflecting the carbon price into electricity price.[70] Eurofer maintains that the electricity price has risen by 40% in France and Germany in the last two years, partly because of the passing-through of the opportunity cost (Eurofer, 2004a). In Germany, Thyssen Krupp is appealing the problem to the electricity market regulator (Ball, 2006). The Germany electricity market regulator is investigating whether the electricity generation sector abused their market power to raise electricity rates and the Germany government will impose tougher emission reduction requirements on the electricity generation sector from 2008 (Ball, 2006). As explained in Section 4.5, the electricity cost of the total steel production cost in the BOF process is small. Nevertheless, the European steel companies consider that the economic impacts of the electricity price increase are significant, partly because it is difficult for them to reflect the cost in the price in the competitive international market.

The second reason why the European steel companies consider the economic impacts of the EU ETS significant relates to the future uncertainties with the volume of emission allowances. While the European steel companies presently have sufficient emission allowances, there is no guarantee whether the allowances remain sufficient, since the volume of steel production as well as GHG emissions production change over time. In addition, the national governments may change the level of the emissions allowances onward. There is a criticism especially from the NGOs and research communities that the national governments provided excessive volume of emission allowances in the pilot phase.[71] There are prevailing opinions at the EU level that the national governments need to limit the volumes of the allowances from 2008.

The third reason is that while the European steel companies are not either large steel importers or exporters, they still trade steel in the international market. Their sales are likely to be affected if they increase steel prices due to the EU ETS. Corus Group stated in an interview that the shares of European steel possibly decrease both in the domestic and foreign markets. According to the company, if the steel companies in the EU increase the steel price in the EU market, there will be more steel with a lower price especially from Eastern European countries to the EU market. Corus Group stated that as for foreign markets, for example, The European steel companies might lose in competition against a Korean steel maker in the United States, which is a large steel market for foreign steel markers after China.

According to Eurofer, in the absence of immediate technologies to reduce GHG emissions at their steel production sites, there are three options that European steel companies can consider in response to the EU ETS (Eurofer, 2004a). The first option is to purchase emission credits that are "economically acceptable" from CDM and JI projects. This point is elaborated in the next section. The second option is to reduce a volume of steel production. According to Eurofer, this will bring negative impacts on the EU economy such as loss of employment and

---

[70] According to Eurofer, the energy-intensive industry sectors consider that there is a lack of competition in the electricity generation market. The market is dominated by a small number of large players. They have dominant power to pass their carbon costs onto wholesale prices, regardless of a source of electricity generation, whether it is renewable or non-renewable.

[71] In April 2006, member state governments announced that the industry sectors under the EU ETS are producing less CO_2 emissions than the allocated volumes of emission allowances. This information became a trigger to pull down the price of EUAs.

competitiveness. Corus Group stated in an interview “because of the EU ETS, we made some decisions not to produce steel with an expectation that it would in fact lead to more revenue.” The company also mentioned that it decided not to construct a new sinter plant and purchase pallet from South America.

The third option for European steel companies to cope with the EU ETS is to relocate production sites outside of the EU and to import steel to the EU. Eurofer elaborates this option as follows:

> EU steel producers may have to move production to countries not subject to emissions limitations according to the Kyoto Protocol, either by relocation of our own production units or by increased purchases of semi-finished steel such as slabs, again with a possible net increase of global CO_2 emissions (Eurofer, 2004a).

Several steel experts stated in interviews that some European steel companies have already relocated their production plants to South America because of the concerns over the EU ETS. This trend raises a serious concern over carbon leakage as discussed in Section 6.4.2.2.

7.4.4 Clean Development Mechanism (CDM) and Joint Implementation (JI)

European steel companies generally support an implementation of the project-based mechanism. Eurofer states that it seeks an “immediate and unconditioned link between ETS and JI/CDM and all credits generated by CDM/JI projects should be available for conversion into allowances by the Linking Directive.” (Eurofer). As mentioned above, the Linking Directive was adopted at the European Commission in September 2004 to make it possible to trade credits generated through CDM and JI projects in the EU ETS. Corus Group’s manager also stated in an interview that the company is in favor of the project-based mechanism and linking it to the EU ETS, because when the CERs and ERUs enters the emissions trading market in the EU, the price of the EUAs will drop.

It appears, however, that European steel companies are not interested generally in conducting CDM and JI projects. This is sharply contrasted to the Japanese steel companies participating in the carbon credit procurement funds, having a CERs purchasing agreement through a HFC-23 decomposition project and exploring energy efficiency improvement projects such as CDQ in China. Corus Group explicitly states in its response to the Carbon Disclosure Project’s questionnaire that “we have not participated in CDM/JI projects to date and have no plans to do so in the near future” (Corus Group, 2006). In an interview, Corus Group’s manager stated that while the company monitors the development on CDM/JI, it does not intend to conduct any projects in the foreseen future.

It became clear that the reasons for the indifference to CDM/JI projects among European steel companies are threefold. First, European steel companies have sufficient or surplus emission allowances between 2005 and 2007 under the EU ETS. There is no urgent need to obtain additional credits to meet their capped CO_2 emissions reduction target. Second, there is an agreement between the member state governments and industry sectors in several European countries that the government is responsible for obtaining credits through CDM/JI projects. In the case of the Netherlands, for example, an introduction of the Energy Efficiency Benchmarking Covenant was contingent on the government being responsible for obtaining necessary credits through CDM/JI projects and not imposing additional carbon tax upon the industry sectors. As described above, the government has implemented carbon credit procurement programs. On the other hand, under the Energy Efficiency Benchmarking Covenant, it has become necessary under the agreement for the industry sectors to reach the level of the top 10% of energy efficiency in the world-class ranking.

Third, European steel companies do not have vital technologies or patents for steel manufacturing process. In general, there are separate manufacturers that provide steel production technologies to the steel companies in Europe.[72] This makes a sharp contrast to Japanese steel producers. In the case of Japan, while steel companies operate steel plants, they also manufacture their own plants. Therefore, they consider CDM and JI activities as a channel to sell their technology to the steel plants in the developing countries. The Japanese steel companies own the key elements of the patent relating to the CDQ technology, for example.

7.4.5 Post-Kyoto policy instruments

As illustrated in Section 7.2.3.5, there are remarkable initiatives at the EU level to discuss possible policy instruments in the post-Kyoto period. The European Commission outlines its strategy after 2012 in the publication titled “Winning the battle against climate change”. The EU Council of Ministers is presently suggesting ambitious GHG emissions reduction targets (15-30% and 60-80% reductions by 2020 and 2050). There is a strong regulatory pressure to the energy industry sectors in the EU to reduce GHG emissions.

Amid the policy dialogue on the post-Kyoto policy instruments, the main concern among European steel companies is a loss of competitiveness in the global market. In the document titled “Eurofer’s concerns regarding the future EU climate change policy (post 2012)”, Eurofer expressed its concern as follows:

> The European steel companies are ready and willing to take their share of the effort to limit GHG emissions. Our main concern, however, is that this effort should not lead to them being driven out of the EU, as from the efficiency point of view, a relocation outside the EU would be the worst solution: no real global reduction of GHG and increased emissions from transport. We urge the [European] Commission to acknowledge and address their very real concerns of internationally affected steel companies as regards their competitiveness and growth prospects in the EU (Eurofer, 2004b).

The issue of utmost importance for the European steel companies in the post Kyoto regime is to include steel companies in other regions that are currently free from obligation to reduce GHG emissions under the Kyoto Protocol. They consider an inclusion of steel companies in other regions as a necessary condition for the continuation of the EU ETS. Corus Group maintains, “we expect EU ETS to continue in the future…however, in order to address competitiveness distortions within the steel sector we would like to see the same rules and regulations applying on a global basis, but without fundamental change to the way this policy is applied, this seems unlikely” (Corus Group, 2006). With this respect, they support European Commission’s endeavor “to persuade all major world emitters to commit to a binding scheme, including the United States and rapidly emerging economies such as China and India” (European Commission, 2005).

Two additional points are clear in regards to European steel companies’ positions on the post Kyoto policy instruments. First, They are in favor of a sectoral approach in the post Kyoto period. Thyssen Krupp proposes a voluntary benchmarking scheme to measure GHG emissions release of steel plants against the best-in-practice steel plant (Still, 2003). According to Theyssen Krupp, an introduction of a benchmarking scheme is “the only long-term solution for the steel industry” (Still, 2003). Corus Group’s manager stated in an interview, “the post

[72] Martin Cames at Öko-Institut in Germany indicate that this is also the case with the electricity generation sector in the EU. He argues that the technology providers such as Siemens and AEG develop technologies for the electricity generation sector, while the electricity generation firms are not involved in the development. This approach of technological innovation is not necessarily common among industry sectors. For example, firms in the automobile and chemical industry sectors pursue research and development by themselves to produce new technologies (Cames, 2006).

Kyoto regime should be based on a sectoral or unit performance based scheme including the U.S. and other steel makers not covered by the current Kyoto Protocol." They are generally against an absolute value-based approach.

Second, the European steel companies consider that further research and development efforts are crucial in providing a long-term solution to reduce GHG emissions on a large scale. They stress the ULCOS consortium as the main platform to work on the efforts. While they recognize IISI's CO_2 Breakthrough Program as another platform, their attention is seemingly rather geared toward ULCOS program. The reason for this may be related to the fact that the ULCOS consortium is better funded by the member companies as well as by the European Commission, as illustrated above.

Summary of Chapter 7

This chapter examined the European institutional dimensions and corporate climate change strategy of two European steel companies: Arcelor and Corus Group. At the national level, it paid a particular attention the institutional dimensions in the Netherlands. It was recognized that the EU ETS is playing an important role in shaping corporate climate change strategy of the European companies. The next chapter investigated the U.S. institutional dimensions and corporate climate change strategy of the single large steel company with BOF operations in the U.S.: US Steel.

Chapter 8: U.S. firms

8.1 Overview of U.S. steel industry sector

The United States is the third largest steel producer after China and Japan with total production of crude steel of 98.9 million tons in 2004 (International Iron and Steel Institute, 2005). The BOF and EAF are responsible for 46.4% and 53.6% of the total steel production respectively (International Iron and Steel Institute, 2005). The United States is one of a few major countries where the EAF process accounts for half of the total steel production. This is an interesting aspect of the U.S. steel industry sector as the BOF process is dominant in the major steel producing countries including China, Japan and EU countries. As illustrated above, the U.S. is the second largest steel importing country in the world. During the 1990s, the U.S. steel industry experienced a series of bankruptcies due to a loss of market share and to higher labor costs. As the U.S. economy has grown since the 1990s, a quarter of the steel demand in the local market is met by imports.

After the World War II, the U.S. was the leading steel producing country. The country produced nearly half of the production in the world. Since the 1960s, however, the global competition has grown from Japanese and European producers. Facing the loss of market shares, bankruptcy and strong pressures from labor unions, the Bush Administration imposed a protective tariff on steel imports from non-NAFTA countries in 2002. The administration later withdrew the tariff, after it was found to be illegal under the WTO.

United States Steel Corporation (US Steel hereafter) is the single dominant steel company in the United States with the BOF operation. US Steel is the seventh largest steel company with 20.8 million tons of crude steel production in 2004. Nucor is the world's largest steel company producing steel through EAF process or mini-mills. In 2004, The company produced 17.9 million tons of crude steel in 2004. While the company makes steel from scrap or recycled steel, it is the ninth largest steel company in the world with respect to the volume of steel production. Because of its size, the company is often referred as the "giant mini-mills".[73] As mentioned earlier, however, this research focused on the BOF operations. Therefore, Nucor is excluded from the targets of analysis.

According to the American Iron and Steel Institute (AISI), the U.S. steel industry has reduced its energy intensity per ton of steel by 28% (American Iron and Steel Institute, 2005b). The inventory released by the EPA suggests that the industry reduced its emissions from 85 million tons to 51 millions of CO_2e from 1990 to 2004 (Environmental Protection Agency, 2006). However, the inventory also indicates that the steel industry sector is the largest CO_2 emissions releaser after the electricity generation sector in the country.[74]

While the United States signed the Kyoto Protocol, the Bush Administration announced in March 2001 that the U.S. will not ratify the Protocol. The energy intensive sectors in the U.S. have become free from any regulatory pressures to reduce GHG emissions since then. Presently, while the Bush team is in power, there is no prospect that the U.S. government will make a commitment at the international level to the target and timetable approach taken in the UNFCCC negotiations. However, since the U.S. is the largest GHG emissions producer, accounting for approximately one quarter of the global emissions, it should become actively involved in reducing its carbon dioxide footprint. The countries that ratified the Kyoto Protocol, especially the EU countries, began to pressure the U.S, government to consider its participation into the post-Kyoto regime. In the search for a possible convergence

[73] The figures mentioned in this paragraph are cited from the following IISI publication: International Iron and Steel Institute (2005) World Steel in Figures 2005. Brussels.

[74] The electricity generation sector is by far the largest GHG emission producing sector accounting for 34% of the total GHG emission release in the U.S.

on the climate change strategy, it is important to investigate how the U.S. energy-intensive industry sectors formulate climate change strategies and management.

It appears, however, that the information and data on this subject are extremely limited. This is mainly because the country does not have an international commitment to reduce GHG emissions. The companies in the country are free from any regulations. There is no urgent need for the U.S. energy-intensive industry sectors to formulate it. Section 8.2 illustrates the U.S. institutional dimensions. An analysis of the U.S. steel industry sector is presented in subsequent sections.

8.2 U.S. institutional dimensions

8.2.1 Divergent factor: Societal concerns about climate change

A public survey conducted by GlobalScan in 2006 suggests that only 49% of the people in the United States answered that climate change is a serious problem (GlobeScan, 2006). This rate is low compared to other developed countries such as France (70%), Germany (73%), Japan (75%), and UK (70%). The survey concludes that the only countries where this is not a majority position are the United States and six developing countries (China 39%, Indonesia 44%, Kenya 44%, South Africa 44%, Philippines 46% and Nigeria 47%). Furthermore, according to the survey, while only 8% of the surveyed people answered that climate change is not a serious problem on average, 21% of the surveyed people in the United States gave the same answer. This illustrates a sharp contrast in public opinion on climate change between the United States and the rest of the countries analyzed in this thesis research.

It is important, however, to note that the United States has a solid historical background for the environmental NGOs to be active in the domestic debates on climate change. The U.S. -based Sierra Club and the North America division of Greenpeace were very active in promoting actions to prevent climate change when the first IPCC assessment report was released in 1990. The NGOs such as the Environmental Defense Fund (EDF) and Ozone Action are progressive in advocating domestic policies to cope with climate change. In the U.S. there are also renowned research institutes such as World Research Institute (WRI), Worldwatch Institute and the Pew Center on Global Climate Change. They have been actively providing research outputs into the UNFCCC negotiations.

In recent years, however, the level of the NGO’s activism on the climate change issue dramatically toned down in the United States. The NGOs community in the U.S. is not playing an important role in providing a pressure to the industry sectors and the government to cope with climate change.[75] Apparently, the decision of the Bush Administration to withdraw the Kyoto Protocol had a serious impact on the dialogues that were taking place between the NGOs community and the government as well as the industry sectors. Bang and Heggelund succinctly illustrates this point as follows:

> As a result of the change of the U.S. administration and the statement by President Bush that the United States would not become a party to the Kyoto Protocol, environmental NGOs have almost given up on promoting the treaty in the U.S. Although European NGOs have been able to influence both international and domestic climate change policy, U.S.-based NGOs have focused on international talks, business and consumers to compensate for lack of access to their home government (Bang et al.,

[75] In the last two to three years, however, there are some changes in the level of the NGO’s activism in the U.S. The NGOs have increased their pressure and have attempted to make changes in the activities of many states, cities, companies and within the U.S. congress.

2005).

Before President Bush's announcement, there was a high level of discussions between the NGOs and the industry sectors. The companies that decided to take confrontational strategy and to denounce the Kyoto Protocol formed the Global Climate Coalition (GCC). With a facilitation of the EDF, the companies acceptable to the voluntary actions to reduce GHG emissions, on the other hand, formed the Partnership for Climate Action (Christiansen, 2003, Bang et al., 2005).[76] They announced that they would reduce GHG emissions by 15% relative to the 1990 level by 2010 under the partnership. After the Bush Administration retreated from the Kyoto Protocol, however, the sharp contrast in their stances on climate change disappeared. The communications between companies and NGOs and the government seemed to fade away. For the U.S. companies, there are no needs to fight against a possible introduction of mandatory regulations. While some companies such as Dupont and BP left the GCC because they changed their strategy on climate change, many firms did not find a *raison d'etre* to be part of the coalition any longer.[77]

It is clear that the pressures from the NGOs community to the companies to cope with climate change have been very weak. There are not strong societal concerns toward climate change either. On the other hand, the scientific community is recently becoming a strong source of pressures to cope with climate change. In response to the request of the White House, in 2001 the National Academy of Sciences conducted an investigation on the causes of climate change and submitted a report titled "Climate Change Science: An Analysis of Some Key Questions" to the White House. The report concluded that global warming is occurring due to human activities. It also endorsed IPCC's previous analysis by stating "the IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in GHG concentrations accurately reflects the current thinking of the scientific community on this issue" (National Academy of Sciences Committee on the Science of Climate Change, 2001). Other organizations such as the American Meteorological Society, the American Geophysical Union and the American Association for the Advancement of Science (AAAS) also issued their statements concluding that the evidence for human modification of climate is compelling (Oreskes, 2004). Those views presented by the U.S. scientists had an impact on those in the government and industry sectors that once rejected the Kyoto Protocol to reconsider their views and positions on climate change in recent years.

8.2.2 Divergent factor: Regulatory culture and schemes

The U.S. regulatory schemes in the environmental area are typically characterized by its command-and-control approach. During the negotiation toward the Kyoto Protocol, however, a possible adoption of a market-based mechanism to control GHG emissions was one of the main interests of the government. On the other hand, the EU was generally skeptical about an introduction of a market-based mechanism. When Bill Clinton and Al Gore came to the office in 1992, they began to consider an adoption of the model of the SO_2 trading scheme to GHG emissions control. The sulfur dioxide trading scheme was launched in 1990 under the Clean Air Act. In Kyoto in 1997, the Administration argued strongly to include the trading scheme as part of the Protocol.

The U.S. government has not ratified the Kyoto Protocol, however. Half a year before the Protocol was signed in Kyoto, the U.S. Senate adopted in a 95:0 vote so-called the Byrd-Hagel Resolution in the Congress (Senate Resolution 98, 6/1997) (Ochs and Sprinz, 2005). The resolution prevented the Administration from putting the

[76] The major companies that were initially the members of the GCC are Dupont, Exxon, Ford, Royal Dutch/Shell, Texaco, British Petroleum, General Motors, and DaimlerChrysler. The present members of the Partnership of Climate Action include Alcan, Royal Dutch/Shell, British Petroleum, Entergy, Ontario Power Generation and Suncor Energy.

[77] The GCC website (http://www.globalclimate.org/) is no longer active either.

Protocol to a vote in the Congress. As Ochs and Sprinz argues, in fact, the Kyoto Protocol never had a chance of ratification under the Clinton Administration either (Ochs and Sprinz, 2005).

