Alma Mater Studiorum – Università di Bologna

DOTTORATO DI RICERCA IN
LAW & ECONOMICS

Ciclo XXI

Settore scientifico-disciplinare di afferenza: Scienze economiche

TITOLO TESI

ECONOMIC ANALYSIS OF THE EUROPEAN CLIMATE POLICY: THE EUROPEAN EMISSIONS TRADING SCHEME

Presentata da: STEFANO CLO’

Coordinatore Dottorato

LUIGI ALBERTO FRANZONI

Relatore

VINCENZO DENICOLO’

Esame finale anno 2010

Index

Chapter 6 - Analysis of the Allocation Rules: Do Polluters Pay under Grandfathering?

Chapter 7 - ETS Reform and Carbon Leakage: Assessing the Inconsistencies of the New ETS Directive

Chapter 8 - Summary and Conclusions

List of Abbreviations:

BaU:	Business as Usual
CCGT:	Cycle Combined Gas Turbine
CDM:	Clean Development Mechanism
CER:	Certified Emissions Reduction
CH4:	Methane
CI:	Carbon intensity
CITL:	Community International Transaction Log
CO_2:	Carbon Dioxide
COP:	Conference of the Parties
EEA:	European Environmental Agency
EC:	European Commission
ERU:	Emissions Reduction Units
ETS:	Emissions Trading Scheme
EU:	European Union
EU ETS:	European Union's Emissions Trading Scheme
EUA:	Emissions Unit Allowance
GHG:	Greenhouse Gas
GDP:	Gross Domestic Product
HFCs:	Hydro- fluorocarbons
IEA:	International Energy Agency
IPCC:	International Panel on Climate Change
JI:	Joint Implementation
MAC:	Marginal Abatement Cost
MS:	Member States
MW:	Megawatt
NACE:	Nomenclature statistique des activités économiques dans la Communauté européenne
NAP:	National Allocation Plan
N_2O:	Nitrous Oxide
OECD:	Organization for Economic Co-operation and Development

Ph.D: Philosophiae Doctor

PFCs: Perfluorocarbons

ppm: parts per million

PPP: Polluter Pays Principle

SF_6 Sulphur hexafluoride

TI: Trade Intensity

UK: United Kingdom

UNFCCC: United Nations Framework Convention on Climate Change

USA: United States of America

WEO: World Energy Outlook

WRI: World Resource Institute

Chapter 1 - Introduction

The last two decades have experienced an increasing awareness about global warming, its causes, and potential effects on the ecosystem, in general, and on humankind, in particular. Global warming is nowadays recognized as one of the most impressive global negative externalities and market failures generated by the current economic system (Stern et al. 2006). In an attempt to safeguard against the risk of massive damage caused by a change in climate, the international, European and national institutions have committed to clear environmental goals aimed at stabilizing the global temperature at a non-dangerous level. In 2005, with the entry into force of the Kyoto Protocol, the ratifying Parties have committed to reduce by 2012 their emissions to 5.2% below the level of 1990. After having ratified the Kyoto Protocol, the European Commission (hereinafter EC) published the 2007 communication *"Limiting Global Climate Change to 2° Celsius: The Way Ahead for 2020 and Beyond"* in which it expressed its firm intention to enforce emissions reduction climate policies even beyond the terms of the Kyoto Protocol. At the end of 2008, the European Climate Package, which imposes a unilateral 20% emissions cut below the 1990 emissions level to be met by 2020, was finally approved.[1]

Such emission reduction targets are ambitious and costly as they require substantial investments to move to a low-carbon economy. In the light of the trade-off between environmental protection and economic growth, mitigating climate change without preventing the economy from growing has become one of the most important issues on the global and European political agenda. Clear, credible and efficient economic instruments have to be designed in order to induce a reduction of greenhouse gas (hereinafter GHG) emissions and to achieve the emissions reduction targets in a cost-effective way. According to the Law & Economics literature, a *cap and trade* system—where a limited number of freely tradable polluting property rights is generated and assigned to economic agents—gives optimal incentives to induce efficient emissions reduction (e.g. Coase 1960, Dales 1968). Indeed, according to the Coase theorem, as long as transaction costs tend toward zero, free bargaining ensures that tradable permits are allocated to those who value them most, while emissions are reduced where marginal abatement costs are lowest. As a consequence, in the long

[1] In September 2009, at the time of writing this thesis, the world most influential economies are negotiating on a post-Kyoto cooperative international treaty aimed at imposing new emissions reduction targets at a global level

run polluters’ marginal abatement costs (MAC) are going to be equalized and the final permits’ price will equal the lowest MAC.

In Europe, the political will to move toward a low-carbon economy has favored the institution of a Cap and Trade System—the European Emissions Trading Scheme-(ETS)—aimed at facilitating the achievement of the Kyoto target in a cost effective way by promoting emissions reduction on behalf of the biggest European polluters in the energy and industrial sectors. The scheme for GHG emission allowances trading within the Community has been established by the Directive 2003/87 proposed by the European Commission and approved by all EU Member States (hereinafter MS) and by the European Parliament. Successively to the new more ambitious European emissions reduction target (-20% by 2020) which was set by the 2008 EU Climate Package, a new Directive 2009/29 has been designed which amends the first ETS Directive 2003/87, and will reform the ETS institutional framework and extend the ETS to a Post-Kyoto trading period (2013-2020).

According to the European ETS Directive, the ETS was expected to promote emissions reduction in an efficient and cost-effective way (art.1), by reducing the GHG emissions where the marginal abatement costs are lowest. In fact, the European Commission estimated that “the scheme should allow the EU to achieve its Kyoto target at a cost of between € 2.9 and € 3.7 billion annually. This is less than 0.1% of the EU's GDP. Without the scheme, compliance costs could reach up to € 6.8 billion a year”(EC 2004: 6). In spite of these declarations, the partial results achieved during the first ETS trading period seem to suggest that the ETS is far from being an effective and market oriented mechanism.

Therefore, this thesis intends to assess the effectiveness of the ETS in promoting a cost-effective emissions abatement to facilitate the achievement of the European emissions reduction targets. The main questions we want to answer with this thesis are “is the ETS a cost-effective mechanism to reduce emissions in order to comply with the EU Kyoto target?” and “in the case that inefficiencies are identified, can the ETS performance be improved by correcting the relevant legislation?”

So far, we have clarified the general questions we want to answer through this research. The next section will present the structure of this research, the topics to be discussed and the methodology which has been adopted to analyze the ETS and assess its effectiveness.

Section 3 will describe the scope and boundaries of this research, contextualizing the European climate policy within the more extended scientific, political, economic and legal debate concerning climate change and the international efforts—the Kyoto Protocol, in particular— aimed at inducing global and collective action to reduce the world greenhouse emissions to a safe level. Section 4 describes the synopsis of this thesis.

2. Methodology and Content of the Research

After having clarified the main purpose of this thesis, this section describes the general methodology adopted to assess the effectiveness of the ETS. Following the Law & Economics approach, the effectiveness of the ETS will be assessed through an economic analysis of its legal framework and institutional design. First, a positive analysis is conducted to assess whether the ETS has been affected by some inefficiencies or fallacies. Then, when some inefficiencies are identified, it becomes necessary to investigate to what extent they can be considered a consequence of the underlying European institutional design and legal framework. Afterwards, in the case the ETS institutional design has been found ineffective or distortive, we will proceed to assess whether and how the ETS inefficiencies can be reduced by improving the European legislation. This second part constitutes the core of the normative analysis of the thesis.

The positive-normative approach of this thesis will be applied at two parallel levels. First, a macro-level analysis of the ETS will be developed, focusing on the **ETS cap level**. The purpose of this analysis is to assess the stringency of the ETS cap. In fact, the level of the ETS cap determines the amount of emissions the ETS sectors have to reduce and how the emissions reduction burden deriving from the Kyoto Protocol is going to be divided among ETS and non-ETS sectors. Therefore, assessing the stringency of the ETS cap and determining whether the emissions reduction burden deriving from the ratification of the Kyoto Protocol has been divided between ETS and non-ETS sectors in a cost-effective way will help us to understand if and how much MS rely on this economic flexible mechanism to comply with the Kyoto target.