The Bush Administration came to the office in 2001. The Administration made it clear that the government does not have any intention to ratify the Kyoto Protocol. The reasons for not supporting the Protocol are threefold. First, the scientific uncertainties associated with the projection of global warming presented by the atmospheric scientists are too great. Second, the fact that the developing countries are free from emissions reduction obligations under the Protocol brings serious concerns about loss of competitiveness of the economy. Third, an adoption of "targets and timetables" in the Protocol are too harmful to the economy. With this respect, President Bush contended that it "would lead to an even more dramatic shift from coal to natural gas for electric power generation and significantly higher electricity prices" (Bush Jr., 2001, Christiansen, 2003).[78]

Instead, the Administration proposed the National Climate Change Technology Initiative in 2001. The objective of the initiative is to encourage research and development on technologies to reduce GHG emissions. In 2002, the Administration announced the U.S. Global Climate Change Initiative. The primary goal of this initiative was to reduce GHG emissions intensity of the U.S. economy, measured as GHG emissions per unit of total GDP, by 18% in the period of 2002 and 2012. This initiative has received strong criticism from the research community for the fact that the goal of the GHG emissions reduction is based on the historical trend of the GHG emissions reduction. The scientific community demonstrated that no emissions reduction efforts are necessary to achieve the goal. Overall, the regulatory pressures to reduce GHG emissions are extremely weak at the U.S. federal government level. In response to the Global Climate Change Initiative, however, the industry sectors announced a voluntary GHG emissions reduction plan called Climate VISION in 2003. The acronym "VISION" stands for "voluntary innovative sector initiative: opportunity now". As seen in the following section, 12 industry sectors announced their emission reduction targets and timetables for reduction including electricity generation, steel, semiconductor and other sectors.

While the U.S. Congress voted for the Byrd-Hagel Resolution in 1997, there have been some initiatives in the Congress to deal with climate change in recent years. The Senators, Joseph Lieberman and John McCain have taken the most prominent initiative. They proposed a bill called the 'Climate Stewardship' Act to introduce a cap-and-trade GHG emissions trading scheme covering all major industry sectors. The bill was defeated in the Senate by 43 to 55, which, however, indicated that there is some level of support in the Senate for the introduction of an emissions trading scheme. Lieberman and McCain announced that they will reintroduce the bill in subsequent years (Pianin, 2003).

There are increasing initiatives at the state governmental level. In 1997, Oregon enacted legislation requiring new energy facilities to avoid, sequester, or displace a portion of their previously unregulated CO_2 emissions. In 2001, Massachusetts capped the GHG emission releases from the electricity generation sector to reduce emissions by 10% in the next several years. In 2001, six New England states and five eastern Canadian provinces agreed to introduce a regional standardized GHG emission inventory as a basis for GHG emissions reduction. New Jersey is planning to reduce emissions by 3.5% from 1990 levels by 2005. California established a registry for GHG emissions in anticipation of new regulations. Similar initiatives have been taken in Illinois, Wisconsin, Minnesota,

[78] A supportive view of President Bush's argument against the Kyoto Protocol can be found in an article written by Coon. Coon maintains, "the global economy would be better served if the United States continued to lead opposition to the Protocol's command-and-control regulatory approach and looked for alternative ways to encourage nations to reduce emissions voluntarily". See Coon, C. (2001) Why President Bush is right to abandon the Kyoto Protocol. The Heritage Foundation.

Michigan and Ohio.[79]

Compared with the other developed countries that ratified the Kyoto Protocol, the regulatory pressures to the industry sectors to reduce GHG emissions are weak in the United States. No tax scheme or emissions trading scheme is under discussion at the federal level. While the EU and other countries attempt to persuade the U.S. government to participate in the climate change regime in the post-Kyoto period, the discussion on the subject is not taking place on the U.S. side.

8.2.3 Voluntary scheme: Climate VISION

The steel industry sector in the U.S. maintains that it can reduce GHG emissions most efficiently through an implementation of a voluntary program under the Climate VISION. AISI (American Iron and Steel Institute) has initiated a program to improve energy efficiency by 10% by 2012 relative to the 2002 baseline.

However, the details of the program are not disclosed. It is unknown whether there is a monitoring, verification, auditing scheme under the program. In addition, the nature of the initiative is conducted on a unilateral basis. The goal was established without a formal negotiation with the government or consultation process with stakeholders. With this respect, the nature of the voluntary scheme is different from the European voluntary schemes discussed earlier. It can be said that the U.S. scheme falls into the type 3 of the OECD classification of the VEA indicated in Section 1.2.2.3: unilateral (or independent) voluntary environmental codes and action plans (UVEPs) remaining outside the formal governmental policy framework.

8.3 First level of analysis: U.S. corporate climate change strategy and management

This section presents an analysis of the U.S. corporate climate change strategy and management. As stated above, availability of information on the U.S. steel industry's initiatives appear to be limited. It is not deniable that the quality and quantity of the gathered information are relatively poor. The analysis was conducted in a very brief fashion compared to the previous analyses on Japanese and European firms.

As mentioned above, US Steel is the single dominant steel company in the U.S. with the BOF operation. While the volume of Nucor's steel production is reaching close to that of US Steel, Nucor produces steel by using scrap steel through the EAF operation.[80] Since this study focuses on the integrated steel production, it excluded Nucor from

---

[79] The information provided in this paragraph was drawn from two publications summarizing policy development on climate change in the United States. One publication titled "Climate Change Activities in the United States 2004 Updates" was published by the Pew Center on Global Climate Change. The other publication titled "Europe Riding the Hegemon? Transatlantic Climate Policy Relations" was published by Ochs and Sprinz. Ochs and Sprinz argue that "clearly, the initiatives originating in the Congress as well as on the state and local levels have not yet been sufficiently welcomed by the international community. On the other hand, local and regional initiatives should be seen as valuable components but not substitutes of effective (inter)national climate change policy". See Ochs, A. & Sprinz, D. F. (2005) Europa Riding the Hegemon? Transatlantic Climate Policy Relations. Potsdam, Potsdam Institute for Climate Impact Research.

[80] Nucor is the world's largest company producing steel through the EAF process or mini-mills. According to IISI, in 2004, The company produced 17.9 million tons of crude steel in 2004 (International Iron and Steel Institute, 2005). It collects approximately 5 million tons of steel scrap from automobiles. With respect to the volume of steel production, it is the ninth largest steel company in the world. Because of its size, the company is often referred to as the "giant mini-mills". The company produces bar, sheet, structural and plate products. Its products are sold to steel service centers, manufactures and fabricators. The company operates facilities in 14 states in the U.S. and employs approximately 11,000. In 2002, Nucor purchased Birmingham Steel Corporation, which includes four operating mills in Alabama, Illinois, Washington and Mississippi. The company's revenue was US$ 9.49 billion in 2005.

the analysis. US Steel is therefore, the only company for analysis in Chapter 8. This section first presents overviews of US Steel and of the American Iron and Steel Institute (AISI), the steel industry organization in the United States.

8.3.1 Company overviews

8.3.1.1 US Steel

US Steel is the largest steel company in the United States. The company is the seventh largest in the world with 20.8 million tons of crude steel production in 2004 (International Iron and Steel Institute, 2005). The predecessor of US Steel, USX-US Group was founded in 1901 headquartered in Pittsburgh, Pennsylvania. The Group spun off its steel-related business into a separate entity and United States Steel Corporation (US Steel) began to operate independently in 2002. The remaining energy business of USX became Marathon Oil Corporation. US Steel has 12 blast furnaces and nine finishing plants in the United States. The company has several BOF integrated steelworks in the U.S. including the Gary Works (Illinois), Great Lakes Works (Michigan), Granite City Works (Illinois), Mon Valley Work's Edgar Thomson Plant (Pennsylvania), and Fairfield Works (Alabama). The Gary Works in Illinois is the largest integrated steel facility in the United States. It also has steelmaking subsidiaries in Slovakia and Serbia. US Steel Kosice (USSK) in the Slovakia produces and sells steel mill products and coke to the central European market. The US Steel Balkan (USSB) based in Serbia acquired National Steel in 2003 strengthening its position in the domestic flat rolled market. In addition to primary steel operations, US Steel participates in several joint ventures including the USS-POSCO Industries.

In response to the economic changes during the 20th century, the company reduced its domestic steel production capability through a number of restructurings. The production peaked at 35 millions tons of crude steel production in 1953. The number of its employment was greatest during the World War II with 340,000 employees but decreased to 52,500 in 2000. The company’s revenue was US$ 15.41 billion in 2005.

8.3.1.1 American Iron and Steel Institute

AISI was founded in 1855. It is a non-profit and lobbying organization headquartered in Washington D.C., comprising 32 integrated and electric furnace steelmakers and suppliers to the steel industry in the United States. The organization publishes position papers on the public policy issues including trade, energy and environment, market development and manufacturing and technologies. It publishes position papers on climate change. The organization serves as a focal point for implementing the North American part of the CO_2 Breakthrough Program launched by the IISI (For the IISI, see Section 6.3.2.9).

8.3.2 Analysis

8.3.2.1 Policy statement

US Steel does not provide policy statements on climate change frequently. The following is one of a few statements made in the response to a questionnaire sent by the CDP in 2004:

> The policy and regulatory response to climate change concerns could result in commercial disadvantage if, similar to the Kyoto Accords, they result in mandatory controls and/or limits that are not internationally uniform giving some countries, especially developing countries, unfair advantage (United States Steel, 2006).

As pointed out above, the Bush Administration discusses that the developing countries do not have the GHG emissions reduction targets under the Kyoto Protocol. This is a main reason for its rejection to the Protocol. US Steel shares the same view with the Administration as illustrated in the above statement.

8.3.2.2 Organizational structure

US Steel began to involve senior-level officers in the climate change issue. Climate Change is the responsibility of the Vice President-Environmental Affairs. The company reports that the Climate Change/Global Warming Committee is recently formed “to propose policy, recommend appropriate steps and assist in implementation” (United States Steel, 2006). The Committee is co-chaired by the Executive Vice President, Chief Operating Officer and the Vice President-Law and Environmental Affairs. The Executive Environmental Committee has general oversight over environmental matters. Involvement of senior level officers may indicate that the company began to recognize an importance of responding to the regulatory development in the domestic and international arena.

8.3.2.3 Information disclosure

The information that the company discloses on climate change is limited. The company does not publish an environmental or sustainability report. It does not make any specific references to climate change in its annual report. The only information that the company provides to the public is its answer to a questionnaire sent by the CDP in 2006. The level of the information disclosure is extremely low compared to the steel companies in other regions.

8.3.2.4 Measurement

Unlike the European steel companies, US Steel does not have any obligations to measure GHG emissions release. The company does not have any emissions reduction target either. It reports that “ while US Steel has always strived to continually improve its environmental performance, we have not established reduction targets and do not have a firm date for the establishment of targets” (United States Steel, 2006).

8.3.2.5 Internal and external financial accounting

US Steel has not yet integrated the costs and revenues associated with climate change initiatives into their external financial accounting. No climate change related costs and revenues are contained in its annual report. It is not clear whether or not they are integrated in their internal accounting. No climate change-related costs and revenues are reported in their publicly available reports.

8.3.2.6 Product development

As is the case with steel companies in the other regions, US Steel has received increasing pressure to develop steel products that contribute to fuel efficiency improvements from domestic automobile makers and users. Facing the drastic increase of the fuel prices in the last three years, automobile users are becoming more sensitive to fuel efficiency in the U.S. In response to the pressures, the U.S. steel and automobile companies have formed a research consortium called the Auto/Steel Partnership. The members of the partnership include three major automobile companies including DaimlerChrysler, Ford, General Motors as well as three major steel companies including US Steel, Dofasco and Mittal Steel USA. The consortium has been working on a research project to develop the ULSAB.

8.3.2.7 Technological innovation

US Steel emphasizes that its energy consumption and GHG emissions release are reaching the theoretical minimum level. The company states "US Steel is not aware of any technologies [to reduce GHG emissions] that are currently available that can be economically employed in the company" (United States Steel, 2006). It maintains that technological breakthrough is necessary to make further GHG emissions reduction. As illustrated above, this is the same argument presented by Japanese and European steel companies.

On the other hand, the U.S. steel industry has launched the North American version of the CO_2 Breakthrough Program. The program is receiving funding support from the U.S. Department of Energy (DOE). The approach of the program is similar to the ULCOS consortium launched by European steel companies. The program identifies potential technologies and assesses technical and economical feasibility of each technology within an established deadline. According to AISI, the U.S. steel industry has a particular interest in the following four area of technologies (Energetics Inc., 2003):

- Geological sequestration;
- Closed-cycle biomass such as CO_2 capturing with biomass and conversion of the biomass to fuel;
- Advanced scrap recycling and scrap processing such as increased energy efficiency of scrap melting and optimization of the elemental characteristics of scrap;
- Alternative reducing agents such as use of charcoal, hydrogen and a combination of carbon and hydrogen.

The program is presently investigating the feasibility of each technology in collaboration with academic institutions. It seems that there is a high level of interest in geological sequestration technology. The European and Japanese steel companies share the same interests in this technology, as discussed earlier.

8.3.2.8 Integrated chain management/life cycle assessment

It appears that US Steel does not take into account GHG emissions in its supply chain management. In response to CDP's questionnaire, the company answered that it does not estimate indirect GHG emissions associated with its supply chain and does not have any plan to do so in the future (United States Steel, 2006). A lack of the initiative is in sharp contrast with to steel companies in the other regions that are putting efforts to integrate LCA or green purchasing scheme into their strategies and procedures.

8.3.2.9 Partnership/membership

US Steel participates in the North American CO_2 Breakthrough Program as well as in the global program established by the IISI. The company is a member of the AISI. The AISI organizes workshops and conferences inviting managers of European steel companies and IISI who are experts on climate change issue. It seems that the institute is keen to learn from the experiences of European steel companies about the EU ETS and other policy instruments being implemented in the EU. On the other hand, US Steel and AISI are not proactive in participating in the climate change related workshops. The presentations on their climate change initiatives are hardly seen anywhere.

8.4 Second level of analysis: U.S. corporate responses to the climate change policy instruments

As indicated in Section 8.2.2, the regulatory pressures to the energy intensive sectors to reduce GHG emissions are weak in the United States. Presently, there are no policy instruments such as a carbon tax or emissions trading scheme at the federal level. In 2005, when the Energy Policy Act was under deliberation, there was a discussion about a possible introduction of a mandatory emissions trading scheme in the Conference Committee. However, the items on the emissions trading scheme were subsequently removed from the text, in the Committee.

8.4.1 General position on climate change policy instruments

The position paper published by AISI illustrates the present position of the U.S. steel industry sector on the climate change policy instruments. The following is a sentence in the position paper:

> [AISI] oppose[s] any climate related legislation as we have already passed the effective, alternative voluntary, technology-driven approach to reduce energy-intensity to achieve GHG reductions and stability as part of the Energy Policy Act of 2005 (American Iron and Steel Institute, 2006).[81]

The steel industry sector is concerned about a possible introduction of the policy instruments in the future. As described above, there is an increasing support for a mandatory emissions trading scheme in the Congress. The AISI expresses a concern of the steel industry sector as follows:

> As other nations proceeded to implement the Kyoto Protocol, the Senate voted in 2005 on legislation sponsored by Senators John McCain and Joseph Lieberman to impose mandatory CO_2 reporting and controls. It was defeated but not in a manner that gives us comfort on this approach for the future...Mandatory greenhouse gas emissions reporting and controls remain a high priority for the environmental community. Senators McCain, Lieberman and Bingaman will again introduce climate change legislation in spite of the fact the Congress endorsed meaningful and effective climate provisions in the recently passed energy bill (American Iron and Steel Institute, 2006).

The following briefly describes the stances of the US Steel on climate change policy instruments.

8.4.1 Emissions trading scheme

As described in Section 8.2.2, the United States was an ardent supporter for the emissions trading scheme in Kyoto, where the EU was skeptical about the scheme in the beginning. A document published after an OECD workshop in 1999 suggests that the US Steel was not opposing the scheme back then. The following sentence was found in a document written by a manager of US Steel who attended an OECD workshop:

---

[81] While they are some provisions in the Energy Policy Act regarding energy efficiency, renewable energy and climate change, it does not have remarkable impacts on GHG emissions reduction. See United States House of Representatives (2005) Summary of Policy Provisions of the Energy Policy Act of 2005 Conference Report. Washington D.C.

> Our experience suggests that a cap-and-trade model may be the most user-friendly, so long as there is an open market, credits are guaranteed by the seller, baseline performance is measurable and verifiable, and the program is broad and enforceable (Carson and Winkelman, 1999).

It seems that there is a change in the company's view on an emissions trading scheme, since it experienced the EU ETS in the EU. As described in Section 8.3.1.1, the company has a steelmaking subsidiary in Slovakia presently covered under the EU ETS. The following illustrates its present view on the emissions trading scheme:

> We do not support emissions trading schemes, such as presently in effect in the EU. US Steel's subsidiary operation, Slovakia (USSK), is currently under the EU scheme and has experienced significant difficulties particularly with, but not limited to, both inter- and intra- country allocations (United States Steel, 2006).

8.4.2 Clean Development Mechanism and Joint Implementation

It is unknown what the company's position is on CDM and JI. The following sentence was found the document written by a manager of US Steel who attended the above-mentioned OECD workshop in 1999 (Carson and Winkelman, 1999):

> Flexible instruments [indicating CDM and JI], developed and utilized wisely, have the real potential for aiding the growth of developing countries in an environmentally protective way, while reducing the global emission of greenhouse gases without placing an undue burden on the economies of the Annex I countries.

8.4.3 Post-Kyoto policy instruments

In the U.S., there is currently virtually no regulatory pressure on the steel industry sector to investigate or formulate its position on the post-Kyoto policy instruments. The position of the U.S. steel industry sector on this subject is unclear.

It seems, however, that the U.S. steel industry sector is in favor of voluntary and technology-based schemes. The U.S. companies have been implementing the North American part of the CO_2 Breakthrough Program launched by the IISI. They emphasize that its energy consumption and GHG emissions releases are reaching the theoretical minimum level and technological breakthrough is necessary for further GHG emissions reduction. In addition, they joined the Asia-Pacific partnership on Clean Development and Climate. They may consider a sectoral approach as an acceptable option alternative to the Kyoto approach after 2012.

Summary of Chapter 8

This chapter examined the U.S. institutional dimensions and corporate climate change strategy of the single large-scale steel company with BOF operations in the U.S. It was recognized that the rejection of the Kyoto Protocol by the Bush Administration has had an influence of formulating corporate climate change strategy of the U.S. steel company. The next chapter investigated the Korean institutional dimensions and corporate climate change strategy of the single large steel company with BOF operations in South Korea: POSCO.

Chapter 9: Korean firm

9.1 Overview of Korean steel industry sector

South Korea is the fifth largest steel producer in the world with total production of crude steel of 47.5 million tons in 2004 (International Iron and Steel Institute, 2005). As illustrated in Section 4.2.1, however, the country is not ranked on the lists of the top 15 steel importing and exporting countries. This indicates that there is a strong local demand for steel. The country's economy is still growing rapidly. In South Korea, POSCO (Pohang Iron and Steel Company) is the dominant steel company producing over three quarters of total national steel production. In fact, POSCO is the only fully integrated steel producer in South Korea. The other steel producers conduct EAF operation. POSCO is the fourth largest steel company in the world with crude steel production of 30.2 million tons in 2004 (International Iron and Steel Institute, 2005).