Second, a micro-analysis of the ETS will focus on the **allocation rule** adopted to assign the initial number of allowances among the ETS sectors. The choice between **grandfathering** and **auctioning** impacts the ETS sectors' costs as well as competitiveness on the secondary markets, and these allocation rules will be compared according to both an efficiency and an equity approach. The main purpose of this analysis is to assess whether grandfathering can be considered – in theory and in practice – an efficient and fair allocation rule. This will be done by clarifying the conditions under which this allocation rule is consistent with the polluter-pays principle.

This research will be developed following a **chronological order** to better specify the evolution of the European legislation regulating the ETS and its consequential impact on the tradable permits market. First, the stringency of the ETS cap and the ETS allocation rule, as they have been designed by the first ETS Directive 2003/87, will be analyzed in order to assess whether the ETS performance and the emergence of some market inefficiencies during the first trading period 2005-2007 can be considered a consequence of the ETS regulation. Afterwards, some normative considerations aimed at modifying the ETS cap stringency or the adopted allocation rule will be advanced in order to reduce and correct the ETS inefficiencies by improving the European legislation. In the light of these normative conclusions, the content of the new ETS Directive 2009/29 will be finally discussed to assess whether, and to what extent, the way the ETS has been reformed actuality improve its effectiveness during the third ETS trading period 2013-2020.

After having specified the general structure and methodology of the research, the next section will describe the scope and boundaries of the thesis.

3. Context, Scope and Boundaries of the Research

This section intends to specify the scope and boundaries of this research, which was developed through the 1st of September 2009.[2] As previously mentioned, this thesis focuses on the EU ETS and on the European legislation which has established it.

The main attempt of this research is to assess the effectiveness of the cap and trade scheme launched in Europe to promote the abatement of emissions with the purpose of complying with the Kyoto emissions reduction target. The decision to focus only on the European ETS economic instrument implies that this thesis does not intend to bring any new insight to the debate about climate change, its potential evolution and effects—that would be mainly a scientific task. The aim of this research is neither to

[2] Therefore, any legal, political or economic event which has taken place after this deadline – such as the post-Kyoto negotiation to be held in Copenhagen in December 2009 - could not be taken properly into account in this thesis

establish if the Kyoto target is efficient nor whether it can ensure an optimal environmental protection. For, this would be a purely economic task requiring the estimation and balancing of economic costs and benefits linked with climate change and its mitigation. The thesis will not question the efficiency of the Kyoto target itself and its allocation among the EU MS. That is, analyzing the Kyoto Protocol and the benefits and costs related to this international treaty goes beyond the scope of this research. In fact, it is important to stress from the very beginning that I consider the Kyoto emissions reduction target as a given, and by questioning the effectiveness of the EU ETS to reach a political target, I make no attempt to infer any conclusion concerning the efficiency of the Kyoto Protocol in general.

Rather, under a Law and Economics perspective, the main purpose of this research is to analyse if and to what extent the legal and economic instruments defined to reach the Kyoto target (which is taken as a given and is not questioned) can be considered effective. In the case that inefficiencies are identified, this research will develop some normative considerations aimed at correcting and improving them. Indeed, this thesis has been developed on the preposition that an economic instrument, such as the emissions cap and trade scheme, can be more or less effective in reaching a goal even if the goal has not been properly chosen.

Despite the fact that we have limited the project to the consideration of the ETS and the European legislation, it is important to mention that both the European climate policy and the ETS have been developed within a more general scientific, economic and political context and debate about the following:

1. the scientific analysis of the causes of global warming, its evolution and potential consequences,
2. the economic analysis of the costs and benefits of climate change and its mitigation,
3. the political process aimed at mitigating climate change by promoting cooperation at an international level and by inducing an effective reduction of GHG emissions at a local level.

As previously mentioned, these scientific, economic and political topics will not be deeply analyzed, questioned and discussed. Nevertheless, it is important to be aware that the ETS and the European climate policy have been developed within this general framework, which will be shortly reviewed in the initial introductory chapters of this thesis.

4. Synopsis of the Research

After this first introductory chapter, **chapter 2** contextualizes the European ETS economic mechanism within the broader scientific and economic debate about both climate change and its mitigation costs and policies. We initially clarify what is meant by the term “global warming”, its causes and its main anthropogenic sources, as well as the possible natural consequences linked to different climate scenarios. Next, this chapter focuses both on the economics of climate change and on the economic debate concerning the costs and benefits of global warming as opposed to the costs and benefits of its mitigation. Then we shortly review the different economic models adopted to assess the optimal level of emissions reduction, highlighting the different assumptions, methodologies and contrasting results without pretending to assess which are the most reliable. Afterwards, we introduce the economic concept of *negative externality* and briefly summarize the problems that have to be addressed when dealing with the provision of *global public goods*. Finally, the chapter describes the political and juridical pathway that has brought about the entry into force of the Kyoto Protocol, the first international treaty aimed at stabilizing the emissions of GHG at a safety level; it will do so by focusing on the Protocol’s content, namely the emissions reduction targets and the flexible mechanisms established to reach them. Moreover, given that the Kyoto Protocol *de facto* does not impose any emissions reduction commitment on the US and on the developing countries (Carraro et al. 2009), introducing the Kyoto Protocol is crucial to underline from the very beginning the unilateral nature of the European climate policy, which is aimed at achieving a stringent emissions reduction target in an asymmetric geo-political scenario.

Chapter 3 presents a taxonomy of the legal rules and economic instruments which can potentially address the problem of environmental externality, and in particular the problem of climate change. Under a Law & Economics perspective, it is possible to separate legal and economic instruments that intervene ex-post—such as the liability regime—from other regulatory instruments that intervene ex-ante. Moreover the different legal instruments can be classified according to their degree of flexibility: ranging from the more interventionist and direct Command and Control type of regulation to the market-oriented economic instruments, such as pollution taxes and the cap and trade system.

Focusing on the mechanism of Cap and Trade as implemented by the European legislation in the form of the Emissions Trading Scheme, this research is not aimed at developing an exhaustive comparative analysis of the different competing legal solutions. Nevertheless, this chapter intends to review the properties and the related advantages and disadvantages of the most important legal and economic instruments adopted so far in the field of environmental law. It will do so in order to explain why, among them, the cap and trade system has been chosen first in the Kyoto Protocol and then within the European legislation as the principle legal and economic instrument to address the problem of climate change. The emergence of the cap and trade scheme is also explained from the perspective of political economics which takes into consideration how the private interests of the regulated parties tend to influence the type of adopted regulation.

Chapter 4 focuses on the implementation of the Kyoto Protocol in the European legislation and in particular on the Directive 87/2003/EC which establishes the Emissions Trading Scheme. This chapter intends both to introduce the economic and legal background of the ETS and to describe the functioning and the most important features of the ETS that will constitute the core of this thesis. Starting with a brief reminder of the importance of the previous experience of the American SO_2 emissions trading program, this chapter describes both the origin of the EU ETS within the legal framework of the Kyoto Protocol and the role it covers within the European climate policy. The legal nature of the allowances within the field of property law is also briefly discussed.

The ETS is contextualized in a temporal and spatial framework. The length of the ETS regulation and its subdivision into different trading periods is specified together with its scope: the amount of emissions and number of emissions sources that fall within the ETS. This specification is important to underline that the ETS regulates only a subset of the GHGs and emissions sources covered by the Kyoto Protocol. Moreover, this chapter describes the responsibilities that the MS have in implementing the ETS at national level. The functioning of the National Allocation Plans is explained in order to highlight how many responsibilities have been decentralized and delegated at national level according to the principle of subsidiarity.

Finally, this chapter intends to illustrate how the ETS can impact the secondary market—in this case the electricity generation market— by inducing a reduction of emissions through a switch to less carbon-intensive fuels. As such, the indicator of CO_2 theoretical coal-to-gas switch price is also introduced.

Chapter 5, which along with chapter 6 and 7 constitutes the core of this thesis, develops an analysis of the ETS at a macro-level, focusing on the level of the ETS cap.[3] The purpose of this chapter is to assess the effectiveness of the ETS in promoting emissions reduction required to comply with the Kyoto Protocol commitment. In particular, this chapter analyses the extent to which MS are effectively relying on the ETS to comply with their Kyoto commitments. In order to do so, it determines whether the emissions reduction burden deriving from the ratification of the Kyoto Protocol has been divided between ETS and non-ETS sectors in a cost-effective way. Therefore, this chapter focuses mainly on the ETS cap and on its stringency, where the ETS cap indicates the proportion of emissions that the ETS sectors are legally required to abate and, consequently, the amount of emissions the non-trading sectors have to reduce to comply with Kyoto commitments.

A theoretical benchmark is determined to assess the ETS cap stringency and to evaluate if emissions permits have been over-allocated during the first and second ETS trading periods.

Over-allocation is defined here as occurring when the ETS cap exceeds a theoretical ETS cap that would impose an emissions reduction burden on the ETS sectors proportional to the share of European emissions they produce. The analysis clarifies how the emissions reduction effort has been divided between ETS and non-ETS sectors, highlighting to what extent MS effectively rely on the ETS to comply with their Kyoto commitment. Finally, the inefficiencies concerning permits over-allocation are analysed, namely cross-subsidization from non-ETS to ETS sectors, national subsidy to the ETS sectors, lack of harmonization within the ETS and consequential distortion of competition in the secondary markets.

After having discussed the ETS effectiveness by assessing the ETS cap stringency at a macro-level, **chapter 6** focuses on the allocation rule adopted during the first and the second ETS trading periods, which is grandfathering: the initial allocation of

[3] Part of this chapter has been published as a research article in the international review *Climate Policy*. For major details see: S. Clò (2009), "An analysis of the EU Emissions Trading Effectiveness", *Climate Policy*, 9, 227–241

allowances free of charge proportionally to historical emissions. The main purpose of this chapter is to assess whether grandfathering can be considered – in theory and in practice – an efficient and fair allocation rule. This will be done by clarifying the conditions under which this allocation rule is consistent with the polluter-pays principle. The basic question is the following: do polluters pay under grandfathering – or not?[4]

Taking into account the complexities inherent in the interpretation of principles, the chapter presents the polluter-pays principle as it distinguishes between an efficiency and an equity interpretation. In the light of these different interpretations, this chapter develops a comparative analysis between grandfathering and auctioning in order to assess to what extent the different allocation criteria can be considered efficient and fair. Finally, this chapter analyses whether the theoretical findings concerning the efficiency and fairness of grandfathering are still valid within the ETS. By highlighting the inefficiencies that have emerged at the time of applying this allocation rule in the ETS, the chapter concludes by determining some conditions that have to be satisfied in order to ensure the consistency of grandfathering with the efficiency interpretation of the polluter- pays principle.

Chapter 7 focuses on the reform of the ETS. In the light of the new ETS Directive 2009/29/EC, which has amended the first ETS Directive, this chapter is aimed at assessing if and how the ETS functioning will be effectively improved during its third post-Kyoto trading period (2013-2020).

The chapter focuses on the major provisions of the new ETS Directive and on the variables previously analysed in chapters 5 and 6, namely the ETS cap setting procedure and the allocation rule. After recalling the inefficiencies that emerged in the past trading periods, this chapter analyses how these variables have been reformed in order to assess if and to what extent the new ETS Directive will improve the ETS functioning by increasing its effectiveness, avoiding undesirable distributive effects and granting higher harmonization within the market aimed at minimizing distortion of competition.

The chapter focuses on the phenomenon of Carbon Leakage that could emerge by strengthening the ETS cap and by passing from grandfathering to auctioning. The

[4] Part of this chapter has been originally published as a research article written jointly with Edwin Woerdman and Alessandra Arcuri in the *Review of Law and Economics*. For major details see: E. Woerdman, A. Arcuri and S. Clò (2008), "Emissions Trading and the Polluter-Pays Principle: Do Polluters Pay under Grandfathering?", *Review of Law and Economics*, 4(2)

methodology to assess the ETS sectors' exposure to Carbon Leakage is described and the results of the EC quantitative assessment are presented and discussed. Particular attention is devoted to the discussion of both the criteria and the level of data aggregation adopted to assess the risk of Carbon Leakage in order to determine if and when the defined procedures can be considered as having a solid economic background and when they can be regarded as mainly political or extra-economic.

Finally **chapter 8** summarizes the main conclusions that have been reached as a result of this research.

Chapter 2. Climate Change and the Kyoto Protocol: an Overview

1. Introduction

In order to facilitate cost-effective compliance with the European emissions reduction target established in the Kyoto Protocol, a system of tradable emissions allowances has been established in Europe. This thesis intends to assess the effectiveness of the Emissions Trading Scheme in facilitating the European compliance with its emissions reduction target, which is taken as a given. This means that we do not intend to draw any conclusions about the efficiency of the emissions reduction targets established in the Kyoto Protocol, nor about the efficiency of the Kyoto Protocol itself. We do not exclude the possibility that an effective instrument can be established to comply with an inefficient target.

Nevertheless, for the purpose of this thesis, it can be useful to contextualize the European ETS economic mechanism within the broader scientific, economic and political debate about both climate change and the Kyoto Protocol. In fact, in order to discuss the ETS, it is first necessary to introduce the flexible mechanisms established by the Kyoto Protocol to facilitate the achievement of the national emissions reduction targets. Moreover, given that the Kyoto Protocol *de facto* does not impose any emissions reduction commitment on the US and on developing countries (Carraro et al. 2009), it is crucial to underline from the very beginning the unilateral nature of the European climate policy, which is aimed at achieving a stringent emissions reduction target in an asymmetric geo-political scenario. In fact, this thesis does not pretend to explain why the European Union has committed to such an ambitious and asymmetric target; nor does it intend to assess the efficiency of the European emissions reduction target itself. Nevertheless, as chapter 7 on Carbon Leakage will discuss, the effectiveness of the ETS itself risks being jeopardized by the unilateral and asymmetric nature of the European climate policy.

This chapter is structured as follows. First, we clarify what is meant by the term “global warming” (section 2), what are its causes and its main anthropogenic sources (section 3) and the possible natural consequences linked to different climate scenarios (section 4). After addressing these issues, this chapter focuses both on the economics of climate change and on the economic debate concerning the costs and benefits of global warming as opposed to the costs and benefits of its mitigation. Different economic models to assess the optimal level of emissions reduction and to determine more appropriate mitigation policies have been proposed. Section 5 briefly reviews this literature, highlighting the different assumptions, methodologies and contrasting results without pretending to assess which are the most reliable.

Afterwards, section 6 introduces the economic concept of *negative externality* and briefly summarizes the problems that have to be addressed when dealing with the provision of *global public goods*. Section 7 recalls the political and juridical pathway that has led to the entry into force of the Kyoto Protocol, the first international treaty aimed at stabilizing the emissions of GHG at a non-dangerous level. The most important environmental principles that during the last decades have been recognized within the international environmental legislation are briefly described and both the content and the major innovations of the United Nation Framework Convention on Climate Change are reviewed. Section 8 introduces the content of the Kyoto Protocol (the emissions reduction targets and the flexible mechanisms established to reach them). Section 9 concludes.

2. What is Global Warming?

Solar radiations constitute the principal source of temperature on Earth. Of course, solar radiations reach different planets and satellites within the solar system; however, the Earth is the only planet warmed by the sun where life has flourished. What makes the difference is the atmosphere, which is composed of a mix of different gases: 78.08% nitrogen, 20.95% oxygen, and a lower amount of the so-called “trace-gases” such as water vapour, methane, and carbon dioxide (CO_2) which are extremely important. In fact, like glass in a greenhouse, thanks to these “trace-gases”, the atmosphere is able to be penetrated by the radiations in the visible part of the spectrum, and at the same time it can absorb and retain low frequency radiations, such as infra-red. This means that solar rays can first pass the atmosphere and reach the Earth; secondly, the rebounded rays are partly captured by the atmosphere, which “captures” them as it allows a rise in the Earth’s temperature.

The presence of GHGs is therefore crucial for life to take place on Earth: without GHGs the Earth’s temperature would be around zero and life would not be possible. However, as the concentration of GHGs in the atmosphere increases, the amount of solar rays captured by the atmosphere increases and the global temperature increases as well, thereby incurring the risk of compromising the equilibrium of the ecosystem.