POSCO increased dramatically its volume of steel production over the last 20 years. POSCO has two main integrated steel plants in Pohang and Gwangyang. In addition, POSCO operates a joint venture with US Steel, USS-POSCO located in Pittsburg, California. The Pohang plant was constructed in four phases between 1970 and 1981. The plant produced 12.67 million tons of crude steel in 2004. The Gwangyang plant was constructed in four phases between 1982 and 1992. The plant produced 16.23 million tons of crude steel in 2004.

With an increase of steel production, POSCO has produced a larger volume of GHG emissions over the last two decades. However, South Korea does not have GHG emissions reduction target under the Kyoto Protocol. The country ratified the Protocol as a non-Annex I country in 2002. There have not been any regulatory pressures to POSCO to reduce GHG emissions. On the other hand, South Korea has experiences dramatic economic growth in the last two decades and the country is no longer recognized as a developing county. South Korea obtained the OECD membership in 1996. There is an increasing pressure to the Korean energy-intensive industry sectors both at the domestic and internal level to reduce GHG emissions.

It appears through our research that availability of information the Korean steel industry's initiatives is extremely limited. There are two possible reasons for the limited availability of information. The first reason is associated with the fact that South Korea is a non-Annex I party. The country as well as the industry sectors in the country do not have any commitments to reduce GHG emissions. For the steel industry sector in South Korea, there is not urgent need to formulate climate change strategy and management. Their strategy and management do not need to be as sophisticated as is required for European or Japanese companies. An interviewed POSCO manager stated that "we will wait and see what other steel companies in Europe and Japan will do with climate change."

The second reason is related to the trend where climate change has begun to appear as a politically sensitive issue in the country. There has been a discussion whether the country shall accept a GHG emission reduction target in the post Kyoto period. Several anecdotes indicate that Korean policymakers in government consider that it will become inevitable to accept a GHG emission reduction target in the post Kyoto period. In response to a possible introduction of a regulatory scheme, corporate managers in the Korean steel industry sector are becoming more sensitive in handling the corporate information on climate change.

9.2 Korean institutional dimensions

It seems that there is a growing concern about climate change in the Korean society. A public survey conducted in 2006 demonstrates that the rate of the people who answered climate change as a serious problem reach 63% in

South Korea (GlobeScan, 2006). A NGO based in South Korea, the Korean Federation for Environmental Movement (KFEM) illustrates the Korean societal sentiments:

> There is growing evidence that South Korea is vulnerable to the impacts of climate change. The year of 1998 in Korea was marked by the hottest spring in history, severest floods in summer and an autumn hotter than summer. The distinctions between South Korea's four beautiful seasons which have been a great pride for its people are becoming blurred, with the southern part of the nation turning into a subtropical area without winter (Korean Federation for Environmental Management, 1998).

As the economy has grown over the last three decades, there has been a significant increase of GHG emissions release in the country. In 1990, the volume of CO_2 emissions production was estimated at 65 million tons of CO_2. It is expected to grow to 217 million tons in 2010 and 281 million tons in 2020 (Korean Federation for Environmental Management, 1998). This indicates that the volume of country's GHG emission released may quadruple in the next three decades. On one hand, South Korea does not have a GHG emissions reduction target under the Kyoto Protocol. On the other hand, there is a growing pressure on the country for making a commitment to establish the target in the post Kyoto period.[82]

In 1998, the industry sectors agreed with the Ministry of Commerce, Industry and Energy (MOCIE) to have a voluntary agreement to reduce GHG emissions. (The Ministry of Commerce Industry and Energy and Korea Energy Management Corporation, 1998). The agreement does not have a legally binding nature but is linked with financial incentive schemes including tax exemptions and subsidies for investment in energy conservation efforts. With this respect, this voluntary agreement may be considered as a type 2 under the OECD classification indicated in Section 1.2.2.3: negotiated voluntary environmental agreements (NEAs).

POSCO signed the voluntary agreement in December 1998. The company agreed to reduce energy consumption by 5.9% relative to 1997. According to the company, it reduced GHG emissions by 6.0% in 2001 and 9.4% in 2003. The company concluded a second voluntary agreement with the government to reduce energy consumption by 6.9% by 2008 relative to 2003 (POSCO, 2005).

Presently, there are no mandatory schemes for GHG emission reduction in South Korea. As described above, however, as the discussion on the post-Kyoto regime proceeds, there will be domestic and international pressures to introduce a regulatory scheme in South Korea. The Ministry of Commerce, Industry and Energy (MOCIE) and the Ministry of Environment (MOE) recognize emissions trading as a possible policy instrument to introduce in the future.

9.3 First level of analysis: Korean corporate climate change strategy and management

This section presents an analysis of Korean corporate climate change strategy and management. As stated above, availability of information on the Korean steel industry's initiatives appears to be extremely limited. It is not deniable that the quality and quantity of the gathered information are relatively poor. The analysis was conducted in a brief fashion compared to the previous analyses on Japanese and European firms. The thesis author collected some

[82] A Korean magazine, Economy 21, published an article to present a similar view as follows: "since there are opinions that South Korea's position will change once the first Kyoto Protocol obligatory enactment period has passed." When from next year on the compulsory burden of reducing greenhouse gas according to the second public commitment period (2013-2017) becomes real, South Korea could also become an Annex-I-country". See Youn, H. (2004) Emission trade, no time to wait! *Economy 21.* (Some words are replaced to correct grammatical errors.)

information through open-ending interviews with POSCO corporate managers. POSCO is the only steel company that conducts an integrated steel production operation in South Korea. POSCO is therefore, the only company for analysis in this section.

9.3.1 Company overview

As described above, POSCO is the fourth largest steel company in the world with crude steel production of 30.2 million tons in 2004. The company has two main integrated steel plants in Pohang and Gwangyang with 12.67 million tons and 16.23 million tons of crude steel in 2004, respectively. The company is presently enjoying large profits given the robust steel demand in the local market as well as in China.

On the other hand, many steel experts consider that the growth of the company may decline in the near future. The steel price is expected to drop because many manufactures in South Korea began to purchase cheaper steel from China. An interviewed POSCO manager contends that when Chinese steel production meets its demand around 2008 and 2010, it will begin to overflow into the international market. According to the view of the manager, POSCO may begin to decrease its production level then as Japanese steel companies did in the 1980s.

It was noted that with increasing global competition, the company is aggressively investing into steel production in foreign countries especially in China and India. By 2006, POSCO had 26 subsidiaries and invested $2.4 billion in China especially in galvanized and stainless steel to supply global automobile and appliance producers that have opened plants in China. In 2006, the company began operating the Zhangjiagang Pohang Stainless Steel (ZPSS) steel mill capable of producing 0.6 million tons of stainless steel and hot-rolled products annually. As a result, it became the first foreign firm operating an integrated stainless steel mill in China; handling the entire production process from smelting iron ore to finished products.

In 2005, POSCO signed a memorandum of understanding with the state government of Orissa in India. Under the agreement, POSCO plans to invest US$12 billion to construct a integrated steel plant with four blast furnaces with an annual production capacity of 12 million tons of steel in Orissa. The Orissa State government promised to provide POSCO with a total of 600 million tons of iron source over the next 30 years. For POSCO, securing an access to raw material has been its strategic interest and the company took this opportunity to do so. If the project proceeds, it will become the largest foreign direct investment in India. According to a POSCO manager, this is the first case where a steel company built an overseas plant with 100% of its own funds.

9.3.2 Analysis

9.3.2.1 Policy statement

POSCO does not provide policy statements on climate change frequently. The following is one of a few statements made in response to a questionnaire sent by the CDP in 2003:

> With the ratification of the Kyoto Protocol, the pressure for a GHG reduction commitment from the developing countries including South Korea is predicted to increase and POSCO is focusing its efforts on devising a long-term and systematic plan to deal with this issue (POSCO, 2003).[83]

[83] Some words are replaced to correct grammatical errors and to change styles to the extent that it will not affect a message of the original sentences.

It is clear from this statement that POSCO recognizes the increasing pressure to reduce GHG emissions. It is unknown, however, how the company responds to such a pressure from this statement.

9.3.2.2 Organizational structure

POSCO has the Environment and Energy Committee. The Committee consists of executives and department managers. It is responsible for reviewing environmental and energy management data and supporting top management decisions on essential environmental matters. The Environment and Energy Department is located at the corporate headquarter. The department establishes a general guidance for its environmental management at the plant level and attends overseas meetings to monitor a policy-related development outside. The plant-level Environment and Energy Department at Pohang and Gwagyang plants formulate and carry out action plans. According to an interviewed manager, climate change is becoming a larger issue in the overall environmental issues.

9.3.2.3 Information disclosure

POSCO discloses some information on its climate change strategy and management. The company illustrates it in its Sustainability Report. In addition, POSCO responds to a questionnaire sent by the CDP every year. However, it began to decline disclosure of its answers recently. On the other hand, POSCO was selected in 2006 as a company in CDP's Climate Leaders Index as the “best in class” in the response to the CDP questionnaire. Since the answers are not disclosed, it is not possible to see what level of information the company provided to the CDP.

9.3.2.4 Measurement

In South Korea, there are no obligations to measure GHG emissions release. Under the above-mentioned voluntary agreement with the government, however, companies including POSCO submit their operational report to the South Korea Energy Management Corporation (KEMC). POSCO reports that the company reduced CO_2 emissions from 2.09 tons CO_2/ton steel in 1990 to 1.99 tons CO_2/ton steel in 2001 (POSCO, 2003).

9.3.2.5 Internal and external financial accounting

POSCO has not yet integrated the costs and revenues associated with climate change initiatives into their external financial accounting. No climate change related costs and revenues are reported in the annual report. It is not clear whether the company integrated them in internal accounting. No climate change-related costs and revenues are reported in the reports that are publicly available.

9.3.2.6 Product development

As it is the case with the Japanese and European steel companies, POSCO have been receiving an increasing pressure to develop steel products to improve fuel efficiency of automobiles from domestic automobile makers and users. South Korea is in a similar situation with Japan with respect to its dependency on energy imports from foreign countries. The country imports 97% of its energy and therefore, the Korean economy is vulnerable to oil price increases. There is a strong demand from automobile users for energy efficient vehicles. In response to such a pressure, POSCO has been working to develop the ULSAB.

9.3.2.7 Technological innovation

POSCO points out two technological measures to reduce GHG emissions. The first measure is to introduce a new blast furnace process called FINEX. FINEX is a technology being developed by POSCO and Austrian technology provider since 1992. It uses cheaper and abundant iron ore powder and coal rather than processing steel through sintering and coke production process. The technology reduces SOx emissions by 92%, NOx emissions by 96% and CO_2 emissions by 19% compared to conventional blast furnace (POSCO, 2003, Innovest Strategic Value Advisors, 2005). The company presently operates a FINEX demonstration plant with an annual capacity of 0.6 million tons.

The second measure is to introduce waste heat recovery systems including CDQ and TRT technologies. As described earlier, the CDQ is a technology developed by the Japanese steel companies. POSCO purchased CDQ from Nippon Steel for an installation at its steel plants. The company plans to install the technology at most of its plants by 2010. The company has installed TRT at nearly all of its steel plants.

9.3.2.8 Integrated chain management/life cycle assessment

There are some initiatives to integrate climate change issues in supply chain management. POSCO has implemented a “green purchasing system” since 2002 to prioritize a procurement of environmentally sound materials from its suppliers (POSCO, 2003). The company investigates the degree of GHG emissions in the context of LCA. It states “to improve our efforts, we participated in the LCA Project of the IISI from 1995 to 2000 and carried out a preliminary LCA study. Furthermore, we implemented a company-wide LCA system from 1999 to 2000” (POSCO, 2003).

9.3.2.9 Partnership/membership

POSCO participates in the CO_2 Breakthrough Program facilitated by the IISI. As described above, IISI serves as a forum to exchange information among the steel companies and as a research house to analyze the industry trends. POSCO has dispatched their staff to IISI to investigate how other steel companies cope with climate change. Especially, the company is interested in understanding what European steel companies are dealing with policy instruments such as the EU ETS. An interviewed POSCO manager stated that the company is trying to understand the lessons from the experiences of European steel companies that are valuable for the company in formulating climate change strategy and management.

9.4 Second level of analysis: Korean corporate responses to the climate change policy instruments

This section addresses an analysis of the Korean firm’s responses to the climate change policy instruments. As stated earlier, availability of information on the Korean steel industry’s initiatives appears to be extremely limited. In addition, climate change policy instruments are not introduced in the country except the voluntary agreement scheme described in the previous section. The below analysis is brief compare to the previous analysis on Japanese and European firms.

9.4.1 General position on climate change policy instruments

According to an interviewed POSCO manager, company’s general positions on climate change are summarized in the following three points. First, POSCO supports both the Kyoto Protocol and Asian Pacific Partnership on Clean Development and Climate. It supports the “target and timetable” initiative taken by the developed countries under the Kyoto Protocol. As for the Asian Pacific Partnership, South Korea is one of the six countries taking part in the agreement. The company considers that the voluntary initiative is complementary to the Kyoto Protocol. Second, the company recognizes IISI's Breakthrough Program as a focal scheme to investigate technologies to reduce GHG emissions in a greater scale. At this point, POSCO shares the same view with European and Japanese firms that due to the technological constraint, it is becoming extremely difficult to reduce GHG emissions in a drastic scale. Third, the company considers that it can afford time until it formulates a concrete plan and strategy on climate change. As quoted above, a POSCO manager in an interview stated that the company can wait and see what other European and Japanese company will do with climate change. The manager added that for now the company focuses on gathering information on the regulatory development in Europe and on analyzing what possible impacts the regulations many have upon steel companies in Europe.

The manager did not express an objection to any specific policy instruments under way in Europe and Japan. This response should not be interpreted that the company does not have strong objections to the policy instruments and is willing to accept them in the future. It is rather related to the fact that the company is at an early stage in its formulation of a climate change strategy.

9.4.2 Emissions trading scheme

As stated above, POSCO is paying a particular attention to the regulatory development in Europe, especially the EU ETS. The company is studying what possible impacts might be brought when a similar scheme is introduced in South Korea in the post-Kyoto period. POSCO has a concern about possible economic impacts that the EU ETS may bring to steel companies in the EU. The company understands that there is strong resistance to the EU ETS among European steel companies. According to an interviewed manager, there are several lessons that the company has learned through its observation on the dialogue between the member state governments and steel companies in the EU. Among all, it learned that European steel companies have been lobbing successfully against the member state governments in the allocation of emission allowances. Their pressure led to the governments' allocations of sufficient allowances to the steel companies. According to the manager, the company learned that it is essential for a company to provide explanations and have a dialogue with the government if a regulatory scheme such as emissions trading scheme is discussed in South Korea.

9.4.3 Clean Development Mechanism

POSCO is interested in conducting CDM projects. In 2005, the company announced to develop Afforestration/Reforestation (AR) projects as a CDM activity in China, India, Vietnam, Cambodia, Indonesia and Brazil. According to an interviewed manager, the purpose of exercising CDM projects to acquire credits as its initiative to offset carbon emissions and count as part of their emissions reduction efforts. The initiative is not based on economic interests. The company does not intend to sell the obtained credits through the implementation of the projects to other companies.

The company is also interested in energy efficiency improvement projects in the steel industry sector as a CDM activity. However, an interviewed manager stated that the absence of approved baseline and monitoring methodologies is becoming a constraint to take the initiative. (As mentioned in Section 6.4.3, none of the methodologies in the steel industry sector are approved at the CDM Executive Board.)

Summary of Chapter 10

This chapter examined the Korean institutional dimensions and corporate climate change strategy of the single large scale steel company with BOF operations in the U.S.: POSCO. It was recognized that POSCO began to formulate its corporate climate change strategy. The company may receive a stronger pressure to do so in the near future as South Korea may play an important role in the post-Kyoto regime as an OECD country. The next chapter is conclusions. It summaries the answers to the research questions addressed in this research.

Chapter 10: Conclusions

The previous four chapters described the results of the empirical research on corporate climate change strategy and management in the steel industry sector. This study examined the steel companies in Japan, the EU, the U.S. and South Korea[84]. It investigated their strategy and management on GHG emissions reduction as well as their responses to the climate change policy instruments including the Kyoto and post-Kyoto policy instruments.

This research addressed the following three questions:

1. What are similarities and differences in corporate strategy and management on GHG emissions reduction among the steel companies?

2. What are similarities and differences in their responses to the climate change policy instruments among the steel companies?

3. What are the main factors that contribute to formulation of corporate climate change strategies and management as well as their responses to the climate change policy instruments? Are they economic, technological or institutional factors or a combination of them?

This chapter summarizes the answers to the research questions. Before presenting a summary for each question (Section 10.1), the thesis author addresses a main statement of this thesis attained through the empirical study as well as several findings that support this statement:

MAIN STATEMENT: The institutional and technological dimensions are playing an important role in shaping corporate climate change strategies both at the first level (the strategic level) and at the second level (the policy-specific level) among the steel companies analyzed in this empirical research. The influence of the economic dimensions is observable at the second level to a lesser extent.

This study showed that the international regulation (Kyoto Protocol) is turning into a coercive pressure on the European and Japanese steel companies to move toward isomorphism. This is the first finding from this research. As discussed in Chapter 2, isomorphism is a concept introduced by DiMaggio and Powell. DiMaggio and Powell argue that the behaviors among organizations begin to resemble one another because if these organizations share the same "organizational field", they tend to be equally affected by the external forces (Section 2.1.5). The empirical study indicated that there are increasing trends for isomorphism between the European and Japanese companies with respect to corporate climate change strategies. There is a high level of similarities between them in the areas of policy statements, organizational structures, information disclosure, accounting and integrated supply chain/life cycle assessment. The European and Japanese companies have strong initiatives in the first three areas and some initiatives in the last two areas.

The similarities are particularly remarkable in comparison with the corporate strategy of the U.S. and Korean steel companies on climate change. The empirical study demonstrated that the Kyoto Protocol has contributed to strategic convergence between the European and Japanese steel companies. The Kyoto Protocol has become a

[84] The firms investigated in this study are Nippon Steel (Japan), JFE (Japan), Arcelor (Luxemburg/France/Spain/Belgium), Corus Group (The Netherlands/UK), US Steel (U.S.) and POSCO (South Korea). In this section, Nippon Steel and JFE are referred as the Japanese steel companies, Arcelor and Corus Group as the European steel companies, US Steel as the U.S. steel company and POSCO as the Korean steel company.

coercive force leading to isomorphism between them.

While the international regulation is turning into a coercive pressure on the European and Japanese steel companies to move toward isomorphism, it is becoming a divergent pressure on the European/Japanese and U.S./Korean steel companies in the formulation of climate change strategy. This is the second finding from this research. It was observed in the empirical study that the Kyoto Protocol has contributed to the sharp difference between the Japanese/European steel companies and the U.S./Korean steel companies. There is a high level of similarities between the U.S. and Korean steel companies with respect to the lack of initiatives in the areas of policy statement, information disclosure, measurement, accounting and integrated supply chain/life cycle assessment. The U.S. and Korean steel companies do not have an initiative in these areas, while the European and Japanese steel companies have some or strong initiatives in them.