This is what we generally mean by the term "global warming" which refers to the phenomenon resulting from the rise in the concentration of GHGs in the atmosphere.
Based on the analysis of historical data, scientific research nowadays has reached two important conclusions. First, it has been established that the concentration of GHGs in the atmosphere is increasing, causing an indirect increase in the Earth's average temperature— a phenomenon that is known as the so-called global warming effect. Second, the increased concentration of GHGs in the atmosphere has been caused by human economic activity and by the combustion of fossil fuels.
At the time this thesis was developed, the last published report of the Intergovernmental Panel of Climate Change (IPCC fourth assessment report 2007)— the leading scientific body for the assessment of climate change, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) and composed by thousands of scientists— asserted that:

> *The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 parts per million (ppm) to 379 ppm in 2005. The atmospheric concentration of carbon dioxide in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores. The annual carbon dioxide concentration growth rate was larger during the last 10 years (1995–2005 average: 1.9 ppm per year), than it has been since the beginning of continuous direct atmospheric measurements (1960–2005 average: 1.4ppm per year)* (p.2)

3. The Sources of Emissions

Nowadays, it has been widely accepted that the increase in the concentration of GHGs in the atmosphere has been principally caused by anthropogenic economic activities, including industrial production, energy generation, transportation and the change of land use, such as deforestation. In fact, most of these activities require the combustion of fossil fuels, which causes the emission of greenhouse gases. It is possible to determine a direct correlation between economic growth and the increase in GHGs. According to Kaya (1990), the amount of carbon dioxide emissions released into the atmosphere depends directly on the GDP, which can be further decomposed into different variables:

1. the rate of population growth,
2. the GDP per capita,
3. the energy intensity of the technologies adopted to produce (amount of energy required to produce one unit of output), which depends on the efficiency and performance of the technological processes, and
4. the carbon intensity of the energy use, which mainly depends on the fuels that are burned.

$$\boldsymbol{CO_2 \textit{ emissions} = \textit{Population x (GDP percapita) x (energy use/GDP) x} (CO_2 \textit{ emissions/energy use})}$$

The World Resource Institute (WRI) has classified the most important world economies according to these variables.

Table 1 – Key Variables reflecting Energy related Co2 emissions

	Cumulative CO_2 emissions[5] (MtCe)	Yearly CO_2 emissions (MtCe)	CO_2 per capita (MtCe)	Income per capita $Intl 2005 Per Person	Carbon Intensity of Energy Use (TCe/TOilEq.)	GHG Intensity of the Economy (tCe/Mill. Intl $)
USA	91,088.4	1,575	5.3	42.672	0.68	123.7
Japan	12,154.8	340.5	2.7	31.041	0.65	85.9
EU 27	83,447.1	1.124.2	2.3	27.642	0.62	83.6
China	27,075.4	1.693.9	1.3	4.521	0.90	285.6
India	7,487.3	363.3	0.3	2.416	0.64	135.5

Source: WRI 2009

From the data reported in the table above, it is possible to observe a direct correlation between income and emissions per-capita: countries with a higher level of income per-capita tend to experience a higher level of emissions per-capita. Moreover, it is possible to observe that, on average, the more a country is industrialized, the higher the amount of cumulative and per-capita emissions is. Thus, emissions are mainly driven by economic growth, which is associated with an increase in energy consumption. This correlation has been strongly supported by previous economic

[5] Cumulative emissions have been calculated from 1850 to 2006

research. Using a panel data composed of 163 countries, Neumayer (2004) shows that the correlation between per-capita CO_2 emissions and per-capita GDP is nearly 0.9. Similarly, Huntington (2005) shows that in the United States a 1% increase in the GDP per capita has led to a 0.9% increase in emissions per capita, *ceteris paribus.*

However, the marginal variation of emissions per unit of production tends to decrease for decreasing levels of carbon and energy intensities. In other words, the more a technology is efficient (low energy intensity) the lower the level of emissions released for any unit of production tends to be. This relation demonstrates that while industrialized countries emit more than developing countries because they experience higher production and GDP rates, they nevertheless tend to experience lower levels of emissions per unit of production than developing countries because they use more efficient and less polluting technologies, and on average they produce at a lower energy intensity rate than developing countries.

The *Kaya equation* and the data reported in the previous table can be useful for two reasons. First, they give some basic indications regarding which variables have to be taken into account when modelling future emissions scenarios. Second, they offer some indication as to where and how emissions can be reduced. In fact, knowing the sources of emissions, the variables which influence emissions and where CO_2 emissions are produced is a pre-requisite to understanding where and how such emissions can be abated.

We can assert that population growth is likely to provoke an increase in GHG emissions, as well as an increase in the GDP, unless it results in the introduction of more efficient and less energy intensive technologies that can work with less carbon intensive fuels.

The Kaya equation suggests different strategies to reduce CO_2 emissions: one might either diminish the overall level of population and GDP growth—an option that is neither politically nor economically acceptable—or, alternatively, one might improve the energy efficiency of the technologies and reduce the carbonic intensity rate of the economy. It is important to observe that in the past decades, despite the fact that the industrialized countries have experienced an improvement in energy efficiency and a reduction of carbon intensity, emissions have continued to rise since the GDP and population have increased at a faster rate. We can conclude that the real challenge facing market based instruments such as the ETS is to create the right incentives to innovate and adopt more efficient and less carbon intensive technologies, without compromising economic growth.

4. Emissions Projections and Climate Scenarios

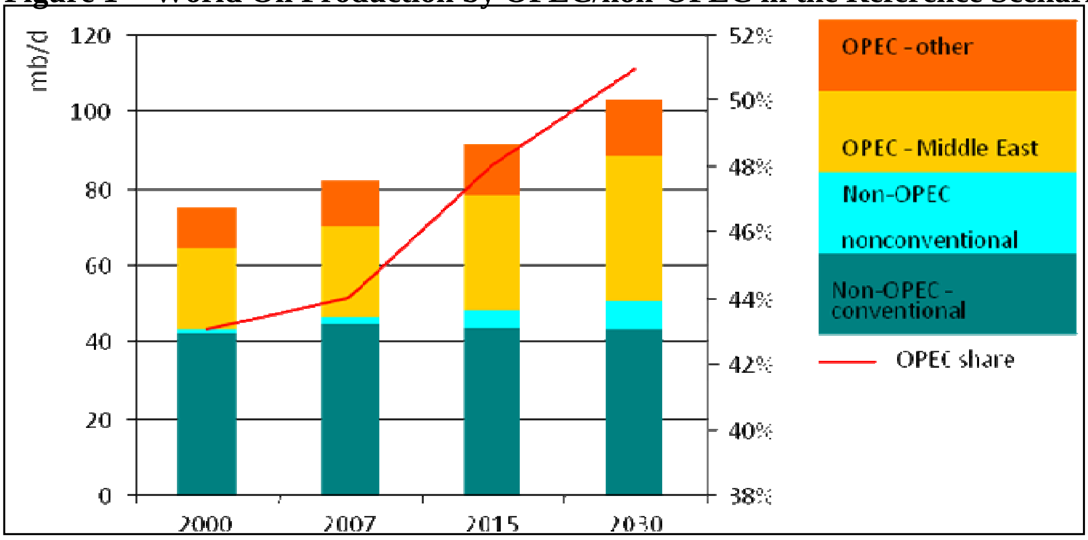
During the past decades the anthropogenic economic activity has caused a higher concentration of GHGs in the atmosphere and, consequently, a rise in the global temperature. Such a causal relation has been supported by the analysis of historical data. Conversely, many uncertainties affect the ability to build future climate scenarios that are widely accepted in the scientific community. Many scientific and economic uncertainties limit the ability to assess the future trend of emissions, preventing us from predicting both how the variation of the concentration of the GHGs in the atmosphere will impact the global temperature exactly and how the change in climate will affect the ecosystem.

Such a complexity is mainly caused by the so-called natural feedback loops: natural phenomena that are interdependent with climate change because they are influenced by the variation of global temperature, and that at the same time influence the climate conditions. Feedback loops may be positive, thus having an exponential reinforcing effect on warming, or they may be negative, in which case they have a countering and balancing effect on the change in climate conditions. An example of negative feedback is the "iris effect": just as the iris of our eyes closes up when the light increases, an increase in temperature may produce more water vapour resulting in a higher number of clouds that limit the sun rays (e.g. Lindzen et al. 2001). In this case the ecosystem, like Adam Smith's invisible hand, would be sufficient to bring the global temperature to a sustainable equilibrium. A case of positive feedback is the Albedo Effect (Palle et al. 2004): white areas tend to reflect sunlight while black areas tend to absorb it. So, as the ice increasingly melts, the Earth's tendency to reflect the sun rays decreases and the world ends up absorbing more light and consequently warming up even more.

Although scientific and economic uncertainties impede us from reaching widely accepted conclusions about the future trend of climate and its impact on the ecosystem, many climate scenarios have been developed and their conclusions look quite straightforward. The IPCC has extrapolated some Business as Usual (BaU) emissions scenarios by projecting the past economic and emissions trends into the future under the assumption that no policy will be developed to mitigate climate change. These scenarios describe some possible environmental and economic impacts that, in spite of not being certain, represent a risk that governments have to take properly into account.

The IPCC's first report (2000) concluded that, unless the world economy was de-carbonized, by the end of the century the concentration of GHGs would reach 800 ppm, thereby causing an average increase in the world temperature between 1.4°C and 5.8°C (the range of different possible temperatures is due to the uncertainty of the world feedback). In 2007, a new IPCC report concludes that, at the current rate of growth, the global temperature will probably rise between 1.1°C and 6.4° C by the end of the century. In spite of the scientific uncertainty, the effects on the temperature increase the risk of triggering natural catastrophes: a rise in the sea level, a decrease in agricultural production, increases in extreme weather events such as hurricanes, and so forth. Also the World Energy Outlook (WEO), elaborated by the International Energy Agency (IEA) in 2008, reaches some worrying conclusions. The IEA future BaU emissions scenarios are simply not sustainable from both an environmental and a socio-economical perspective. On top of climate change, the lack of energy-security supply constitutes another problem underlined by the IEA.

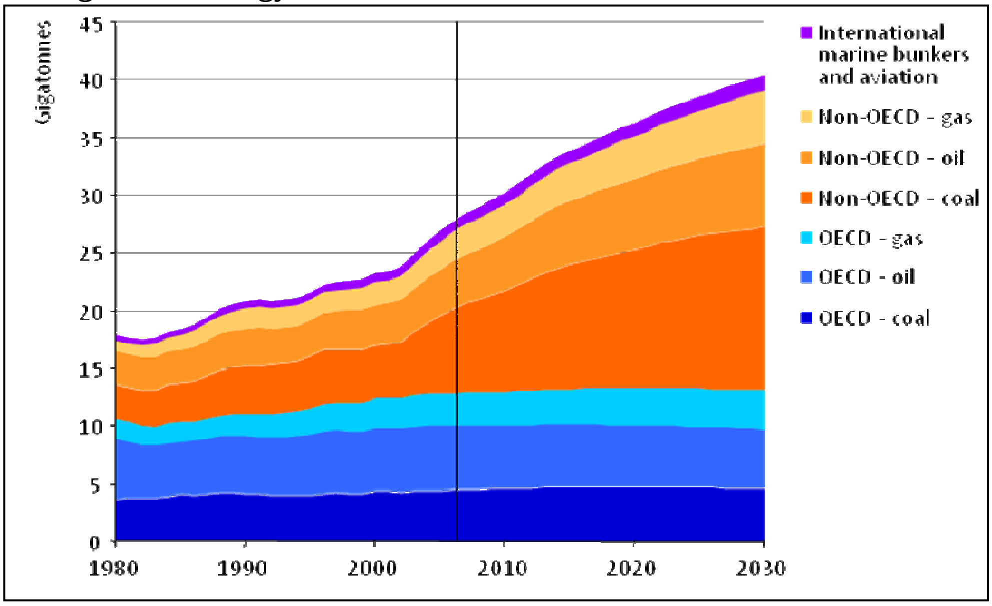
Figure 1 - World Oil Production by OPEC/non-OPEC in the Reference Scenario



Source: IEA 2008

The figure above shows that in the WEO reference scenario oil remains the most important energy source experiencing an increase in daily production (104 million barrels in 2030) which comes mainly from the OPEC countries. These figures imply that a capacity of 64 million barrels should be installed in order to satisfy the increase of the world demand, an amount which is six times higher that the actual oil capacity in South Arabia. In this scenario, also the CO2 eq. emissions from energy sources would increase exponentially from the actual 27 billion tonnes to 40 billion tonnes in 2030. Such an increase of emissions is expected to come from non-OECD countries, mainly China, India and the Middle-East, because of the more rapid population and GDP growth there than in developed countries (see figure 2 below).

Figure 2 - Energy-related CO2 Emissions in the Reference Scenario



Source: IEA 2008

Although these scenarios remain uncertain, the risks they may involve are sufficiently high to call for intervention aimed at stabilizing emissions at a safe level. The obvious conclusion is that this BaU emissions scenario can be mitigated only through collective and global action against climate change which involves both developed and developing countries. First a problem of evaluation has to be solved: using a cost-benefit analysis economists have to determine what the optimal amount of money to spend is in order to reduce emissions to a non-dangerous level. Secondly, a problem regarding incentives needs to be addressed: how to promote collective action against climate change. The following paragraph shortly discusses both these evaluation and incentive problems.

5. The Economics of Climate Change

While scientific research on global warming has increasingly focused on the causes of climate change—on its possible future trend and on its consequences for the ecosystem—economic analysis has been increasingly applied to climate change in order to quantify in monetary terms the costs and benefits linked to climate change and its mitigation. This economic analysis attempts to assess the size of the climate externality and the optimal level of emissions that should be reached—a level where the social marginal costs of climate change equal the related social marginal benefits.

The existing literature has developed different methodologies to assess the costs of climate change in the case of non-intervention and the costs and benefits (or costs avoided) related to climate change mitigation policies. Depending on how the costs and benefits of climate change are quantified, the optimal equilibrium could change, calling for one particular climate policy instead of another.

Bringing new insights to the economic debate concerning the assessment of the marginal costs and benefits of emissions and the optimal social level of CO_2 emissions goes beyond the scope of this thesis. However, for the purpose of this research, it can be useful to review the relevant contributions in this field, highlighting the main findings and controversies.

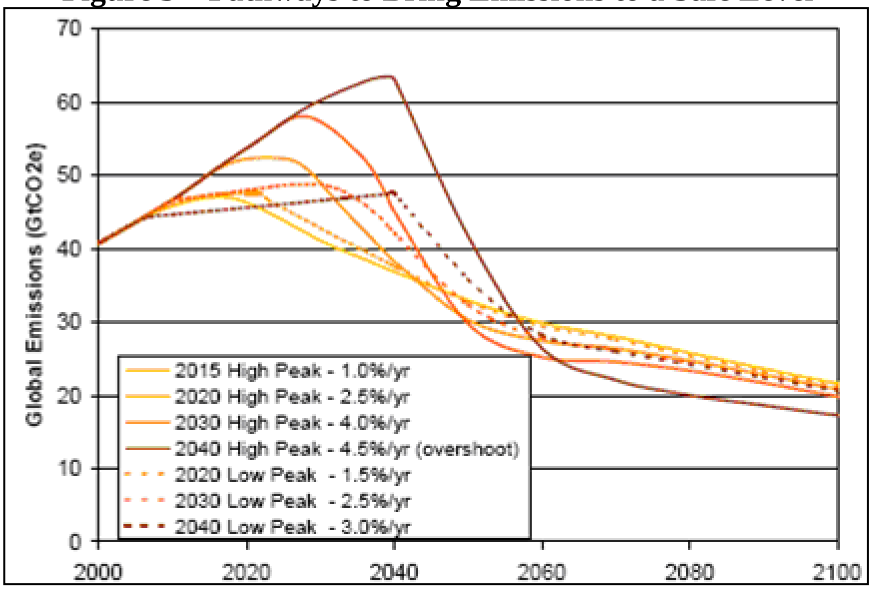
The results of different economic models are not uniform and usually differ depending on many underlying assumptions, factors and variables that have been taken into account. Among them, we can mention the following: (a) how marginal abatement costs are estimated, (b) which emissions scenarios are taken into account, (c) or the rate at which environmental friendly and efficient technologies are developed and introduced within the economy. Other important factors influencing the assessment of the costs of climate change mitigation include the time of intervention and the social rate at which future costs and benefits are discounted. Economists heatedly debate whether it is more efficient to call for fast intervention to safeguard against climate change or to call for a gradual reduction of emissions. Some economists argue that, as emissions stay for a long time in the atmosphere, it is irrelevant to reduce emissions today, or even in twenty years. Instead, these economists call for a gradual reduction of emissions, which should take place only after more environmental friendly and efficient technologies have been developed in order to reduce the marginal cost of abatement. According to this analysis, the faster emissions are reduced, the costlier abatement is. Among others, Nordhaus (2006) argues that “the efficient or ‘optimal’ economic policies to slow climate change involve modest rates of emissions reductions in the near term, followed by sharp reductions in the medium and long term” (p.6).