On the other hand, there was an indication that the business strategy of the U.S. steel company on climate change was not different from the European steel companies before the Bush Administration rejected the Kyoto Protocol. After the rejection of the Kyoto Protocol, however, there has not been a strong regulatory pressure to the U.S. steel company to integrate climate change into its business strategy. While the European and Japanese steel companies have continuously received a regulatory pressure associated with the Kyoto Protocol, the U.S. and Korean companies have been free from it. It was concluded that the regulatory pressure is becoming a divergent pressure on the analyzed steel companies. This finding supports Kolk's empirical findings on convergence between Europe and Japan as well as increasing divergence between Europe and the U.S. in environmental reporting.

There is another factor that is contributing to generating divergence among the analyzed steel companies in the EU, Japan, the U.S. and Korea. This study showed that the differences in the local regulatory culture and schemes are turning into a divergent pressure (country of origin effect) on the companies in the formulation of climate change strategy. This is the third finding from this research. It became clear through the study that there are different regulatory schemes as well as different regulatory cultural backgrounds to reduce GHG emissions among the analyzed countries. In Japan, there is a lack of initiatives at the governmental level to introduce policy instruments on GHG emissions. The initiatives are only taken on a voluntary and unilateral basis by the industry sector. In the EU, the European Commission as well as the national governments in the region is progressively taking initiatives to install climate change policy instruments, while there is a great variety in the degree of the regulatory or coercive pressures among the EU member states. In the United States, the regulatory pressures for the industry sectors to reduce GHG emissions have been extremely weak or non-existent since the Bush Administration rejected the Kyoto Protocol. It was concluded that since the regulatory pressures are created in the unique local regulatory culture, the pressures are turning into a divergent pressure on the companies in the formulation of climate change strategies.

Aside from the institutional dimensions, this study demonstrated that technological dimensions are becoming important factors in generating divergence on climate change strategy. This is the fourth finding from this research. Technological factors were recognized as important factors in generating some key differences between the Japanese and European steel companies in their strategies as well as in their stance toward the climate change-related specific policy instruments. The strategic interest of Japanese companies in the cooperation with the developing countries through CDM, for example, is driven by their strong technological capability. Lack of interest among European steel companies in CDM is associated with the fact that they do not hold major patents for the steel producing technologies. It was also observed in the empirical study that technological dimensions are creating some differences between the Japanese and European steel companies in their strategic view toward the post Kyoto regime.

This study also revealed that the economic dimensions become central to the corporate manager's decision-making on climate change strategy when the costs and benefits of specific policy instruments are expected to be high. This is the fifth finding from this research. Steel company managers, for example, take into account the economic structure of the global steel market as well as the economic impacts of the Chinese markets in the formulation of climate change strategy. On the other hand, there is a great level of uncertainty with the assessment of the costs and benefits of the policy instruments. Under the circumstances filled with uncertainty, the institutional factor is playing far more important role in shaping corporate manager's perceptions and decision-makings on climate change. This finding coincides with Oliver's thesis that "the institutional influences are stronger under conditions of uncertainty, because managerial discretion is higher when the economic consequences of actions are unclear".

10.1 Results of the empirical study

10.1.1 The first level of subject area: climate change strategy and management

The subject area investigated in the empirical study include 1) policy statement, 2) organizational structure, 3) information disclosure, 4) measurement, 5) accounting, 6) product development, 7) technological innovation, 8) integrated supply chain/life cycle management and 9) partnership/membership. As illustrated in Section 3.5, this study placed a research focus on the management area and profit opportunity/new business development area. This research heeded a particular attention to a possible Stiglerian situation where a strategic focus on technological innovation or integration of climate change issues into business development to a lesser extent may stimulate corporate responses to climate change regulations and even lead to the "first-mover advantage" in international competition as discussed by Michael Porter.

Table 32 summarizes the findings on each subject area:

Table 32: The findings on each subject area at the first level of analysis

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
1	**Policy statement**	Have explicit statements on climate change. Emphasize the high level of energy efficiency and state that it is becoming harder to achieve further improvement. The statements in response to the regulatory pressure which may lead to regulatory isomorphism between the Japanese and the EU firms.	Have explicit statements on climate change. State that the energy efficiency level is reaching the theoretical minimum. The statements in response to the regulatory pressure which may lead to regulatory isomorphism between the EU and Japanese firms.	Does not have a clear statement on climate change. Only a few descriptions about their policy and strategy on climate change. Supports Bush Administration's policy for the country being separate from the Kyoto Protocol. Indication of no regulatory pressure.	Does not have a clear statement on climate change. Only a few descriptions about their policy and strategy on climate change. Recognizes the increasing pressure to reduce GHG emissions. Indication of cognitive pressures which may lead to mimetic isomorphism.
2	**Organizational structure**	Climate change policy adopted by the environmental department under the direct supervision of CEO. CEO provides a direct guidance on strategy against carbon tax and domestic emissions trading. Regulatory pressure is observed in the formation of the organizational structure.	Climate change policy adopted by the environmental department under the direct supervision of CEO. CEO provides a direct guidance on strategy toward the EU ETS. Regulatory pressure is observed in the formation of the organizational structure.	Climate change issues handled by the Executive Environmental Committee. However, an involvement of the senior officers is weaker than Japanese and European companies.	Climate change issues handled by the Environmental and Energy Committee. However, no direct CEO's guidance on climate strategy was documented.

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
3	Information disclosure	High level of disclosure. Some reference to the climate change issue in the annual report. Publishes sustainability reports where they discuss climate change initiatives. They publish technical reports and position papers on climate change. However, they do not disclose data on actual GHG emissions release with a concern that the data may be used as a basis for a future introduction of a regulatory scheme.	High level of disclosure. Some reference to the climate change issue in the annual report. Publishes sustainability report where to discuss climate change initiatives. Publish technical reports and position papers on climate change. Disclose detailed data on actual GHG emissions release. This is mandatory under the EU ETS indicating a regulatory pressure on this subject area.	Low level of disclosure. No reference to the climate change issue in the annual report. Does not publish an environmental or sustainability report.	Middle level of disclosure. No reference to the climate change issue in the annual report. However, the company publishes sustainability reports where it discusses climate change initiatives. It does not publish a technical report or a position paper on climate change.
4	Measurement	Have begun to measure the volume of GHG emissions production internally. However, do not disclose or report a methodology for measurement. There is a third party auditing process, but the results are not published. This may be the result of the absence of regulatory pressure.	Measures the volume of GHG emissions production under the EU ETS. Measurement and reporting to the national governments are mandatory under the EU ETS. There is a third party auditing process.	Unknown. The company states that it has not established a GHG emissions reduction target and does not intend to do so.	Unknown. It seems, however, there are some attempts to measure volume of GHG emissions production. There are some illustrations on the measurement in their sustainability report.

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
5	**Accounting**	Similar to Arcelor and Corus Group, some efforts are observed to calculate climate change related costs internally (environmental management accounting). The efforts are, however, weaker than Arcelor and Corus Group in the absence of a domestic regulatory pressure. No initiative to integrate them into the external financial accounting. No climate change related costs are described in annual report.	Some efforts to calculate climate change related costs internally (environmental management accounting). Using the internal accounting data to compare the costs of internal emission reduction costs with the costs to purchase emission allowances. The use of internal accounting driven by the economic incentive. However, no initiative to integrate them into the external financial accounting. No climate change related costs are described in the annual report.	Consideration of climate change related costs in the internal accounting is unlikely (environmental management accounting). No initiative to integrate them into the external financial accounting, either. No regulatory pressures to force the firm to consider it.	Consideration of climate change related costs in the internal accounting is unlikely (environmental management accounting). No initiative to integrate them into the external financial accounting, either. No regulatory pressures to force the firm to consider it.
6	**Product development**	Strong initiatives to develop lightweight steel for the automobile body. The pressure comes from the automobile producers to substitute steel with other cheaper materials such as aluminum and plastic. The other pressure comes from the automobile users to produce higher and energy efficient automobiles.	Strong initiatives to develop lightweight steel for the automobile body. The pressure comes from the automobile producers to substitute steel with other cheaper materials such as aluminum and plastic. The other pressure comes from the automobile users to produce higher and energy efficient automobiles.	Similar to the Japanese and European companies, strong initiatives are observed to develop lightweight steel for the automobile body even in the absence of the international and domestic regulatory pressures. The pressures from the automobile producers as well as the users are affecting their strategy to produce lightweight steel.	Similar to the Japanese and European companies, strong initiatives are observed to develop lightweight steel for the automobile body even in the absence of the international and domestic regulatory pressures. The company is equally receiving the increasing pressures from the automobile industry producers and users.

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
7	**Technological innovation**	Claim that with the current technology, further improvement in GHG emissions is harder to achieve. Stress that technological breakthrough is necessary to reduce GHG emissions in a greater scale. Strong interest in carbon capture and storage as a breakthrough technology. Displays strong interest in the recovery of process gas by utilizing CDQ and TRT.	Claim that the energy efficiency level is reaching the theoretical minimum. Stress that technological breakthrough is necessary to reduce GHG emissions in a greater scale. Strong interest in carbon capture and storage as a breakthrough technology. Recognize the ULCOS consortium as a platform for technological breakthrough.	States that the company is not aware of any technologies that can be economically employed to reduce GHG emissions. Strong interest in carbon capture and storage as a breakthrough technology. Launched the North American version of the CO_2 Breakthrough Program.	Strong interest in carbon capture and storage as a breakthrough technology. Recognizes a new blast furnace process called FINEX as a way forward to reduce GHG emissions. Similar to the Japanese companies, the company exhibits interest in the process gas recovery technologies including CDQ and TRT.
8	**Integrated chain management life cycle assessment**	Some initiatives to integrate climate change into supply chain management. Considers the scale of GHG emissions in the procurement process of raw materials. Evaluate the scale from the LCA viewpoint.	Some initiatives to integrate climate change into supply chain management. Arcelor monitors GHG emissions from the procurement of raw materials through its environmental data management system. Evaluate the scale of GHG emissions from the LCA viewpoint.	The company explicitly states that it does not consider the management of its indirect GHG emissions and will not do so in the future.	Some initiatives to integrate climate change into supply chain management. The company implements a green purchasing program to prioritize a procurement of environmentally sound materials from its suppliers. Evaluate the scale of GHG emissions from the LCA viewpoint.

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
9	**Partnership/membership**	Participate in multilateral and regional fora. Members of IISI's CO_2 Breakthrough Program. Established a cooperation agreement with the China Iron and Steel Association (CISA). Chairs the steel task force in the Asia-Pacific Partnership on Clean Development and Climate. Nippon Steel participates in the IPCC discussion session.	Participate in multilateral and regional fora. Members of IISI's CO_2 Breakthrough Program. Formulated the ULCROS consortium through Eurofer to promote cooperation among steel companies in EU. Arcelor has a bilateral agreement with Nippon Steel and Corus Group has a similar agreement with JFE. Participate in the climate change related workshops and conferences at the EU and UN levels.	Participates in multilateral and regional fora. Is a member of IISI's CO_2 Breakthrough Program. Formulated the American Iron and Steel Institute (AISI). Invited European a steel expert in a workshop for information exchange. However, the company is not proactive in participating in climate change related workshops and conferences.	Participate in multilateral and regional fora. Member of IISI's CO_2 Breakthrough Program. The company is keen to learn about the development in the EU through IISI. Has a bilateral agreement with Nippon Steel. Participates in the Asia-Pacific Partnership on Clean Development and Climate.

10.1.1.1 Policy statement

Section 3.5.1 illustrated the research items on policy statement. The first item was to investigate the existence of a policy statement in 1) annual report, 2) corporate environmental and sustainability report and/or 3) position papers. The second research item was the contents of a policy statement. The thesis author attempted to extract a key message in the statement which may be considered as an expression of the firm’s policy or strategy on climate change. The third research item was to contemplate whether the institutional factors are playing an important role in shaping the policy statement. In particular, the thesis author considered a possible influence of a regulatory pressure on the companies in forming their policy statement. The following presents a summary of the empirical study that we conducted in Chapter 6 (Japanese firms). Chapter 7 (European firms), Chapter 8 (U.S. firms) and Chapter 9 (Korean firm).

The Japanese and European companies have an explicit policy statement on climate change. They describe their policy and strategy in their corporate environmental and sustainability report. They also make clear in the policy statements their positions on climate change policy instruments proposed by the governments such as carbon tax and the emissions trading scheme. It is concluded from the analysis of policy statements that the Japanese and EU firms recognize climate change as an important management issue to handle. On the other hand, the U.S. and Korean firms do not have a clear policy statement. They only have a few descriptions about their policy and strategy on climate change.

This empirical study then looked into the contents of the policy statements. The Japanese companies (Nippon Steel and JFE) maintain in their statements that since they have reached a high level of energy efficiency in the steel production, it is becoming harder to improve the performance to reduce GHG emissions. The European companies (Arcelor and Corus Group) also emphasize the same point by stating that their energy efficiency level is reaching a theoretical minimum level. It is observed that the Japanese and European companies made the statements in response to a regulatory pressure to introduce policy instruments such as carbon tax and emissions trading scheme.

While the American company (US Steel) does not have a clear policy statement, it provides its view on a regulatory scheme that may be introduced in the future. The company stresses the possible negative impacts on their business operations. It expresses its support toward the Bush Administration’s policy for the country being separate from the Kyoto Protocol and taking only the voluntary initiatives to reduce GHG emissions. On the other hand, the Korean steel company (POSCO) recognizes an increasing pressure to reduce GHG emissions even in the absence of the GHG emissions reduction target under the Protocol. Interestingly enough, while the U.S. and South Korea do not have GHG emissions reduction targets under the Kyoto Protocol, there is a sharp contrast between the two steel companies on their policy and strategy on climate change. The case of the Korean company is considered as an indication of a cognitive pressure that may lead to mimetic isomorphism. This point is further elaborated in Section 10.2.

10.1.1.2 Organizational structure

Section 3.5.2 illustrated the research items on organizational structure. The first item was to investigate an executive officer(s) is involved among the firms analyzed in this study. In particular, it was decided to examine whether or not there is a direct guidance or supervision from a CEO on the management of the climate change issue. The second research item was to examine which department/committee handle climate change within the firm. In addition, it was decided to speculate whether the institutional factors are playing a role in shaping an organizational structure. The following presents a summary of the empirical study.

It was observed that all steel companies researched in this study have an environmental or sustainability department to cope with climate change. They also have a senior executive officer responsible for climate change. Their management board addresses the issue. There are communications between the management and business operations on the issue.

The empirical study investigated whether there is a direct involvement of a senior executive officer or CEO. The differences in the level of the involvement were observed in the study. In the case of Nippon Steel and JFE, there is a direct guidance from CEO on the climate change issue. The CEO is directly involved in the decision-making on the climate change issue. The president of Nippon Steel serves as a vice-president of the Nippon Keidanren coordinating the voluntary GHG emissions reduction scheme among the industry sectors in Japan. He is vocally expressing a concern about a possible introduction of the carbon tax and domestic emissions trading scheme on behalf of the Japanese industry as a whole.

Involvement of a senior executive officer is also the case with the European steel companies. Senior executive officers are involved in the dialogue at the EU level about the EU ETS. As presumed in Section 3.5.2, the implementation of the EU ETS has become a trigger to encourage a communication between the management and the business operations at the plant level. The preparation for the EU ETS has, in fact, required a close communication between the senior level managers and the steel plant managers among the European steel companies. It was found that the regulatory pressure to implement the EU ETS is taking a strong role in changing the level of the communication on the climate change issue and formulating firm's organizational structure among the European steel firms.

It can be concluded that the Japanese and European have an established organizational structure as well as the direct involvement of a senior executive officer to translate a management vision or strategy into business operations. On the other hand, the U.S. and Korean steel companies have weaker involvement of a senior executive officer. With respect to the degree of the direct guidance from the CEO, it is uncertain in the case of the U.S. and Korean steel companies.

10.1.1.3 Information disclosure

Section 3.5.3 illustrated the research items on information disclosure. The three questions addressed in this research were 1) whether a firm describes climate change initiatives in the annual report, 2) whether a firm publishes corporate environmental or sustainability report and/or position papers on climate change and 3) whether a firm publishes technical reports on climate change. In addition, it was decided to investigate to what extent a firm voluntarily discloses the information based on the request from the CDP. The following presents a summary of the empirical study.

There is a great degree of variance on the level of information disclosure among companies. The Japanese, European and Korean companies publish a corporate environmental or sustainability report and discuss their climate change initiatives in their report, while the U.S. firm does not publish it. The Japanese and European companies have a reference to the climate change issue in their annual report. Nippon Steel, Arcelor, Corus and US Steel responded to CDP's information request and agreed to disclose their information on CDP's website (www.cdproject.net), while JFE and POSCO responded to the request but declined to disclose the information.

It was found that the level of the information disclosure among the Japanese and European companies is much higher than in the U.S. and Korean companies. There is a sharp difference in the level of information disclosure between the Japanese/European and the U.S./Korean steel companies. Besides the environmental or sustainability report, the Japanese and European companies have other publications on climate change including technical reports and position papers. It can be concluded that there is a certain level of willingness among the Japanese and European companies to communicate with internal and external stakeholders.

Between the European and Japanese companies, the European companies have higher level of information disclosure. The European companies disclose detailed data on actual GHG emission releases since, as discussed earlier, it is mandatory for them to report the data to the national governments under the EU ETS. The national governments disclose the data in the reports concerning the national allocation plan under the EU ETS. The Japanese steel companies as well as the steel companies based in the other countries are hesitant to disclose such data with the strong concern that the data may be used as a basis for a future introduction of a regulatory scheme.

10.1.1.4 Measurement

Section 3.5.4 illustrated the research items on measurement. The three questions addressed in this section were 1) whether a firm measures the GHG emissions production, 2) whether a firm discloses or reports a volume of the GHG emissions production, and 3) whether a firm obtains a verification from a third party organization with respect to the approach and the results of the measurement. In addition, it was decided to speculate whether the institutional factors are playing a role in company's decision to measure a volume of GHG emissions production. The following presents a summary of the empirical study.

The European companies measure, disclose and report a volume of the GHG emissions production. They also obtain verification from a third party organization on the results of the measurements. The European companies are the only companies that take the thorough approach to the measurement among the analyzed ones. Under the EU ETS, it is required to measure and report their GHG emissions to the national governments. The European Commission provides the rules and instructions specified in the Monitoring and Reporting Guidelines. Under the Guidelines, it is also required to obtain verification by an independent accredited body for the reporting contents. The thesis author observed the strong regulatory pressure to the European companies to measure the GHG emissions production compulsory.

While the Japanese companies have begun to measure GHG emissions internally, they do not disclose or report their approach or methodology associated with the measurement. While there is a third party auditing process, there is no transparency in the auditing process itself. They do not disclose the auditing results.

On the other hand, it is unknown whether and to what extent there are initiatives to measure the GHG emissions production among the U.S. and Korean companies. US Steel states that the company has not established a GHG emissions reduction target and does not intend to do so. It is unknown either whether or not it measures the volume of its GHG emissions. As for POSCO, there are some attempts to measure the volume of its GHG emissions production. There are some illustrations on the measurements in its sustainability report.

It was found that the European and Japanese companies are the only companies to measure the volume of GHG emissions. In our conclusion, this is an indication that the European and Japanese companies recognize climate change as an important management issue. As seen in the case of the European companies, regulatory pressure is playing an important role in encouraging the firms measuring the volume of their GHG emissions.