Other economists argue that the more we wait to reduce emissions, the higher the costs of intervention will be. According to the Stern Review:

> *"Stabilising at or below 550 ppm CO_2e (around 440 - 500 ppm CO_2 only) would require global emissions to peak in the next 10 - 20 years, and then fall at a rate of at least 1 - 3% per year (…) Delaying the peak in global emissions from 2020 to 2030 would almost double the rate of reduction needed to stabilise at 550 ppm CO_2e. A further ten-year delay could make stabilisation at 550 ppm CO_2e impractical, unless early actions were taken to dramatically slow the growth in emissions prior to the peak"* (p. 218).

This conclusion is driven by the consideration that the more we wait to reduce emissions, the faster we will have to intervene to bring the increasing level of emissions to a safe level, as shown by the figure below.

Figure 3 – Pathways to Bring Emissions to a Safe Level

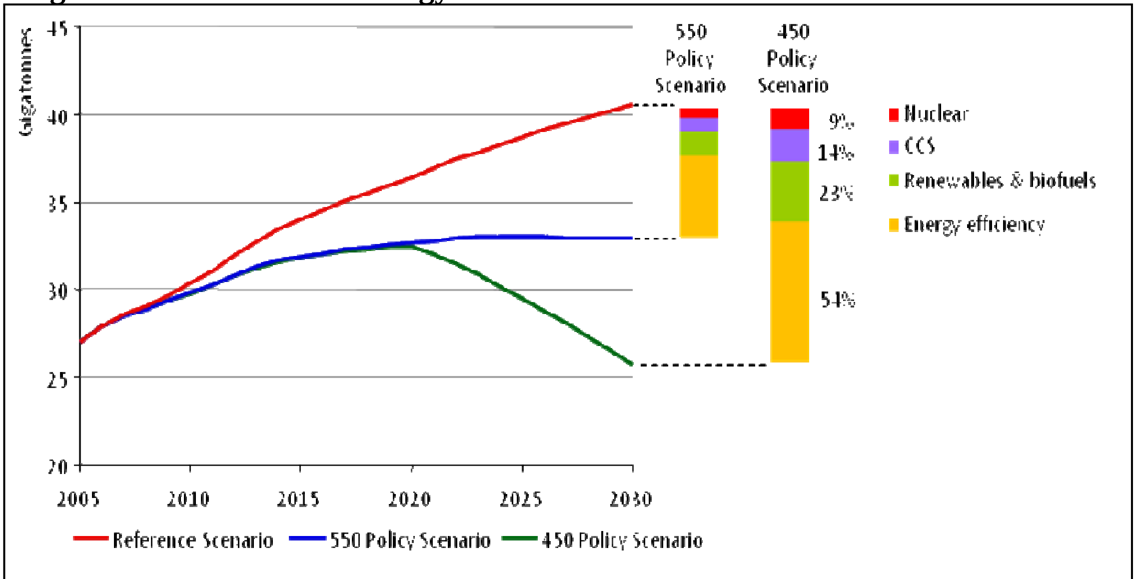


Source: Meinshausen et al. 2006

Starting from the findings of the IPCC model, the Stern Review argues that if the concentration of emissions were to exceed 550 ppm (parts per million), the global temperature would rise more than 2°C, causing catastrophic and damaging effects. Instead, 450 ppm is considered a safe level of emissions concentration. While the 450 ppm goal is very ambitious, as it requires fast and costly intervention to reduce emissions by 7%, the 550 ppm target would involve substantial climate risk. Notwithstanding, it would be easily achievable with the existing technologies by investing 1% of the global GDP. In June 2008, Stern corrected his analysis asserting that "to get below 500ppm would cost around 2% of the GDP" because of a faster than expected climate change (Jowit and Wintour 2008).

The WEO 2008 has also described two alternative emissions reduction scenarios. According to the IEA, the first *550 ppm policy scenario* could be achieved by investing 0.25% of the World GDP and by establishing a CO2 price of 90$. Under this scenario the global temperature would increase by 3°C. The second *450 ppm policy scenario* would require more substantial investments equal to 0.6% of the global GDP and a CO2 price of 180$. Under this scenario the global temperature would increase by 2°C, stabilizing at a safe level.

Figure 4 - Reductions in energy-related CO2 emissions in the climate scenarios



Source: IEA 2008

The Stern Review and the WEO 2008 argue that the stabilization of emissions gases in a range between 450 and 550 ppm would imply a 2- 3°C increase in the global temperature: a target that could be reached by investing between 0.4 and 2% of the global GDP. These costs would increase if the climate policies were postponed in time, since a faster emissions reduction would then be required. On the contrary, according to the BaU emissions scenario, where no measures undertaken to abate emissions, the global temperature would increase by 5-6°C by the end of this century, causing an economic loss that the Stern Review estimates between 5 and 20% of the global GDP.

According to the Stern Review, fast intervention to mitigate climate change is not only environmentally friendly but also economically sound.

Many economists have supported this view. “The world would be foolish to neglect this strong but strictly time-bound message” commented A. Sen, while R. Solow has argued that “[s]ooner is much better”. J. Stiglitz – another Nobel Prize in Economics – commented in this way: “it makes it clear that the question is not whether we can afford to act, but whether we can afford not to act”.

Other economists have criticized the assumptions adopted in the Stern Review which have led to these conclusions. According to Nordhaus (2006), “The Review’s unambiguous conclusions about the need for extreme immediate action will not survive the substitution of assumptions that are consistent with today’s marketplace real interest rates and savings rates.” Similarly, Dasgupta (2006) has argued that “the strong, immediate action on climate change advocated by the authors is an implication of their views on intergenerational equity; it isn’t driven so much by the new climatic facts the authors have stressed”.

The emergence of this economic dispute is related to the fact that climate change has different effects in the time-spatial framework creating the difficulty of doing cost-benefit analysis across borders and generations. First, the increase of the temperature would have different effects in different parts of the world: while countries close to the Equator risk facing massive damage, northern countries, such as Russia or Greenland, would benefit from an extra couple of degrees, since many uninhabitable areas would become more comfortable, and many natural resources—such as oil reserves—would become more easily accessible. According to Mendelsohn et al. (2006), the GDP in the former Soviet Union countries would increase by almost 11% after a global temperature increase of 2.5%. The non-homogeneous effects of global warming around the world make global cooperation aimed at mitigating climate change more difficult.

Another related problem regards the different statistical value of life across countries. Rich countries are willing to invest more money in health protection and safety than developing countries, leading some economists to conclude that life in developed countries is valued more than life in developing countries. Moreover, the classic economic assumption of diminishing marginal utility implies that the same monetary damage has a higher impact on poorer than richer people. Of course, both the social optimum and the welfare assessment of the market equilibrium differ depending on the value that is attached to life and the environment. According to many economists, equity weighting of costs and benefits is required to reflect the law of diminishing marginal utility and to measure the social cost of carbon (Pearce, Cline et al. 1996). As it will be explained in the following sections, the social cost of carbon corresponds to the environmental damage caused by the emission of greenhouse gases; this damage is likely to be borne by a third party – namely, society as a whole –and without any right to compensation. According to Anthoff et al. (2009) the higher the equity weighting, the higher the social cost of carbon. In fact, "[e]quity-weighted estimates of the marginal damage cost of carbon dioxide emissions are substantially higher than estimates without equity-weights; equity-weights may also change the sign of the social cost estimates" (Anthoff et al. 2009, p.1).

Another heavily debated issue is the choice of the social discount rate which has to be applied in order to assess the net present value of the costs and benefits. These costs and benefits—in the alternative cases of intervention and non-intervention against global warming—will have to be borne by future generations because of climate change. Discounting is a measure of time preferences, and the choice of the discount rate reflects the value that today is attached to the future. People attaching higher value to present than to future consumption are represented by a high discount rate, which in turn reflects a high degree of impatience. Since climate change has long term effects, the adoption of normal discount rates (between 3% and 6%) would lower the net present value of high and costly damage caused by global warming in the long run. Therefore, some economists have used a lower discount rate in order to equally evaluate future and present events. In fact, as the discount rate decreases, the social cost of future damage and the social cost of carbon emissions increase as well as, thus calling for stronger and faster climate mitigation policies. For instance, the Stern Review adopts a 0.01% discount rate, concluding that the CO_2 social cost is 310 $/ton. On the contrary, by using a 3% discount rate in the "Dynamic Integrated Model of Climate and the Economy" (DICE), Nordhaus estimates a CO_2 social cost equal to 13$/ton. This is not to say that one discount rate is better or more correct than the other; simply put, different discount rates reflect different political preferences and result in a different estimation of the environmental costs of carbon emissions.