10.1.1.5 Accounting

Section 3.5.5 illustrated the research items on accounting. The first research item was to investigate whether environmental management accounting is internally utilized to calculate climate change related costs and benefits. It was presumed that a regulatory pressure may be taking its role in a company's decision to exercise environmental management accounting. The second research item was to examine whether environmental financial accounting was introduced as part of the financial reports being presented to external stakeholders or shareholders. It was presumed that the pressures from stakeholders such as the information request through the CDP may have been influential. The following presents a summary of the empirical study.

There are some efforts among the European and Japanese companies to introduce environmental management accounting to calculate internally the climate change related costs. As presumed in Section 3.5.5, in the case of the European companies, the increasing costs associated with the EU ETS are the reason for them to introduce environmental management accounting. Under the EU ETS, it is necessary for them to calculate the costs because, whether it is large or small, the EU ETS is leading to financial impacts upon them. There is a strong regulatory pressure as well as a strong economic incentive to meet the regulatory compliance in the cost efficient manner. In addition, in order to minimize the costs to comply with the GHG emissions reduction target under the EU ETS, the European companies have begun to compare the costs of internal GHG emissions reduction measures with the costs to purchase emission allowances from the emissions trading market. (This behavior is described by the economic theory of the Kyoto mechanism illustrated in Section 2.1.2).

The Japanese companies also exercise environmental management accounting to seek to quantify the climate change-related costs as well as to identify cost-saving opportunities in their operations. However, as indicated in Section 6.3.2.5, their initiatives in environmental management accounting seem to be much weaker than the European companies due to the lack of the regulatory compliance costs. There is no reporting among the U.S. and Korean companies about calculation of the climate change related costs. It is unlikely that they are considering environmental management accounting to quantify climate change related costs and or benefits. Thus, the thesis author observed a sharp difference between the European companies and the companies in the other region. It is concluded that the regulatory pressure as well as the economic incentive is playing an important in the firm's decision to conduct environmental management accounting.

There are no companies in this research that have introduced environmental financial accounting as part of the financial report. No companies have yet integrated the climate change costs and revenues into their external accounting. No climate change related costs and revenues are described in the annual reports. On the contrary to the presumption presented in Section 3.5.5, it can be concluded that the pressures from the stakeholders such as the information request through the CDP has not been influential to stimulate the firms to introduce an accounting system for external purposes. The thesis author also paid attention to the fact that the discussion on the application of environmental financial accounting in the climate change area has only begun a few years ago. It is concluded that due to the weak external pressures as well as due to the absence of guidelines, the companies are not prepared to take the initiative in environmental financial accounting.

10.1.1.6 Product development

The initiative to integrate the climate change issue into product development presently concentrates on the development of lightweight steel for the automobile body. There is a pressure from the automobile industry to substitute steel with cheaper and lighter materials such as aluminum and plastic. With the increasing price of oil, there is also a pressure from the automobile users to the automobile companies to produce more energy efficient vehicles. This pressure is turning into a pressure on the steel companies to produce lightweight steel.

It appears that all steel companies are taking a challenge to produce lightweight steel. All steel companies are working on the development of the Ultra Light Steel Auto Body (ULSAB). They are equally receiving the increasing pressure from the automobile producers and users to develop the energy efficient products.

10.1.1.7 Technological innovation

All the analyzed companies claim that their energy efficiency level is reaching the theoretical minimum and therefore it is becoming difficult to reduce GHG emissions in a greater scale. The 2001 IPCC report pointed out, however, that there are still several technologies with large potentials in GHG emissions reduction including 1) pulverized coal injection in the blast furnace, 2) recovery of process gas, 3) replacement of OHFs by basic oxygen furnaces BOFs in Russia and China, 4) application of continuous casting and thin slab casting (such as replacement of ingot casting) and 5) second generation smelt reduction processes.

Among these technologies, Japanese and Korean steel companies pay a particular attention to the recovery of process gas by utilizing CDQ and TRT. The Japanese steel companies consider that these measures can be implemented as a CDM activity in the developing countries, especially in China. On the other hand, the European steel companies expressed little interests in these technologies.

All steel companies stress that technological breakthrough is necessary to reduce GHG emissions in a large scale. It appears that the carbon capture and storage technology is the technology of utmost interest among them. This technology has been focused in several regional and worldwide research initiatives including IISI's CO_2 Breakthrough Program and Eurofer's ULCOS.

10.1.1.8 Integrated chain management/life cycle assessment

There are some initiatives among the steel companies to integrate the climate change issue into the supply chain management. The initiatives center on the reduction of the GHG emissions when they procure raw materials. The companies attempt to evaluate their GHG emissions from the LCA viewpoint. There is a joint effort to create a LCI database through the IISI. On the other hand, US Steel has a different position on this matter. The company explicitly states that it does not consider the management of its indirect GHG emissions in the future.

10.1.1.9 Partnership/membership

All companies researched in this study participate in the CO_2 Breakthrough Program facilitated by the IISI. The program serves as a multilateral forum to exchange information on technological innovation among the steel companies in the world. This multilateral forum may become a focal point for technological diffusion for GHG emissions reduction in the future. (This point is further elaborated below.)

There are several bilateral/regional partnerships designed to cope with climate change. European steel companies have formulated the ULCOS consortium through Eurofer to investigate technological innovation for GHG emissions reduction. Arcelor and Nippon Steel have a bilateral agreement to work together on climate change. JFE, Corus Group and Theyssen Krupp have a similar agreement. The JISF has formed an agreement with the CISA to exchange information on the environmental protection measures. This agreement is used as a basis for CDM project development in China. The AISI facilitates the Northern American CO_2 Breakthrough Program mainly including the U.S. and Canadian steel producers. In some occasions, the AISI invites in its workshop the managers of European steel companies and the IISI who are experts on climate change. In 2005, the six counties in Japan, the United States and South Korea announced a voluntary technological cooperation, namely, the Asian Pacific Partnership on Clean Development and Climate. The steel companies in the three countries are expected to discuss a possible cooperation in the Steel Task Force under the policy framework.

10.1.1.10 Interpretation of the results

Overall, it was observed that the firms are receiving pressures from the external environment. Both domestic and international regulations are playing an important role in the formulation of corporate climate change strategies and management. On the other hand, the stakeholder or social pressures on firms were not observed at the first level of the subject area. This finding is consistent with the previous review concerning societal concerns about climate change of each country (See for Japan, Section 6.2.1, for the Netherlands, Section 7.2.1 and 7.2.2, for the U.S., Section 8.2.1 and for South Korea, Section 9.2.1.).

There is a high level of similarities between the Japanese and European firms in climate change strategy and management. As each section above as well as the summary table indicates, the similarities are found in the area of policy statement, information disclosure, accounting and integrated supply chain/life cycle assessment. The Japanese and European firms have strong initiatives in the first three area and some initiatives in the last two areas. On the other hand, there is a high level of similarity between the U.S. and Korean firms for the lack of initiatives. The areas of similarity include policy statement, information disclosure, measurement, accounting and integrated supply chain/life cycle assessment. It is considered that the Kyoto Protocol is contributing to the sharp differences between the Japanese/European firms and the U.S. /Korean firms and becoming a strong source of pressures that influences on the formulation of climate change management and strategy.

On the other hand, there are differences between the Japanese and European firms. The areas of differences are measurement and technological innovation. There are two factors that are contributing to the differences between them. Local regulation is a source of pressures for creating the difference in the measure of GHG emissions release. Under the EU ETS, it is mandatory for the firms under operation in the EU to measure and report to the national governments. Since the domestic emissions trading scheme is not introduced in Japan, it is unnecessary for Japanese firms to measure GHG emissions. As for technological innovation, a technological factor is the critical one in generating the difference between the Japanese and EU firms. Japanese firms displayed strong interest in the recovery of process gas by utilizing CDQ and TRT, while the EU firms did not address technologies of their specific interest apart from carbon capture and storage. The fact that the Europeans steel companies do not hold major patents for steel making technologies is associated with their stance on this matter.

While the institutional dimensions and technological dimensions are playing an important role in shaping corporate climate change strategy and management, the influence of the economic dimensions is harder to perceive at the first level of subject area. This is possibly associated with the fact that the costs and benefits of an introduction of the strategic and management issues at the first level are extremely unclear. The company's strategic change in policy statement or any other items at the first level is extremely difficult to translate into financial or economic values (On the other hand, the significance of the economic dimensions at the second level of subject area is clear, as discussed below). The absence of the economic factors is perhaps an indication of Oliver's hypothesis that are introduced in the beginning of Chapter 2 that "the institutional influences are stronger under conditions of uncertainty, because managerial discretion is higher when the economic consequences of actions are unclear." As described above, the institutional dimensions are taking the most important role in the formulation of corporate climate change strategy and management.

While the U.S. firms and Korean firms are not equally receiving the institutional pressures for the formulation of climate change strategy and management, there are differences in strategy and management in some subject areas including information disclosure, technological innovation and integrate supply chain/life cycle assessment. Concerning these subject areas, the Korean steel firm, POSCO, is comparable with the Japanese and European steel firms. POSCO's strategy is perhaps formulated to cope with the future uncertainty where the company expects that participation toward a regulatory regime in the post-Kyoto period is unavoidable. The concerns for the uncertainty were in fact expressed in the interviews with the company's corporate managers. This is a possible indication of one of DiMaggio's model for isomorphism, that is, "mimetic isomorphism" (The mechanism of mimetic isomorphism is illustrated in Section 2.3.2.1.).

One subject area that is common among Japanese, European, U.S. and Korean firms is product development. All firms have strong initiatives to develop lightweight steel for the automobile body. The thesis author observed that, regardless of the countries and regions under business operation, they equally receive pressures from the automobile producers to substitute steel with other cheaper materials such as aluminum and plastic as well as the pressures from the automobile users for higher fuel-efficient automobiles. The pressures from the automobile industry sectors and users are the factors that were not expected before this research. The significance of the factor is only recognized in the course of the empirical research.

10.1.2 The second level of subject area: climate change policy instruments

The subject areas investigated in the empirical study include 1) carbon tax, 2) national or regional emissions trading schemes, 3) CDM/JI and 4) post-Kyoto schemes. Table 33 summarizes the findings on each subject area:

Table 33: The findings on each subject area at the second level of analysis

		Nippon Steel and JFE	**Corus Group and Arcelor**	**US Steel**	**POSCO**
1	**Carbon tax**	Strongly oppose to an introduction of carbon tax. Carbon tax is the least popular policy instrument among the Japanese steel companies. Express serious concerns about a possible loss of international competitiveness against the neighboring countries free from the mandatory schemes.	Oppose to an introduction of additional carbon tax for a possible loss of international competitiveness, while receiving carbon tax exemptions and funds. The steel companies are opposing at the EC level to remove the existing tax scheme.	Has not been discussed by government for introduction. However, the company is likely be opposed to it if discussion on carbon tax emerges.	Has not been discussed by the government. The company's position on this policy scheme is not well defined yet within the company.
2	**National or regional emissions trading schemes**	Strongly oppose to an introduction of national emissions trading scheme. Emphasize a loss of international competitiveness may possibly occur.	Demonstrates the same concern with the Japanese steel companies. They also discuss that an increase of electricity price has brought a negative impact on operation. States that the regulatory uncertainty is too great, while receiving surplus emissions allowance in the first period of the EU ETS.	Once provided a favorable view on emissions trading scheme when the U.S. signed the Kyoto Protocol, it takes a firm stance against it. The company supports the Bush Administration's voluntary approach on GHG emissions control.	Has not announced its position on the emissions trading scheme. States that it is carefully studying the implications of the EU ETS as a useful case for the formulation of its strategy on the scheme.

		Nippon Steel and JFE	Corus Group and Arcelor	US Steel	POSCO
3	**Clean Development Mechanism /Joint Implementation**	Expressed keen interest in CDM. Taking several initiatives including investment into carbon funds, investment into a HFC 23 decomposition project in China, promoting energy efficiency improvement projects including CDQ and TRT. However, no interest in JI projects (For the reason, See Section 6.4.3).	Generally support CDM/JI implementation. However, not interested in conducting CDM/JI. The reasons include sufficient or surplus emission allowance in the first period of the EU ETS, 2) and lack of vital technologies or patents for steel manufacturing technologies. In addition, in the case of the Netherlands, CDM/JI falls under the government responsibility.	Expressed some interest in CDM/JI before Bush Administration rejected the Kyoto Protocol. The company has a potential interest in CDM/JI.	Conducting afforestration/reforestration (AR) projects as a CDM activity in the six countries. The company is also interested in energy efficiency improvement project as a CDM activity. However, stated that a lack of approved baseline and monitoring methodologies is a constraint.
4	**Post-Kyoto schemes**	Against the country-based approach adopted by the Kyoto Protocol. In favor of a sectoral approach on the voluntary basis. Supports a global technological scheme to improve a diffusion of “best available technologies” (BAT). Recognize IISI’s CO_2 Breakthrough Program as well as the Asian Pacific Partnership on Clean Development and Climate as the focal points for discussion.	Also in favor of a sectoral approach. Emphasize an importance of including the steel companies in other regions (namely, China, India and Brazil) in a post-Kyoto regulatory scheme. While recognizing IISI’s CO_2 Breakthrough Program as a good platform, supports the ULCOS as the main platform to conduct R&D on GHG emissions control.	The position of the company is unclear. In favor of voluntary and technology-based schemes. Have begun to implement the North American part of the CO_2 Breakthrough Program launched by the IISI. The company pays attention to the Asia Pacific Partnership on Clean Development and Climate.	The position of the company is unclear. It is not well defined yet. However participates in both in IISI’s CO_2 Breakthrough Program and the Asia Pacific Partnership on Clean Development and Climate.

10.1.2.1 Carbon tax

Carbon tax is the least popular policy instrument in the steel industry sector. There are strong objections among Japanese and European steel companies against carbon tax. As cited in the previous section, the Japan Iron and Steel Federation (JISF) states that “an introduction of these schemes (indicating both carbon tax and cap-and-trade based emissions trading scheme) will result in a serious loss of international competitiveness against the neighboring countries free from the mandatory schemes.” In Europe, the steel companies in the region are presently receiving carbon tax exemptions and funds. However, there is discussion at the European Commission level to remove them. In response to such a regulatory pressure, Eurofer made an announcement to oppose it. Eurofer maintained that “additional tax in Europe would…seriously undermine the competitive position of the EU industry.” In the case of the U.S. and South Korea, the national governments have not discussed an introduction of carbon tax.

10.1.2.2 National or regional emissions trading schemes

It appears that the national or regional emissions trading scheme is not a popular policy instrument among the steel companies analyzed in this study. In particular, there is a strong objection to an introduction of an emissions trading scheme among the Japanese steel companies. Since the EU ETS was introduced in 2005, the European steel companies have criticized the scheme. On the other hand, the reasons for the objection vary between the Japanese and European steel companies to some degree. The Japanese steel companies emphasize a loss of international competitiveness possibly caused by an introduction of an emissions trading scheme. While European steel companies address the same concern, they also discuss that an increase of electricity price has brought a negative impact on their business operations. They also mentioned that the regulatory uncertainties of the EU ETS are too great in the future, although they have surplus allowances at present. They stated that their national governments may change the level of the granted emissions allowances onward. While the U.S. steel company once provided a favorable view on an emissions trading scheme, it is now taking a firm stance against it. The Korean company has not announced its position on this scheme. The company states that it is carefully studying the implications of the EU ETS to the steel companies in the EU as a useful case study to formulate its view on the scheme.

10.1.2.3 Clean Development Mechanism (CDM)/Joint Implementation (JI)

There are different views on the implementation of CDM and JI projects among the analyzed steel companies. The Japanese steel companies express their keen interest in the practice of CDM projects. They are taking several initiatives on CDM including 1) investment into carbon funds, 3) investment in a HFC-23 decomposition project in China and promoting energy efficiency improvement projects including CDQ and TRT projects as CDM activities. The European steel companies that were researched in this study generally support an implementation of CDM and JI projects. However, they are not interested in conducting them (For the reasons of the absence of their interests in the CDM and JI projects, see Section 7.4.4). The Korean company is conducting AR projects as a CDM activity in the six countries. The U.S. company may have a potential interest in the mechanism as an environmental manager of US Steel expressed it in a workshop in 1999.

The Japanese steel companies are more interested in conducting a CDM than JI activity. In fact, JI has not been their scope of consideration for project implementation. The thesis author identified several reasons for the absence of their interests in JI. One of the reasons was a perceive higher investment risk in the major JI host countries such as Russia and Ukraine (See Section 6.4.3).

10.1.2.4 Post-Kyoto schemes

There are some variances among the steel companies about their views on the post Kyoto schemes. The Japanese steel companies are against the county-based approach adopted by the Kyoto Protocol. They are in favor of a sectoral approach on the voluntary basis. They maintain that there shall be a technological scheme among steel companies to improve a diffusion rate of “best available technologies”. According to their view, this scheme can lead to a drastic reduction of GHG emissions in the short term. They also maintain that CDM and JI can be conducted under this sectoral scheme. In the long term, they recognize that IISI’s CO_2 Breakthrough Program can be the focal point for technological innovation. In addition, they consider that the Asia Pacific Partnership on Clean Development and Climate can be another platform for technological innovation that may invite the countries without an emissions reduction target under the Kyoto Protocol and encourage them to reduce GHG emissions.

The European steel companies researched in this study are also in favor of a sectoral approach. Thyssen Krupp has proposed a voluntary benchmarking scheme against the best-in-practice steel plant. They emphasize, in particular, the importance of including the steel companies in other regions (namely, China, India and Brazil) in a regulatory scheme in the post-Kyoto period. Corus Group states that “in order to address competitiveness distortions within the steel sector we would like to see the same rules and regulations applying on a global basis.” They consider the ULCOS as the primary platform to conduct research and development on GHG emissions. While they name the IISI’s CO_2 Breakthrough Program as another platform in these efforts, it seems that their attention is rather geared toward the ULCOS program.

The positions of the U.S. and Korean steel companies on the possible schemes in the post Kyoto period are unclear. It can be said, however, that in general, the U.S. steel industry sector is in favor of voluntary and technology-based schemes. The U.S. companies have begun to implement the North American part of the CO_2 Breakthrough Program launched by the IISI. The Korean steel company also participates in IISI’s CO_2 Breakthrough Program. The U.S. and Korean steel companies both participate in the Asia Pacific Partnership on Clean Development and Climate.

10.1.3 Three factors in the formulation to firm’s responses to climate change policy instruments: economic, technological and institutional

Overall, there is a high level of similarities among the steel companies in their responses to climate change policy instruments. In particular, their responses to carbon tax and national/regional emissions trading scheme resemble each other. They are strongly opposed to an introduction of these policy instruments. However, there are several important differences in their responses as well. The following sections demonstrate the similarities and differences among them. In addition, they elaborate on the primary factors contributing to the formulation of their responses to the climate change policy instruments.

10.1.3.1 Economic dimensions

The economic factors are playing a major role in the formulation of firm's response to climate change policy instruments. In the course of this research, the thesis author began to recognize an importance of paying an attention to the industry-specific economic characteristics (Section 4.1). It appears that some of the industry-specific economic issues are directly or indirectly associated with a formulation of firm's responses to climate change policy instruments (Section 4.2).

Firstly, the steel market is a global market. Steel is traded in the international market. In contrast, some major industrial commodities such as cement and pulp and paper are mostly traded in the local market (Section 4.1). Secondly, the steel market is a highly fragmented market. Despite a number of mergers resulting in companies such as ThyssenKrupp, Corus and Arcelor, the top ten steel producers only account for 25-30% of the global steel production. The market is still considered fragmented after the recent merger between Arcelor and Mittal. These two characteristics of the steel industry sector indicate that no single steel company has a monopolistic power to control the steel price in the international market. As many steel companies contend, they are most likely price-takers rather than price-makers. This means that they cannot fully reflect the costs incurred by an introduction of a policy instrument into their steel price, since this may lead to a failure of offering a competitive price.

Thirdly, the Chinese steel production and consumption is the largest factor that determines the present and future trends of the global steel market. China is the world's largest single steel producer and consumer, accounting for almost 25 percent of the world's crude steel output. It is widely recognized that Chinese export may begin to swamp the international market around the time of the Beijing Olympics in 2008 or the World Exposition in Shanghai in 2010 at the latest. This means additional costs to reduce GHG emissions may bring a concern about competition against future Chinese steel exporting companies.

After the consideration of the impact of the Chinese market, the thesis author examined the import and export data of the steel products (Section 4.2). There are several country-specific characteristics that require a particular attention in the economic dimensions. Firstly, Japan is the largest steel exporting country. This leads to a concern that the additional cost to their production in Japan may result in a loss of competitiveness of the exporting steel. Secondly, the majority of steel production in the EU is consumed in the local market. This means that as far as the exporting volume is concerned, the level of the economic impacts of a regulatory scheme in the EU may not be as serious as Japan. Thirdly, the United States is the second largest steel importing country. The additional cost to the U.S. steel companies may lead to weaker economic position of them. Fourthly, South Korea is neither a major exporting nor an importing country, while it is the 5^{th} largest steel producing country in the world. This is associated with the fact that there is a strong local steel demand, as the county's economy is growing rapidly. As long as the country's production is geared toward the local market, the economic impacts of introduction of a regulatory scheme may not be significant, since a loss against foreign competitors is not an issue.

Despite the differences among the countries (or companies) in their level of exposure to the international trade, the steel companies analyzed in the study emphasize the above-mentioned industry-specific factors as a basis for their objection against carbon tax and cap-and-trade based emissions trading scheme. They maintain that an introduction of regulatory schemes may lead to negative economic impacts on their business mainly due to the market and economic situation of the steel industry sector. There are shared concerns among them about the negative impacts by carbon tax as well as cap-and-trade based emissions trading scheme.

In contrast, there is a sharp difference between Japanese and European steel companies in their views toward an implementation of CDM projects. The Japanese steel companies investigated in this research recognize CDM as a mechanism through which they can increase their sales of technologies such as the CDQ and TRT (Section 6.4.3). There is a strong economic incentive for them to conduct CDM activities. On the other hand, European steel companies are generally indifferent to the scheme. The reason is associated with the fact that they do not have a key patent for the steel manufacturing process. An economic incentive is lacking among European steel companies for the implementation of the projects (Section 7.4.4).

The economic dimensions also play an important role in the formulation of firm’s stances on the post-Kyoto regulatory schemes. The Japanese and European companies share the view that an involvement of the steel companies that are presently free from the obligations under the Kyoto Protocol is critical in the post Kyoto period. In particular, The European companies are vocally expressing this view. Corus Group, for example, contends “in order to address competitiveness distortion, the same roles and regulations are applied on a global basis” (Section 7.4.5).

10.1.3.2 Technological dimensions

When firms have a better prospect for technological innovation, they may be willing to accept a regulatory scheme. When a small number of companies benefits from technological innovation, they would even support them. The thesis author contended that when we have the Stiglerian situation, we would observe a drastic change in corporate change strategy (Section 2.2.2). However, many steel companies maintained that it is becoming harder to reduce GHG emissions. They emphasize that the majority of GHG emissions in the steel making process is produced not through the combustion process in the blast furnace process but through the chemical reaction. In the steel industry sector, the Stiglerian situation is yet unforeseeable. It is true that there are no positive prospects for evolutional change in technological innovation for drastic GHG emissions reduction.

All steel companies analyzed in this research stressed the importance of research and development efforts for technological innovation. Many consider that a technological regime is the way forward in the post Kyoto period. However, the research efforts are not integrated with one another. They are rather conducted in a turbulent fashion. There are several multilateral and bilateral initiatives taking place in the different parts of the world such as IISI’s Breakthrough Program, the ULCOS program, the BAT initiative, the North American Breakthrough Program and Asia Pacific Partnership on Clean Development and Climate.

The absence of technological innovation for GHG emission reduction has influenced the formulation of firm's responses to the climate change policy instruments. Both the Japanese and European companies maintain that they have reached a high level of energy efficiency in the steel production. According to them, it is becoming harder to improve the performance to reduce GHG emissions. They discuss the technological limit, together with their economic concerns toward a loss in international competitiveness, as one of the main reasons for their objection to carbon tax and emissions trading scheme.

The technological dimensions are playing an important role in making a subtle difference in their views towards the post Kyoto Protocol regime between the Japanese and European companies. The Japanese companies stress an importance of improving the "diffusion rate" of the BAT especially among the steel companies in the developing countries. They consider that there shall be a monitoring process to improve the diffusion rate through international cooperation (Section 6.4.4). On the other hand, while the European companies emphasize an importance of including the steel companies in the developing countries in the post Kyoto regime, they are not keen in discussing a possible cooperation with the steel companies in the developing countries to improve their technological capability to reduce GHG emissions. As described in the previous section, the fact that the Europeans steel companies do not hold major patents for steel making technologies seems to be associated with their stance on this matter.

10.1.3.3 Institutional dimensions

10.1.3.3.1 Societal concerns about climate change

Chapter 2 stated that while this study does not intend to examine a causal linkage between the stakeholder pressures and firm's response to them, it recognizes that firms tend to receive such pressures. The stakeholder pressures may have a direct or indirect influence upon the formation of corporate climate change strategy (Section 2.3.2.2). This thesis author then took into account the stakeholder influence as one of the possible major external pressures to firms.

It appears, however, that strong social concerns and pressures to cope with climate change are not observed in the countries analyzed in this research. Our conclusion is that the efforts to cope with climate change and to reduce GHG emissions in the industry sector are not directly associated with the pressures from their stakeholders.

In Japan, despite the great degree of social movement for environmental protection since the 1970s, there are presently no visible social movements for climate change protection (Section 6.2.1). It was concluded that the Japanese steel industry initiatives to reduce GHG emissions is not originated from the social movement since the 1970s but rather associated with its efforts to save energy and lower energy costs since the oil shock. It was observed in the Netherlands that the environmental NGOs were not initially interested in climate change when the issue was identified as a global environmental issue in the 1980s. In the beginning, the scientific community together with the government took an initiative to begin a public campaign to inform and to engage the citizens in issues of climate change (Section 7.2.1). It is important, however, to point out the fact that this may not be the case with other member states in the EU region. In fact, this case where some joint initiatives by the government and scientific community were found is unique among the EU member states. As this case indicates, the institutional settings surrounding firms differ greatly among the EU member states.

In the United States, the level of the NGO's activism on climate change issue has decreased while the Bush Administration rejected the Kyoto Protocol, while it has increased to some degree in the last three to four years. At present, the scientific community is playing an important role in raising an awareness of the issue among the various segments of the country including the public, the government and industry sectors in the United States (Section 8.2.1). In South Korea, on the other hand, there is a seemingly a growing concern about climate change in the society (Section 9.2).

10.1.3.3.2 Regulatory culture and schemes

It became clear that there are different sets of regulatory and voluntary schemes to reduce GHG emissions among the countries researched in this study. In Chapter 2, this thesis author contended that "the regulatory pressures tend to be created in the unique local regulatory culture and history. The characteristics of the regulatory pressures and the way firms respond to such pressures are often country-specific (or region-specific)." The thesis author observed and confirmed the trends in the analyzed countries.

In Japan, the government's attempt to introduce a regulatory scheme such as carbon tax and emissions trading scheme has been failing so far (Section 6.2.2). In response to the regulatory pressure stemming from the country's commitment to the Kyoto Protocol, however, the Japanese industry sectors established the Nippon Keidanren Voluntary Action Plan on the Environment. This unilateral voluntary scheme is the only major ground for them to reduce GHG emissions. It is interesting, however, that despite the absence of a mandatory scheme, the Japanese industry sectors including the steel industry sector are taking initiatives to reduce GHG emissions. The Japanese industry sectors are taking measures to meet the voluntary emissions reduction targets. This thesis author recognized that there is a cultural factor taking a role in it. He argued that a sense of morality and a fear for being bashed on company's reputation from the society are taking an important role in formulating corporate climate change strategy among Japanese companies.

In the EU, the European Commission and the national governments in the region are progressively taking initiatives to install climate change policy instruments such as carbon tax and emissions trading scheme (Section 7.2.2). The GHG emissions reduction goal that the EU has suggested towards the post-Kyoto period is noteworthy. In 2005, the EU Council of Ministers proposed to reduce GHG emissions by 15-30% and 60-80% by 2020 and 2050 respectively. Generally speaking, the major pressures for the industry sectors to reduce GHG emissions are coming from the governing bodies of the EU and national governments. (It is important, however, to note that there is a great variety in the degree of the regulatory or coercive pressures among the EU member states. The institutional contexts among the states differ greatly.)

Another noteworthy characteristic of the regulatory culture in the EU region is an implementation of voluntary agreements in the environmental area. The Netherlands is one of the most progressive examples in this case. This study briefly reviewed the characteristics of the Dutch voluntary agreements. It recognized the legally-binding nature of the agreement as well as the linkages with public incentive policies, while they are still considered as a voluntary agreement.

In the U.S., the regulatory pressures for the industry sectors to reduce GHG emissions have been extremely weak since the Bush Administration rejected the Kyoto Protocol (Section 8.2.2). Virtually, there are no discussions about a possible introduction of a federal-level tax scheme or emissions trade scheme. There have been only industry-led voluntary initiatives and state-level initiatives. In 2003, the U.S. industry sectors announced a voluntary GHG emissions reduction plan called the Climate VISION. This plan does not have any consultation process with the government and stakeholders, however. It can be only recognized as a unilateral and non-binding commitment on GHG emissions reduction.

In South Korea, there are no regulatory schemes for the reduction of GHG emissions (Section 9.2). The country does not have a GHG emissions reduction target under the Kyoto Protocol. The government does not provide a strong regulatory pressure to the industry sectors to reduce GHG emissions. However, the industry sectors agree with the government in 1998 to have a voluntary agreement to reduce GHG emissions. While the agreement does not have a legally binding nature, it is linked with financial incentive schemes including tax exemption and subsidy for investment into energy conservation facility.

10.2 Convergence and divergence: will we see strategic convergence among the firms?

Section 10.1 answered the three questions addressed in this research. Going through each subject area of analysis individually, Sections 10.1.1 and 10.1.2 answered the first and second research questions. Overall, the thesis author found a high level of homogeneity in corporate climate change strategy between Japanese and European companies. Based on the term introduced by DiMaggio and Powell, there is a "coercive" force leading to isomorphism between them. The acceptance of the emissions reduction target under the Kyoto Protocol is turning into a coercive force for the companies in Japan and the EU.

On the other hand, the thesis author came to recognize that the "normative" pressure to cope with climate change has been generally absent not only in the U.S. and Korea but also in Japan and the EU. The social concerns towards climate change have not been strong enough for the steel companies to take it seriously in the formulation of their climate change strategy. The last type of forces that DiMaggio and Powell discussed towards isomorphism is mimetic force. In fact, there is a trace of mimetic behavior, in particular, with the Korean steel company. POSCO is investigating how the European and Japanese steel companies are coping with regulatory pressures to reduce GHG emissions. Speaking of the EU ETS, for example, the company has learned that it is essential to provide an explanation and have a dialogue with the government on future regulatory schemes as an emissions trading scheme, according to an interviewed company manager. It is possible that other steel companies in the developing countries such as China, Brazil and Russia take a similar mimetic approach, possibly leading to convergent strategy on climate change among steel companies in the future.

Chapter 2 paid particular attention to the trends that may lead to convergence on corporate climate change strategy. One trend was economic globalization. Some scholars argue that because the products and services are traded in the international market, the firm's management and structure are becoming more global. Indeed, the thesis author came to realize that this is the case with the steel industry sector. Steel products are traded in the international market. Raw materials including iron ore and coal are imported from overseas. In addition, there are many international joint ventures taking place in the industry sector.

The other trend was the emergence of climate change as a “global issues arena”. As described in Section 10.1.1.9, there are several international initiatives in the steel industry sector taking place to cope with climate change. The most holistic initiative is the CO_2 Breakthrough Program facilitated by the IISI inclusive of all major steel companies in the world. This program, together with other multilateral, regional, and bilateral programs is likely to be another source of pressure for convergence on corporate climate change strategy.

The thesis author came to realize through this research that there are other convergent trends in the steel industry sector. When this thesis author began this research, he did not presume the existence of such trends. There are three trends of importance. The first trend is the pressure to substitute other materials such as aluminum, plastics and other composite materials for steel. The pressure is coming especially from the automobile industry. Given the unprecedented increase of fuel price, the automobile industry is receiving a strong worldwide pressure from the users to improve fuel efficiency of vehicles. The automobile industry is turning the pressures to the steel industry to develop lightweight steel. Since the pressures are placed on the steel companies on the global scale, all the steel companies are equally receiving the pressure from the automobile industry. The global pressure to produce lighter steel is turning into a convergent force for the steel companies to integrate energy efficiency concerns into their product development.

There is a possibility that the changes in corporate climate change strategy among automobile companies will have an influence on the steel companies in the future. The automobile companies are one of the key customers for the steel companies. The customer’s requests may turn into a strong pressure to the steel companies. Over the last 10 years, there were drastic changes in corporate climate change strategy in the automobile industry. The U.S. automobile companies including Ford, General Motors and DaimlerChrysler were the members of the GCC. They strongly opposed any regulatory measures against climate change. The situation has changed drastically since then. The GCC was dismantled after several key companies left the coalition. Climate change has been integrated as part of the main business management and operations among the automobile companies. The U.S. automobile companies have begun some level of climate change initiatives and programs. The Japanese and European automobile companies that are taking proactive stance on climate change are now producing automobiles at their production sites in the United States. They may provide a pressure to the U.S. steel companies to integrate climate change issues into their business operations. The thesis author expects that the changes in corporate climate change strategy among the automobile companies have a strong influence on the steel companies in the future.

The second convergent trend is the restructuring trend within the steel industry. The merger between Arcelor and Mittal took place in 2006. Corus Group is presently reviewing a proposal for a merger from the Brazilian and Indian steel producers respectively. In response to the restructuring trend, Nippon Steel, POSCO and Shanghai Baosteel are enforcing a strategic alliance among them in order to protect themselves against a possible merger in the future. As mentioned earlier, since the steel industry sector is highly fragmented, it is expected that there are further major mergers in the near future.

These mergers and alliances bring two different strategic and management approaches together. Through the merger between Arcelor and Mittal, for example, Arcelor's strategic and management approach has an influence on the Mittal side (and vice versa). Generally speaking, Arcelor has been proactive in climate change initiatives and programs. It is expected that Arcelor's approach toward climate change is integrated in the merged company. This is also the case with a strategic alliance. Nippon Steel's approach toward climate change will be considered by POSCO and Shanghai Baosteel through the strategic alliance. The restructuring trend among the steel companies can be a source for convergence on corporate climate change strategy among companies.

The third convergent trend is a possible technology spillover. When some companies bring about technological innovation to reduce GHG emissions, they will enjoy the benefits of the innovation for a short period of time (Stiglerian situation). As discussed in Section 2.2.3, however, other companies eventually begin to adopt the same technology and diffuse it in the local and international markets (technology spillover). As illustrated above, the thesis author came to know that technological innovation plays an important role in the formulation of corporate climate change strategy. He therefore considers that technology spillover is likely to lead to strategic convergence among companies in the future.

This study observed not only convergent trends but also divergent trends. With respect to the "home country effects" discussed in Chapter 2, it paid particular attention to 1) societal concerns about climate change and stakeholders' pressures to cope with the issue and 2) regulatory culture and schemes. As for the former, this study concluded that they is not a strong force among the countries researched in this study. There are no strong societal pressures to cope with climate change. On the other hand, this study confirmed that the latter is playing an important role in shaping corporate climate change strategy. Each country has a different regulatory culture and a set of regulatory schemes. Those country-specific cultural parameters and schemes are becoming a strong divergent force among companies in the formulation of corporate climate change strategy.

This thesis author also came to realize that the Kyoto Protocol is a source of strong "coercive" pressures on the companies in the steel industry sector to integrate climate change in their strategy. As mentioned earlier, the thesis author found a high level of convergence in corporate climate change strategy between the Japanese and EU steel companies. The Kyoto Protocol is playing as a "coercive" force leading to isomorphism between them. In the absence of the commitment under the Kyoto Protocol, the strategy of the U.S. company (US Steel) is diverting from the Japanese and EU companies in the sector. This finding is consistent with a finding of Kolk's research described in Section 2.3.2.2 (Kolk, 2005). Kolk investigated whether any convergence in environmental reporting is observed in the triad region including the U.S., EU and Japan. She concluded that considering EU as a whole, there is a convergence between Europe and Japan, while the differences between the U.S. and EU and within Europe have increased.

When the Kyoto Protocol was signed in 1997, the differences in corporate climate change strategy among the steel companies in the three regions (the U.S., EU and Japan) seemed to be insignificant. A document written jointly by the environmental managers of US Steel and Koninklijke Hoogovens (the former Dutch-side of the body of Corus Group) in 1999 suggests that US Steel was also preparing for the mechanism (CDM/JI and emissions trading scheme) proposed under the Protocol (Carson and Winkelman, 1999). In 2001, the Bush Administration came into the office and made it clear that the United States government does not have any intention to ratify the Kyoto Protocol. The announcement made by the Administration has had large impacts on the company's stances on climate change issue since then. In the 10 years since the signing of the Kyoto Protocol, the differences between the United States and Japanese/European steel companies in climate change strategy and management have increased significantly.[85]

Table 34 summaries the findings on the convergent and divergent factors:

[85] Some scholars argue that some U.S. companies in the major industry sectors (such as the automobile sector) began to recognize that they are losing their competitiveness against Japanese and European companies due to the lack of environmentally sound technologies that consumers have began to request. This can be a case of the Porter's hypothesis discussed in Chapter 2.