This thesis does not intend to bring new insight to the debate regarding the economics of climate change and the assessment of the optimal social level of emissions. In fact, this thesis intends to address the “incentive problem” while not questioning the evaluation problem; that is, the emissions reduction target is taken as a given, and its efficiency is not questioned. For the purpose of this research, it is sufficient to stress that almost all scientists recognize that global warming is taking place because of human activity and almost all economists nowadays advocate for intervention as a means of mitigating climate change (for example, commenting on the Stern Review, even Nordhaus, who has questioned many assumptions adopted by Stern, has recognized that “the results are correct in sign if not in size”, while they mainly disagree on the time and on the size of intervention).

The belief that technologies are sufficiently developed to move to a low-carbon economy without compromising economic growth is also widespread. However, as the following sections about public goods and the Kyoto Protocol will clarify, the main difficulty of reducing emissions is not technological or scientific, but rather economic and political.

6. How to Deal with Global Public Goods?

In economics, the emission of greenhouse gases is defined as a *negative externality*: a cost that is not reflected in the market price system and that the emitter does not have to pay. In default of any legal obligation, the damage caused by the emission of greenhouse gases is likely to be borne by a third party—the society as a whole—without any right to compensation. Symmetrically, the preservation of the Earth’s atmosphere can be defined as a *public good*. Economic literature classifies as “public” those goods that are both non rival and non-excludible: use by one agent does not diminish the availability of that good to others, who cannot be excluded from using the same good simultaneously.

When market mechanisms fail to induce spontaneously any internalization of the environmental negative externality, the amount of emissions released into the atmosphere exceeds the optimal social level, at which the marginal costs of pollution equal the marginal benefits. This in turn calls for public intervention aimed at correcting such a market failure and preserving the public good from an excessive private exploitation and depletion (Olson 1965; Hardin 1968; Russett and Sullivan 1971).

First, the optimal social equilibrium has to be assessed by balancing the marginal costs and benefits of pollution. This is a problem of evaluation. Then, the problem of incentives has to be addressed: an effective legal instrument needs to be designed in order to induce an internalization of the environmental externality up to its optimal level at the minimal social cost (Barrett 2002).

Designing an effective legal and economic instrument becomes more problematic when the public good to be preserved and the externality to be internalized are *transnational or global* in nature. Global warming and climate change have been widely identified as a case of transnational negative externality "for which allocative decisions in one country have consequences in another that is not party to the decisions, and no market exists to compensate for the associated costs or benefits" (Arce and Sandler 2001, p. 1).[6] Given the global dimension of climate change, it is unlikely that an independent and unilateral intervention aimed at reducing emissions internally on behalf of one single country can optimally preserve that public good. The preservation of transnational public goods calls for international arrangements and cooperation among states. Therefore, during the past decades, legal and economic scholars have increasingly analysed how to promote international cooperation in order to ensure an optimal reduction of greenhouse gas emissions (Barrett 1990; Martin 1999).

Starting from the basic assumption that states act as rational agents with stable preferences in order to maximize their own welfare or interests (e.g. Goldsmith and Posner 1998, 1999 and 2004; Guzman 2002; Sykes 2004), economic theory tends to foresee insufficient international cooperation, causing a sub-optimal level of environmental protection. That is, despite the fact that reciprocal cooperation would ensure a Pareto-superior outcome where social welfare would be maximized, self-interest states are tempted to defect on cooperation by saving abatement costs while free-riding on other countries' efforts to reduce emissions. This would in turn result in a sub-optimal Nash equilibrium where global public goods would be under-supplied. As argued by Bohringer, "individual rational countries only pursue their own interests and neglect the positive externalities of their reduction measures for other countries. Thus, the level of GHG emission reductions will be too low" (Bohringer 2002, p. 452).

[6] On global and transnational public goods, see Kaul, Grunberg, and Stern (1999) and Sandler (1997, 1998);

We shortly review which factors hinder the capacity to promote effective cooperation at an international level. first, given the global nature of climate change, effective international cooperation requires (a) the participation of a high number of asymmetric countries which (b) are called to bear certain costs (c) despite the uncertainty of future benefits. Many economic models of industrial organization have shown that the probability of a collusive cartel being successful decreases as both the number of participants and their degree of cost asymmetry increase (Kuhn and Motta 1999; Compte et al. 2002; Motta 2004). Similarly, it has been shown that the incentive to defect on international cooperation and to free ride on other countries' efforts to reduce emissions increases as the number of participating countries increases (Carraro and Siniscalco, 1993; Barrett, 1994) and as the degree of costs asymmetries deriving from international cooperation increases among cooperating parties (Botteon and Carraro, 1993). In addition to these shortcomings, other peculiar features making a climate change agreement more complicated than other multilateral environment agreements have been identified. Among them, the high degree of uncertainty characterizing the phenomenon of climate change tends to deter countries from adopting stringent and costly international agreements aimed at reducing carbon emissions. In fact, as previously mentioned, there is disagreement on many features of climate change, such as the effects of climate change, the optimal level of emissions concentrations, the probability of risky events occurring. These and other uncertainties generate a trade-off between the costs, benefits and risk of delayed action, on the one hand, and the costs, benefits and risk of premature abatement action, on the other hand (see Dixit and Pindyck, 1994). This trade-off limits the incentive to enter in a long-term and costly agreement for emissions reduction.

Another factor limiting international cooperation is the lack of efficient technological solutions: contrary to the case of the Montreal Protocol intended to phase out ozone-depleting substances, efficient breakthrough technologies to mitigate climate change have not been identified yet. The impossibility of adopting efficient environmentally friendly technologies limits the incentive to commit to stringent emissions reduction targets (Carraro and Galeotti 2003). Last but not least, international cooperation is hindered by the "absence of a hierarchical command structure" (Barret 2003, p. 46). As pointed out by Carraro, Egenhofer and Fujiwara (2009) "there is no global institutional framework able to deal with the many complexities associated with climate change" (p.2); therefore, international cooperation aimed at reducing emissions cannot be imposed and must be voluntary. Bohringer argues that "the lack of supranational authority that could coerce countries into the implementation of globally efficient climate policies [including] the imposition of fairness principles about how gains from cooperation should be shared" constitutes the main problem in achieving efficient response policies to climate change (Bohringer 2003, p. 454). The fact that states are called to cooperate in a legal setting where "no international legislature exists to pass the equivalent of domestic statutes, and no international court exists with the power to create a general international common law" (Sykes 2004, p. 2) has been widely identified as one of the major constraints limiting the mechanisms favouring the supply of global public goods.

Economic and legal scholars have been increasingly analysing how to design effective mechanisms to promote international cooperation aimed at supplying global public goods (Kaul et al. 1999; Barrett 2002) and how to induce parties to cooperate internationally in spite of "the absence of an effective global governance system" (Carraro et al. 2009, p.3). Different proposals have been advanced in order to create incentives for sovereign states to cooperate (Carraro and Siniscalco 1998; Finus 2003), including how to "fairly" distribute the potential gains from cooperation across countries (Moulin 1990, 1991; Borhinger and Helm 2001). Among others, Stavins and Barrett (2002), Bodansky (2004) and Egenhofer at al. (2004) have reviewed the literature analysing how to increase participation and compliance in international climate change agreements. However, reviewing exhaustively this literature and its main findings goes beyond the scope of this thesis.

For the purpose of this thesis, it is important to mention that, in spite of the legal and economic peculiarities which make an international agreement against climate change particularly thorny, during the past two decades important steps to foster international cooperation in the field of climate change have been made not only on a theoretical, but also on a practical level. Indeed, in spite of the absence of an exogenous enforcing authority, the existence of a variety of endogenously defined mechanisms and remedies within international law has fostered international cooperation at a higher level than as predicted by conventional economic theory.