Table 34: The findings on the convergent and divergent factors

Factors for convergence among firms		**Factors for divergence among firms**
Examined factors 1: DiMaggio and Powell's three mechanisms toward isomorphism (See Section 2.3.2.1)		**Examined factors: Sethi and Elango's home country or country of origin effects (See Section 2.3.3.1)**
Normative pressures: No		Societal concerns about climate change: No. Too weak for firms to consider climate change.
Coercive pressures: Yes. Kyoto Protocol Generating isomorphism between the Japanese and European firms.		Stakeholder pressures: No. Too weak for firms to consider climate change
Mimetic pressures: Yes. In particular, to the Korean firm.		Local regulatory culture and schemes: Yes, they differ greatly.
Examined factors 2: Kolk and Levy's convergent factors (See Section 2.3.2.2)	**Firms**	
Economic globalization: Steel products are traded in the international market.		
Climate change as a "global issue arena": Participation of steel corporate managers in the same fora and establishment of multilateral programs are observed.		
The factors recognized as significant in the course of research		**The factor recognized as significant in the course of research**
Material substitution pressures from the automobile industry sector		Coercive pressures: Kyoto Protocol generating strong divergent trends between the U.S. and European firms.
Customer pressures seeking lighter automobile body for higher fuel efficiency		
Restructuring and consolidation trends among the large firms		
Possible technological spillover		

Will we see strategic convergence towards GHG emissions reduction among the firms in the steel industry sector in the post Kyoto period? The answer to this question is that it depends upon the development in two issues. The first issue relates to how we can continue providing regulatory pressures to the steel companies. Through this research, the thesis author came to a conclusion that whether or not it is a county-based capping scheme such as the Kyoto Protocol, it is essential to provide a regulatory pressure for the steel companies to reduce GHG emissions continuously.[86] As discussed above, the Kyoto Protocol is presently becoming an important source of regulatory pressure for the steel companies to cope with climate change. While a voluntary commitment scheme can be an effective policy instrument in some countries to reduce GHG emissions, its applicability is extremely uncertain on the global scale. As documented in this study,

[86] This suggestion is in conflict with some stances of Japanese and European steel companies on the post Kyoto regime. They maintain that a sectoral scheme on a voluntary basis as their preferable scheme in the post Kyoto period.

there are wide variances among the voluntary schemes introduced by each country. The types and the effectiveness of such schemes are also associated with country-specific regulatory culture and history. Success of a voluntary scheme greatly hinges upon the country-specific conditions.

Strategic convergence is unlikely to occur unless some “coercive” force plays a role in it. As seen above, there are some mimetic forces in the efforts to reduce GHG emissions that are leading to some level of isomorphism among the steel companies. It seems, however, that a mimetic force only take place when a lagging company chases a forerunning company that is receiving a coercive force such as the Kyoto Protocol. The Korean company emulates the European and Japanese companies receiving regulatory pressures from their governments. With respect to a normative force, the thesis author came to realize such a force is, at this time, extremely weak in the countries analyzed in this research. The societal concerns about global warming are not strong enough for the companies to consider. This finding that the coercive force is necessary for convergence of climate change strategy among the steel companies coincides with Hoffman’s finding in the chemical industry. Hoffman found an increasing similarity in environmental strategy in the U.S. chemical industry brought by regulative pressures, followed by normative and cognitive pressures (Hoffman, 2001).

The second issue relates to how we can facilitate a multilateral forum among the steel companies for technological innovation for GHG emissions reduction. At present, however, a facilitation of a multilateral forum is not moving forward. In this endeavor, IISI’s CO_2 Technological Breakthrough Program is the most comprehensive one. However, an IISI manager emphasized some difficulties in achieving consensus among the member steel companies. In the steel industry sector, there are no dominant companies setting a tone in the program. According to the manager, some issues are becoming highly political among member companies. For example, a question as to which GHG technologies to focus upon and to promote under the program is becoming a highly political agenda. There are also new members from China and Russia in the program. There is a wide range of issues at stake which make decision makings harder to reach within the multilateral forum.

As the leaders of many steel companies maintain, there are limits to reduce GHG emissions with the present technological capability. It goes without saying that technological innovation is the key for further GHG emissions reduction. Technological innovation is desperately needed for GHG emissions reduction in the steel industry sector.

References

Akai, K., Okagawa, A., Kusakawa, T. & Saijo, T. (2004) Designing Domestic Institutions to Cope with Global Warming. Osaka, Graduate School of Economics, Osaka University.

Albrecht, J. (2004) Climate policy initiatives, regulatory uncertainties and corporate strategies. *Problems in Perspectives in Management,* 2**,** 98-108.

Albrecht, J. & Arts, B. (2005) Climate policy convergence in Europe: an assessment based on National Communications to the UNFCCC. *Journal of European Public Policy,* 12**,** 885-902.

American Iron and Steel Institute (2005a) How a Blast Furnace Works. Washington D.C.

American Iron and Steel Institute (2005b) US Steel Industry: World Leaders in Energy Efficiency. Washington.

American Iron and Steel Institute (2006) 2006 Public Policy Agenda. Washington D.C.

Anderson, M. & Gardiner, D. (2006) Climate Risk and Energy in the Auto Sector. Boston, CERES.

Anderson, P. & Tushman, M. (1990) Technological discontinuities and dominant design: a cyclical model of technological change. *Administrative Science Quarterly,* 35**,** 604-633.

Arcelor (2004) Annual Report. Luxembourg.

Arcelor (2005) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. Luxembourg.

Arcelor (2006) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. Luxembourg.

Ball, J. (2006) For German companies, new emission caps roil landscape. *The Wall Street Journal.* New York.

Bang, G., Heggelund, G. & Vevantne, J. (2005) Shifting Strategies in the Global Climate Negotiations. Lysaker, Norway, The Fridtjof Nansen Institute.

Baron, D. P. (1995) Integrated strategy - market and nonmarket components. *California Management Review,* 37**,** 47-65.

Baron, D. P. (1997) Integrated strategy, trade policy, and global competition. *California Management Review,* 39.

Beise, M. & Rennings, K. (2005) Lead markets and regulation: a framework for analyzing the international diffusion of environmental innovations. *Ecological Economics,* 52**,** 5-17.

Bennett, C. J. (1991) Review article - What is policy convergence and what causes it. *British Journal of Political Science,* 21**,** 215-233.

Boons, F., Baas, L., Bouma, J. J., Groene, A. D. & Blansch, K. K. (2000) *The Changing Nature of Business - Institutionalizatin of Green Organizational Routines in the Netherlands 1986-1995,* Utrecht, International Books.

Bouma, J. J. & Correljé, A. (2003) Management accounting: decentralization and liberalization. IN BENNETT, M. & RIKHARDSSON, P. M. (Eds.) *Environmental Management Accounting - Purpose* *and Progress.* Kluwer Academic Publishers.

Bouma, J. J., De Graaf, J. F. & Herkstrőter, J. A. C. (2005) A process approach in social accounting: overcoming dichotomies in CSP-research. IN CRAMER, J. & JONKER, J. (Eds.) *Making a Difference, The Dutch Research Programme on Corporate Social Responsibility 2003 - 2004.* The Hague, Dutch Ministry of Economic Affairs.

Bouma, J. J. & Veen, M. V. D. (2002) Wanted: a theory of environmental management accounting. IN BELLETT, M., BOUMA, J. J. & WOLTERS, T. (Eds.) *Environmental Management Accounting: Informational and Institutional Developments.* Kluwer Academic Publishers.

Boyd, C. (2002) Lafarge and global warming. IN PEDLER, R. (Ed.) *European Union Lobbying: Changes in the Arena.* UK: Palgrave, Houndmills.

Brewer, T. & Egenhofer, C. (2005) *The Political Economy of US Responses to Climate Change Issues,* Brussels, Centre for European Policy Studies.

Burton, I. (2000) Adaptation to climate change and variability in the context of sustainable development. IN GOMEZ-ETCHEVERRI, L. (Ed.) *Climate Change and Development.* Yale School of Forestry and Environmental Studies.

Bush Jr., G. W. (2001) Letter to Senator Chuck Hagel.

Buysse, K. & Verbeke, A. (2003) Proactive environmental strategies: A stakeholder management perspective. *Strategic Management Journal,* 24**,** 453-470.

Canadian Institute for Chartered Accountants (2005) MD&A Disclosure about the Financial Impact of Climate Change and Other Environmental Issues. Toronto.

Carson, C. & Winkelman, F. (1999) Industry View on the Climate Change Challenge with Special Emphasis on the Kyoto Mechanism. *BIAC/OECD/IEA Workshop on Climate Change*. Paris.

Ceres (2006) Global Framework for Climate Risk Disclosure: A Statement of Investor Expectations for Comprehensive Corporate Disclosure. Boston.

Christiansen, A. C. (2003) Convergence or divergence? status and prospects for US climate strategy. *Climate Policy,* 3**,** 343-358.

Christmann, P. (2004) Multinational companies and the natural environment: Determinants of global environmental policy standardization. *Academy of Management Journal,* 47**,** 747-760.

Cogan, D. (2003) Corporate Governance and Climate Change: Making the Connection. Boston, CERES.

Cogan, D. (2006) 2006 Corporate Governance and Climate Change: Making the Connection. Boston, CERES.

Coon, C. (2001) Why President Bush is right to abandon the Kyoto Protocol. The Heritage Foundation.

Cortese, A. (2002) As the Earth warms, will companies pay? *New York Times.*

Corus Group (2005) Memorandum from Corus: Current Status of R&D in Corus. London, The United Kingdom Parliament.

Corus Group (2006) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. London.

Crampton, P. (2001) The diffusion of new steelmaking technology. *Resources Policy,* 27**,** 87-95.

Dang, H. H., Michaelowa, A. & Tuan, D. D. (2003) Synergy of adaptation and mitigation strategies in the context of sustainable development: the case of Vietnum. *Climate Policy,* 3**,** 81-96.

David, P. A. (1975) *Technical Choice, Innovation and Economic Growth: Essays on American and British Experience in the Nineteenth Century,* Cambridge, Cambridge University Press.

David, P. A. (2001) Path dependency, its critics, and the quest for "hostorical economics". IN GARROUSTE, P. & IOANNIDES, S. (Eds.) *Evolution and Path Dependency in Economic Ideas: Past and Present.* Cheltenham, Edward Elgar.

David Suzuki Foundation (2006) Who's meeting their Kyoto targets? Vancouver.

De Beer, J. G. (1998) Potential for Industrial Energy-efficiency Improvement in the Long Term. Utrecht, Utrecht University.

Development Bank of Japan (2003) Promoting Corporate Measures to Combat Global Warming: An Analysis of Innovative Activities in the Field. *Research Report No.42.* Development Bank of Japan.

Dimaggio, P. J. & Powell, W. W. (1983) The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *American Sociological Review,* 48**,** 147-160.

Dimaggio, P. J. & Powell, W. W. (1991) *The New Institutionalism in Organizational Analysis*, University of Chicago Press.

Doh, J. P. & Guay, T. R. (2006) Corporate social responsibility, public policy, and NGO activism in Europe and the United States: An institutional-stakeholder perspective. *Journal of Management Studies,* 43**,** 47-73.

Duray, D. (2007) Bush endorses climate study. *Monterey County Herald.*

Energetics Inc. (2003) Outcomes of the CO_2 Breakthrough Program Concept Discovery Workshop. Washington D.C.

Entec Uk Limited and Nera Economic Consulting (2005) EU Emissions Trading Scheme Benchmarking Research for Phase 2. London.

Environmental Protection Agency (2006) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004. Washington.

Euractiv (2005) EU Post-2012 Cimate Change Policy.

Eurofer (2000) The European Steel Industry and the Climate Change. Brussels.

Eurofer (2004a) Competitiveness and Emissions Trading Scheme (ETS). Brussels.

Eurofer (2004b) Eurofer's Concerns regarding the Future EU Climate Change Policy (post-2012). Brussels.

Eurofer (2004c) Eurofer View on Energy Taxation. Brussels.

Eurofer (2006) European Steel Map. Brussels.

European Commission (2000) Implementation of a European Pollutant Emission Register (EPER): Decision by the European Commission. *2000/479/EC.* Brussels.

European Commission (2001) Best Available Techniques Reference Document on the Production of Iron and Steel. Brussels, Integrated Pollution Prevention and Contol (IPPC).

European Commission (2002) The Kyoto Protocol and Climate Change - Background Information Brussels.

European Commission (2005) Winning the battle against climate change, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Brussels.

European Commission (2006) European Steel Technology Platform: From a Strategic Research Agenda to Implementation. Brussels.

European Integrated Pollution Prevention and Control Bureau (2005) BREF: Production of Iron and Steel. Seville, European Commission.

European Parliament (2005) Fact sheets on the European Union. *4.7.2. Steel industry.* Brussels.

Fineman, S. & Clarke, K. (1996) Green stakeholders: Industry interpretations and response. *Journal of Management Studies,* 33**,** 715-730.

Frankhauser, S. (1998) The costs of adapting to climate change. *Working Paper 16.* Washington, Global Environment Facility.

Frooman, J. (1999) Stakeholder influence strategies. *Academy of Management Review,* 24**,** 191-205.

Fukui, K. (2002) Global benefits from private sector initiatives: lessons on the environment from Japan. IN WILFRIDO CRUZ, K. F., JEREMY WARFORD (Ed.) *Protecting the Global Environment Initiatives by Japanese Business.* Washington D.C., The World Bank.

Geels, F. & Kemp, R. (2006) Transitions, transformations, and reproduction: dynamics in socio-technical systems IN MCKELVEY, M. & HOLMÉN, M. (Eds.) *Flexibility and Stability in the Innovating Economy.* Oxford, Oxford University Press.

Gielen, D. & Podkanski, J. (2006) Technological Potentials for CO2 Emission Reduction in the Global Iron and Steel Industry. Paris, International Energy Agency.

Gielen, D. J. & Moriguchi, Y. (2002) CO2 in the iron and steel industry: an analysis of Japanese emission reduction potentials. *Energy Policy,* 30**,** 849-863.

Giorgetti, C. (1999) From Rio to Kyoto: a study of the involvement of non-governmental organizations in the negotiations on climate change. *N.Y.U. Environmental Law Journal,* Volume 7**,** 201-245.

Globescan (2006) 30 Country Poll Finds Worldwide Consensus That Climate Change Is a Serious Problem.

Gough, C. & Shackley, S. (2001) The respectable politics of climate change: the epistemic communities and NGOs. *International Affairs,* 77**,** 329-345.

Gozali, N. O., J.C.Y How & P.Verhoeven (2002) The economic consequences of voluntary environmental information disclosure. IN RIZZOLI, A. E. & JAKEMAN, A. J. (Eds.) *Integrated Assessment and Decision Support: Proceedings of the 1st Biennial Meeting of the iEMSs.*

Grant, R. M. (1991) *Contemporary Strategy Analysis: Concepts, Techniques, Applications,* Oxford, UK, Basil Blackwell.

Green Car Congress (2005) Japan's Environmental Minister Now Calls for Carbon Tax by 2007.

Groenenberg, H. (2002) Development and Convergence: A Bottom-up Analysis for the Differentiation of Future Commitments under the Climate Convention. University of Utrecht.

Hart, S. (1995) A natural-resource-based view of the firm. *Academy of Management Review,* 20**,** 984-1014.

Heichel, S., Pape, J. & Sommerer, T. (2005) Is there convergence in convergence research? An overview of empirical studies on policy convergence. *Journal of European Public Policy,* 12**,** 817-840.

Helme, N. (2005) Sector-Based Approach for "Post-2012". Washington D.C., Center for Clean Air Policy.

Henriques, I. & Sadorsky, P. (1996) The determinants of an environmentally responsive firm: an empirical approach. *Journal of Environmental Economics and Management,* 30**,** 381-395.

Hoffman, A. (2001) *From Heresy to Dogma: An Institutional History of Corporate Environmentalism,* Stanford, Stanford University Press.

Holzinger, K. & Knill, C. (2005) Causes and conditions of cross-national policy convergence. *Journal of European Public Policy,* 12**,** 775-796.

Hu, Y. S. (1992) Global or stateless corporations are national firms with international operations. *California Management Review,* 34**,** 107-126.

Huddle, N., Reich, M. & Stiskin, N. (1975) *Island of Dreams : Environmental Crisis in Japan,* New York, Autumn Press.

Ikuta, T. (2003) Japan's Experiences of Voluntary Approaches for Climate Change Policy. *11th International Conference - the Greening of Industry Network.*

Innovest Strategic Value Advisors (2005) Steel Sector Report. New York.

Intergovernmental Panel on Climate Change (2001a) Climate Change 2001: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, Cambridge University Press.

Intergovernmental Panel on Climate Change (2001b) *Climate Change 2001: Synthesis Report,* Cambridge, Cambridge University Press.

Intergovernmental Panel on Climate Change (2007) Climate Change 2007: The Physical Science Basis, Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

International Emissions Trading Association and the World Bank (2006) State and Trends of The Carbon Market 2006. Washington DC.

International Energy Agency (2004) World Energy Outlook. Paris.

International Iron and Steel Institute (2005) World Steel in Figures 2005. Brussels.

Issb (2004) Japan - exports by destination. London.

Jacobs, M. (1991) *The Green Economy,* London, Pluto Press.

Japan Iron and Steel Federation (2005) Our View on the Global Warming Policy Instruments (in Japanese). Tokyo.

Japan Iron and Steel Federation (2006) Basic Philosophy and Numerical Goals of the Voluntary Action

Program. Tokyo.

Jasch, C. (2006) How to perform an environmental management cost assessment in one day. *Journal of Cleaner Production,* 14.

Jennings, P. D. & Zandbergen, P. (1995) Ecologically sustainable organizations. *Academy of Management Review,* 20**,** 1015-1052.

Jfe Holdings (2005) Environmental Sustainability Report. Tokyo.

Jones, G. R. (1995) *Organizational Theory: Text and Cases,* Reading, Massachussets, Addison-Wesley.

Kane, S. & Shogren, J. F. (2000) Linking adaptation and mitigation in climate change policy. *Climatic Change,* 45**,** 75-102.

Kim, Y. & Worrell, E. (2002) International comparison of CO2 emission trends in the iron and steel industry. *Energy Policy,* 30**,** 827-838.

Klaus, R. & Ziegler, A. (2006) *Environmental Innovations and Economic Success of Firms,* Copenhagen, Environmental Assessment Institute.

Knill, C. (2005) Introduction: Cross-national policy convergence: concepts, approaches and explanatory factors. *Journal of European Public Policy,* 12**,** 764-774.

Kolk, A. (2000) *Economics of Environmental Management,* Harlow, Financial Times Prentice Hall.

Kolk, A. (2005) Environmental reporting by mutinationals from the triad: convergence or divergence? *Management International Review,* 45**,** 145-166.

Kolk, A. & Levy, D. L. (2002) Strategic responses to global climate change: conflicting pressures on multinationals in the oil industry. *Business and Politics*.

Kolk, A. & Levy, L. (2004) Multinationals and global climate change: issue for the automotive and oil industries. *Multinationals, Environment and Global Competition,* 9**,** 171-193.

Kolk, A. & Pinkse, J. (2004) Market strategies for climate change. *European Management Journal,* 22(3)**,** 304-314.

Kolk, A. & Pinkse, J. (2005) Business responses to climate change: Identifying emergent strategies. *California Management Review,* 47.

Korean Federation for Environmental Management (1998) Climate Change and Korea - Perspectives of Korean Environmental Movement. *1998 Environmental NGOs' International Conference-The Roles and Strategies of Developing Countries in Preventing Climate Change.* Seoul.

Koza, M. P. & Thoenig, J.-C. (2003) Rethinking the firm: organizational approaches. *Organization Studies,* 24**,** 1219-1229.

Krasner, S. D. (1983) *International Regimes,* Ithaca and London, Cornell University Press.

Kwong, K., Bennett, J (2002) Recycling practices of spent MgO-C refractories. *Journal of Minerals & Materials Characterization & Engineering,* 1**,** 69-78.

Le Menestrel, M., Van Den Hove, S. & De Bettignies, H. C. (2002) Processes and consequences in business ethical dilemmas: The oil industry and climate change. *Journal of Business Ethics,* 41**,** 251-266.

Levy, D. L. & Egan, D. (2003) A neo-gramscian approach to corporate political strategy: Conflict and accommodation in the climate change negotiations. *Journal of Management Studies,* 40**,** 803-829.

Levy, D. L. & Rothenberg, S. (2002) Heterogeneity and change in environmental strategy: Technological and political responses to climate change in the automobile industry. IN A., H. & M., V. (Eds.) *Organizations, Policy and the Natural Environment: Institutional and Strategic Perspectives.* Stanford, Stanford: Stanford University Press.

Levy, L. & Kolk, A. (2002) Strategic responses to global climate change: conflicting pressures on multinationals in the oil industry. *Business and Politics,* 4**,** 275-300.

Levy, L. & Rothenberg, S. (1999) Corporate strategy and climate change: heterogeneity and change in the global automobile industry. *Belfer Center for Science and International Affairs (BCSIA) Discussion Paper E-99-13.* Cambridge, MA, Environment and Natural Resources Program, Kennedy School of Government, Harvard University.

Lise, B. B. & Lise, W. (2002) Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality. Amsterdam, Institute for Environmental Studies, Free University of Amsterdam.

Louche, C. (2004) Ethical Investment - Processes and Mechanisms of Institutionalisation in the Netherlands. Rotterdam, Erasmus University Rotterdam.

Mastrandonas, A. & P.T. Strife (1992) Corporate Environmental Communications: Lessons from Investors. *Columbia Journal of World Business and Politics,* 27**,** 234-41.

Mathiesen, L. & Mœstad, O. (2002) Climate policy and the steel industry: achieving global emission reductions by an imcomplete climate agreement. Bergen, Norwegian School of Economics and Business Administration.

Matthes, F. (2004) Greenhouse Gas Emissions Trading: Outline of an Emissions Trading Scheme for Japan. Berlin, World Wide Fund for Nature.

Mayer, D. O. (2000) Greenhouse gas emissions and the social responsibility of automakers. *Business and Society Review,* 105 (3)**,** 347-360.

Mckean, M. A. (1981) *Environmental Protest and Citizen Politics in Japan,* Berkeley, University of California Press.

Medhurst, J. (1993) Environmental Costs and Industrial Competitiveness. *Environmental Policies and Industrial Competitiveness***,** 37-47.

Michaelowa, A. (1998) Impact of interest groups on EU climate policy. *European Environment,* 8**,** 152-160.

Michaelowa, A. (2001) Mitigation versus adaptation: the political economy of competition between climate policy strategies and the consequences for developing countries. *HWWA DIscussion Paper 153.* Hamburg, Hamburg Institute of International Economics.

Ministry of Economy Trade and Industry (2004) Interim Report by Global Environmental Subcommittee, Environmental Committee, Industrial Industrial Structure Council: Future Measures for Global Warming. Tokyo.

Ministry of the Environment (2004) Economic Analysis of Environmental Tax: Review of the Present Consultations (in Japanese).

Mitchell, R. K., Agle, B. R. & Wood, D. J. (1997) Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of Management Review,* 22**,** 853-886.

Mizuno, O. (2005) Japan's Climate Change Policy.

Mœstad, O. (2002) Environmental Policy in the Steel Industry Using Economic Instruments. Paris, Organization for Economic Co-operation and Development.

Murtha, T. P. & Lenway, S. A. (1994) Country capabilities and the strategic state - how national political-institutions affect multinational-corporations strategies. *Strategic Management Journal,* 15**,** 113-129.

Nakamura, M., Takahashi, T. & Vertinsky, I. (2001) Why Japanese firms choose to certify: a study of managerial responses to environmental issues. *Journal of Environmental Economics and Management,* 42**,** 23-52.

National Academy of Sciences Committee on the Science of Climate Change (2001) *Climate Change Science: An Analysis of Some Key Questions* Washington DC, National Academy Press.

Neu, D., Warsame, H. & Pedwell, K. (1998) Managing public impressions: Environmental disclosures in annual reports. *Accounting Organizations and Society,* 23**,** 265-282.

Newman, J. (2005) Policies to Reduce Greenhouse Gas Emissions in Industry: Implications for Steel. Paris, Organization for Economic Co-operation and Development.

Nicholls, M. (2005) Bringing risk to account. *Environmental Finance.*

Niizawa, H., Saijo, T. & Yasumoto, A. (2003) Proposal of Upstream Emissions Trading in Japan. Paris, Organisation for Economic Co-operation and Development.

Nippon Keidanren (1997) Keidanren Voluntary Action Plan on the Environment. Tokyo.

Nippon Keidanren (2003) Keidanren Voluntary Action Plan Evaluation Report Fiscal 2002.

Nippon Keidanren (2005a) Request of a new international framework against global warming (in Japanese). Tokyo.

Nippon Keidanren (2005b) Results of the Fiscal 2005 Follow-up to the Keidanren Voluntary Action Plan on the Environment Tokyo.

Nippon Steel Corporation (2005a) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. Tokyo.

Nippon Steel Corporation (2005b) How Steel Products Are Made. Tokyo.

Nippon Steel Corporation (2005c) Sustainability Report. Tokyo.

Nippon Steel Corporation (2006) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire.

Tokyo.

Nordqvist, J. (2006) Climate Change and Industrial Technology Transfer. A Study of Chinese Conditions of Technology and Society. *Faculty of Engineering.* Lund, Lund University.

Nordqvist, J., Boyd, C. & Klee, H. (2002) Three Big Cs: Climate, Cement and China. *Greener Management International,* 39**,** 69-82.

North Carolina Department of Environment and Natural Resources (2005) The Steel Making Industry.

Nuijen, W. C. & Booij, M. (2002) Experiences with long term agreements on energy efficiency and an outlook to policy for the next 10 years. The Hague, Novem.

O'rourke, A. (2002) A new politics of engagement: shareholder activism for corporate social responsibility. *2002/129/CMER.* The Centre for the Management of Environmental Resources, INSEAD.

Ochs, A. & Sprinz, D. F. (2005) Europa Riding the Hegemon? Transatlantic Climate Policy Relations. Potsdam, Potsdam Institute for Climate Impact Research.

Okazaki, T. (2006) Coke Dry Quenching (CDQ) Projects in China. *CTI/Industry Joint Seminar: Successful Cases of Technology Transfer in Asian Countries.* Hanoi.

Okazaki, T., Inui, T. & Takeuchi, A. (2002) Japan's iron and steel industry: an example of the Nippon Steel Corporation. IN WILFRIDO CRUZ, K. F., JEREMY WARFORD (Ed.) *Protecting the Global Environment Initiatives by Japanese Business.* Washington D.C., The World Bank.

Okazaki, T., Nakamura, M. & Kotani, K. (2004) Voluntary initiatives of Japan's steel industy against global warming. Tokyo, Nippon Steel Corporation.

Oliver, C. (1991) Strategic responses to institutional processes. *Academy of Management Review,* 16**,** 145-179.

Olson, M. (1965) *The Logic of Collective Action: Public Goods and the Theory of Groups,* Cambridge, MA, Harvard University Press.

Oreskes, N. (2004) Beyond the ivory tower: the scientific consensus on climate change. *Science,* 306**,** 1686.

Organisation for Economic Co-Operation and Development (2003) Policies to Reduce Greenhouse Gas Emissions in Industry - Successful Approaches and Lessons Learned: Workshop Report. Paris.

Organisation for Economic Cooperation and Development (1999) Voluntary Approaches for Environmental Policy: an Assessment. Paris.

Organization for Economic Cooperation and Development (1996) Pollutant Release and Transfer Registers (PRTRs): A Tool for Environmental Policy and Sustainable Development. Guidance Manual for Governments. *GD(96)32.* Paris.

Osborne, H. (2006) Stern report: the key points. *Guardian Unlimited.*

Oxera (2004) CO2 Emissions Trading: How Will It Affect UK Industry? Oxford.

Oye, K. A. & Maxwell, J. H. (1995) Self-Interest and Environmental Management IN KEOHANE, R. & OSTROM, E. (Eds.) *Local Commons and Global Interdependence.* Sage Publication.

Pianin, E. (2003) Senate rejects mandatory cap on greenhouse gas emissions. *Washington Post.* Washington.

Pinkse, J. (2006) Business Responses to Global Climate Change. *Amsterdam Graduate Business School.* Amsterdam, University of Amsterdam.

Point Carbon (2004) Dutch companies must reduce 8MtCO2 yearly. *Point Carbon Newsletter.*

Porter, M. E. (1990) The competitive advantage of nations. *Harvard Business Review,* 68**,** 73-93.

Porter, M. E. (1991) America green strategy. *Scientific American,* 264**,** 168-168.

Porter, M. E. & Vanderlinde, C. (1995a) Green and competitive - ending the stalemate. *Harvard Business Review,* 73**,** 120-134.

Porter, M. E. & Vanderlinde, C. (1995b) Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives,* 9**,** 97-118.

Posco (2003) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. Seoul.

Posco (2005) Sustainability Report. Seoul.

Reich, R. (1991) *The Work of Nations: Preparing Ourselves for 21st-century Capitalism,* New York, Knopf.

Reinaud, J. (2005) Industrial Competitiveness under the European Union Emissions Trading Scheme. Paris, International Energy Agency.

Resource Renewal Institute (2006) RRI Green Planning Archives, The Netherlands Environmental Policy Profile. San Francisco.

Rondinelli, D. A. & Vastag, G. (1996) International environmental standards and corporate policies: an integrative framework. *California Management Review,* 39**,** 106-122.

Roome, N. (1992) Developing environmental strategies. *Business Strategy and Environment,* I**,** II-24.

Rootes, C. (2002) Global visions: global civil society and the lessons of European environmentalism. *International Journal of Voluntary and Nonprofit Organizations,* 13**,** 411-429.

Rugman, A. M. & Brain, C. (2003) Multinational enterprises are regional, not global. *Multinational Business Review,* 11**,** 3-12.

Rugman, A. M. & Verbeke, A. (1998) Corporate strategies and environmental regulations: An organizing framework. *Strategic Management Journal,* 19**,** 363-375.

Salamon, L. M., Sokolowski, S. W. & K.Anheier, H. (2000) Social Origins of Civil Society: An Overview. *Working papers of the Johns Hopkins comparative nonprofit sector project.* Baltimore, Johns Hopkins University.

Sand, P. H. (2002) The Right to Know:Environmental Information Disclosure by Government and Industry *Berlin Conference on Human Dimensions of Global Environmental Change.* Berlin.

Schoenberger, H. (2000) BREF on the Production of Iron and Steel - Conclusion on BAT *European Conference on "The Sevilla Process: A Driver for Environmental Performance in Industry".* Stuttgart.

Scott, W. R. (1995) *Institutions and Organizations,* Thousand Oaks, Sage Publications.

Scott, W. R. & Christensen, S. (1995) Conclusion - crafting a wider lens. IN CHRISTENSEN, S. (Ed.) *The Institutional Construction of Organisations - International and Longituinal Studies.* California, Sage Publication: Thousand Oaks.

Secretariat, C. C. (2002) *A Guide to the Climate Change Process,* Bonn.

Sen, A. (2003) Ethical Challenges: Old and New. *The Ethical Dimensions of Development: The New Ethical Challenges of State, Business and Civil Society.* Brazil.

Sethi, S. P. & Elango, B. (1999) The influence of "country of origin" on multinational corporation global strategy: A conceptual framework. *Journal of International Management,* 5**,** 285-298.

Sharma, S. & Henriques, I. (2005) Stakeholder influences on sustainability practices in the Canadian forest products industry. *Strategic Management Journal,* 26**,** 159-180.

Simon, H. (1982) *Models of Bounded Rationality*, MIT Press.

Smit, B., Burton, I., Klein, R. J. T. & Wandel, J. (2000) An anatomy of adaptation to climate change and variability. *Climatic Change,* 45**,** 223-251.

Stern, N. (2006) *Stern Review on the Economics of Climate Change,* Cambridge, Cambridge University Press.

Stigler, G. (1971) The economic theory of regulation. *Bell Journal of Economics,* 2**,** 3-21.

Still, G. (2003) Practical solutions for steel to national allocation plans by ThyssenTrupp Steel. Duisburg.

The Ministry of Commerce Industry and Energy & Korea Energy Management Corporation (1998) Guide to Voluntary Agreement System for Energy Conservation and Reduction of Greenhouse Gas Emission. Seoul.

Thomas, C. & Rennings, K. (1999) Determinants of Environmental Product and Process Innovation - Evidence from the Mannheim Innovation Panel and a Follow-Up Telephone Survey. *European Environment,* 9**,** 191-201.

Tolbert, P. S. & Zucker, L. G. (1996) The institutionalization of institutional theory. IN W.R.NORD (Ed.) *Handbook of Organizational Studies.* London, Sage Publications.

Ui, J. (1992) Environmental pollution: basic precepts. IN UI, J. (Ed.) *Industrial Pollution in Japan.* Tokyo, United Nationsl University Press.

United States House of Representatives (2005) Summary of Policy Provisions of the Energy Policy Act of 2005 Conference Report. Washington D.C.

United States Steel (2006) Carbon Disclosure Project Greenhouse Gas Emissions Questionnaire. Pittsburgh.

Usui, M. (1999) 'Multilateral environmental diplomacy: science-politics interface, industry-politics interface and issue linkages in the emerging system of multilateral negotiations'. *Cross-Cultural Business and Cultural Studies* 3.

Usui, M. (2003) Sustainable development diplomacy in the private business sector: an integrative perspective on game change strategies at multiple levels. *International Negotiation,* 8**,** 267-310.

Vernon, R. (1993) Behind the scenes - how policy-making in the European-Community, Japan, and the United-States affects global negotiations. *Environment,* 35**,** 13-&.

Watanabe, K. (2006) The proposals on the IEA's efforts to develop energy indicators. Paris, International Energy Agency.

World Business Council for Sustainable Development (2005) GHG Corporate Accounting and Reporting Standard. Geneva.

Youn, H. (2004) Emission trade, no time to wait! *Economy 21.*

Zarsky, L. (1999) Havens, halos and spaghetti: Untangling the evidence about foreign direct investment and the environment. *OECD conference on foreign direct investment and the environment.* The Hague.

The Daffodil principle

Several times my daughter had telephoned to say "Mother, you must come see the daffodils before they are over." I wanted to go, but it was a two hour drive from Laguna to Lake Arrowhead. "I'll come next Tuesday," I promised a little reluctantly on her third call. Next Tuesday dawned cold and rainy. Still I had promised, and so I drove. When finally I walked into Carolyn's house and hugged and greeted my grandchildren, I said, "Forget the daffodils, Carolyn! The road is invisible in the clouds and fog and there's nothing in the world except you and these children that I want to see bad enough to drive another inch!" My daughter smiled calmly and said, "We drive in this all the time, Mother." "Well, you won't get me back on the road until it clears and then I'm heading for home" I assured her. "I was hoping you'd take me over to the garage to pick up my car." "How far is the drive?" "Just a few blocks," Carolyn said. "I'll drive Mom. I'm used to this weather." After several minutes, I had to ask, "Where are we going? This isn't the way to the car garage!" "We're going to my garage the long way," Carolyn grinned, "by way of the daffodils." "Carolyn," I said sternly, "please turn around." "It's all right, Mother, I promise. You'll never forgive yourself if you miss this experience."

After twenty minutes, we turned onto a narrow gravel road and I saw a small country church. On the far side of the church, I saw a hand lettered sign that read, "DAFFODIL GARDEN." We got out of the car and each took a child's hand. I followed Carolyn down the path. Then we turned a corner and I looked up and gasped. Right before me lay the most glorious sight! It looked as though someone had taken a great vat of gold and poured it down over the mountain peak and slopes. The flowers were planted in majestic swirling patterns, great ribbons and swaths of deep orange, white, lemon yellow, salmon pink, saffron and butter yellow. Each different colored variety was planted as a group so that it swirled and flowed like its own river with its own unique hue. Altogether, there were five acres of daffodils. "But who has done this?" I asked Carolyn. "It's just one woman," Carolyn answered. "She lives on the property and that's home." Carolyn pointed to a well kept A-frame house that looked small and modest in the midst of all that glory. We walked up to the house.

On the patio we saw a large poster. It read "Answers to the Questions I Know You Are Asking." The first answer was a simple one. "50,000 bulbs," it read. The second answer was, "One at a time, by one woman. Two hands, two feet, and very little brain." The third answer was "Began in 1958."

There it was, THE DAFFODIL PRINCIPLE. For me that moment was a life changing experience. I thought about this woman who I had never met. More than forty years ago she had begun (one bulb at a time) to bring her vision of beauty and joy to an obscure mountain top. This unknown woman had forever changed the world in which she lived. She had created something of indescribable magnificence, beauty and inspiration. The principle her Daffodil Garden taught is one of the greatest principles of celebration. That is: learning to move toward our goals and desires one step at a time -- often just one baby step at a time -- and learning to love the doing. When we multiply tiny pieces of time with small increments of daily effort, we too will find we can accomplish magnificent things. We can change the world.

"It makes me sad in a way," I admitted to Carolyn. "What might I have accomplished if I had thought of a wonderful goal thirty-five or forty years ago and had worked away at it 'one bulb at a time' through all those years? Just think what I might have been able to achieve."

My daughter summed up the message of the day in her usual direct way. "Start tomorrow," she said. It's so pointless to think of the lost hours of yesterday. The most desirable way to make learning 'a lesson of celebration' ... instead of a cause for regret is simply to ask, "How can I put this to use today?"

Profile of the author

Present position: Assistant Professor and Associate Dean at International University of Japan (IUJ)

Contact information:

Address: 777 Kokusai-cho, Uonuma-shi, Niigata 949-7277 JAPAN

Telephone from Japan:0257-779-1509

Telephone from overseas:(+81)-257-779-1509

Email: suzuki@iuj.ac.jp

Academic background:

MIA, Columbia University, 1999

MA, Keio University, 1997

LL.B., Hosei University, 1995

University of California Davis, 1993-1994

General research area:

Corporate environmental strategy and management

Environmental and social practices of the multinational firms in the developing countries

Specific research area:

Corporate climate change strategy: Convergence and divergence of climate change strategy among Japanese, EU and US firms

Emissions trading and Clean Development Mechanism (CDM)

Policy options in the post-Kyoto regime

Stakeholder dialogue for low carbon society

Corporate strategy for electronic waste (E-waste) in Asia

Strategic alliance for establishing a sustainable community in Asia

Professional experience:

Senior Analyst, Clean Energy Finance Committee, Mitsubishi Securities, Tokyo

Senior Analyst, Innovest Strategic Value Advisors, New York

Consultant, United Nations Department of Social and Economic Affairs (DESA), New York

Research Assistant, The Center for International Earth Science Information Network (CIESIN), New York

Consultant, United Nations Framework Convention on Climate Change (UNFCCC), Bonn

Margalit Faden took the picture used for the book cover in Urasa, Japan.