International Relations and International Law & Economics scholars have identified a plurality of mechanisms and remedies aimed at inducing international cooperation. Among them, we recall:

1. *Reciprocity*: this mechanism ensures that states taking part in an international agreement perform symmetrically by excluding the combination of asymmetric strategies from the game and by making only the symmetric payoffs available (Fon and Parisi 2003). Already in 1984, Sugden showed that reciprocity can be a powerful mechanism to supply public goods through voluntary contributions given that "individuals act according to some moral principle that requires them to take account of other people's interests" (Sugden 1984, p. 773).
2. *Retaliation*: this mechanism can be brought back to the Friedman's "trigger strategy" where one player commits to cooperate as long as the other player cooperates but punishes the opponent in the case defection from cooperation is observed. In the specific case of "tit for tat strategy" (e.g. Axelrod and Hamilton 1981) the punishment continues as long as the other player defects. The imposition of a punishment in case of defection gives the self-interested agent an incentive to adopt a cooperative strategy. An example is seen in the linkage treaties strategy where it is established that a country that does not comply with a particular treaty has precluded the possibility to participate and to enjoy the benefits deriving from other international agreements, such as trade treaties or Research and Development cooperation treaties.
3. *Reputation*: in 1984 Keohane argued that "regimes rely not only on decentralized enforcement through retaliation but on government desires to maintain their reputations" (Keohane 1984, p. 108). The role of reputation has been identified in the literature of International Law & Economics as one of the relevant mechanisms favouring cooperation among states (see Guzman 2002, 2008; for a more sceptical view of the role of reputation see Goldsmith and Posner 2005). Reputation constitutes an effective mechanism to induce cooperation in the case of repeated games, and it relies on the principle that agents prefer to enter in cooperative agreements with credible and reliable parties. In a context of asymmetric information where countries cannot distinguish and separate ex ante good types from bad types, complying with international agreement becomes a signalling strategy aimed at building a "good type reputation". Therefore, breaching international agreements might be profitable in a one shot game but it imposes an opportunity cost (loss of reputation) that will make it more difficult to build new agreements in the long

term. Reputation is a mechanism that differently from reciprocity and retaliation does not require a high level of coordination; therefore, it tends to be efficient also in those situations with high coordination costs where retaliation and reciprocity strategies are likely to not be effective (Guzman 2006). As argued by Downs and Jones “a major—if not the major—reason why states keep commitments, even those that produce a lower level of returns than expected, is because they fear that any evidence of unreliability will damage their current cooperative relationships and lead other states to reduce their willingness to enter into future agreements” (Downs and Jones 2002, p. 91).

We have shortly recalled why, despite the fact that self-interested states may have an incentive to free ride on other countries’ efforts to reduce emissions, we still observe a certain degree of international cooperation that is higher than what conventional economic theory has predicted. As argued by Keohane “[f]or reasons of reputation, as well as fear of retaliation and concerns about the effects of precedents, egoistic governments may follow the rules and principles of international regimes even when myopic self-interest counsels them not to’’ (Keohane 1984, p. 106).

In order to foster transnational cooperation, specific institutions and agreements have evolved within the body of laws governing relations between states. International agreements among states have widely emerged both as customary international law, which is defined as a “general and consistent practice of states followed by them from a sense of legal obligation”,[7] and in the form of treaties, which have been defined as “an agreement executed by duly authorized officials of signatory states, evincing an intention to make it a binding legal obligation” (Sykes 2004). Or alternatively as a “express promises that are almost always embodied in written form; they often have built-in dispute resolution mechanisms such as international arbitration; and they only bind signatories” (Goldsmith and Posner 1998, p.4).

As argued by Arce and Sandler (2001), in the environmental field, international cooperation has mainly developed in the form of international alliances or treaties. The most important among them is the Kyoto Protocol. The following section shortly describes the political and legal pathway that has led to the entry into force of this

[7] American Law Institute, Restatement of the Foreign Relations Law of the United States § 102 (2) (1987)

international environmental treaty. Although this thesis does not intend to analyse the Kyoto Protocol exhaustively, describing its content, limits and opportunities can be useful to introduce the ETS: the flexible mechanism foreseen by the Kyoto Protocol itself and established in Europe to facilitate compliance with an emissions reduction target.

7. The Pathway toward the Kyoto Protocol

The United Nations Conference on the Human Environment held in Stockholm in 1972 is widely considered one of the first crucial turning points in the development of international environmental law and politics (Munari and Di Pepe 2006). The Conference agreed upon the first international declaration of 26 principles concerning the protection of the environment and the preservation of its resources.[8] On that occasion, the problem of global warming was not officially recognized as a central environmental issue yet; instead, the first significant step to curb climate change was made twenty years later during the United Nations Conference on Environment and Development, also known as the Earth Summit, held in Rio de Janeiro in 1992. On that occasion, the 154 participating Parties agreed upon the Rio Declaration on Environment and Development. Among the 27 principles which form the Rio Declaration, it is important—for the purposes of this thesis— to recall principle 16, widely known as the *polluter pays principle*. According to this principle "[n]ational authorities should endeavor to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment."[9]

During the Earth Summit, the United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature. This environmental treaty, which provides the foundation for international efforts to address the problem of global warming, came into force on 21 March 1994. As declared in art. 2 of the Convention, "the ultimate objective of this Convention […] is to achieve […] the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." Despite the fact that

[8] Declaration of the United Nations Conference on the Human Environment, 1972

[9] Chapter 6 will develop a comparative analysis of the two alternative allocation criteria within the ETS according to an efficiency and an equity interpretation of the Polluter-Pays Principle.

this level was not quantified, art. 2 of the Convention continues declaring that it "should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." Art. 3 specifies the principles that should guide the Parties to implement the provisions of the Convention. Among them, we mention the so-called "precautionary principle" according to which "the Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects." According to the precautionary principle, lack of scientific certainty should not be used as a reason to postpone measures aimed at preventing threats of irreversible damage. It has been argued that this principle is economically grounded (Bohringer 2003). In fact, given the large scientific and economic uncertainties concerning climate change and the risk of extreme and irreversible costly events, risk-aversion favours the adoption of the precautionary principle. Gollier et al. (2000) determine which conditions of scientific uncertainty call for immediate measures. The Convention specifies also that the measures to deal with climate change according to the precautionary principle should be cost-effective so as to ensure the stabilization of greenhouse gases at the lowest possible cost. Accordingly, we will analyse to what extent the ETS—the economic and legal instrument implemented in Europe—can be considered a cost-effective measure to reach the European emissions reduction target at the lowest possible cost.

It is important to mention also the "common but differentiated responsibilities" principle of the Convention according to which "the Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities." According to this principle, while all the Parties who ratified, accepted or approved the treaty are subject to a set of commitments aimed at responding to climate change, such obligations are differentiated among developing and industrialized countries, the latter of which are called to take the lead in combating climate change. For this purpose, the UNFCCC has divided the Parties in two groups. The so-called Annex I Parties are those industrialized countries which have been accumulating GHGs in the past decades and those economies in transition which are members of the OECD. The emissions per-capita of Annex I Parties are higher than those of most developing countries; therefore, as stated in the UNFCCC rulebook “the principles of equity and ‘common and differentiated responsibilities’ […] require these Parties to take the lead in modifying longer-term trends in emissions” (UNFCCC 2002). The second group, called non-Annex I, includes most developing countries that did not contribute to global warming. While non-Annex I Parties are not expected to take the same measures as Annex I countries to de-carbonize their economy, the Convention requires them to take steps to reduce emissions and to report in more general terms on their actions to address climate change.

While “taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances,” Art. 4 of the Convention establishes the commitments that all the Annex I and non-Annex I Parties have to perform. Among these commitments the Parties have to “develop, periodically update, publish and make available to the Conference of the Parties […] national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases.”

Art. 7 of the Convention establishes the Conference of the Parties (COP), the supreme body of the UNFCCC. The COP has the duty “to keep under regular review the implementation of the Convention […] and shall make, within its mandate, the decisions necessary to promote the decisions necessary to promote the effective implementation of the Convention.”

Since the commitments established in the Convention were not sufficient to seriously tackle climate change (UNFCCC 2002), art. 17 of the Convention establishes that the COP can, at any session, adopt protocols to the Convention. Already in the first COP meeting, which took place in Berlin in 1995, the Parties started to negotiate to decide on more detailed emissions reduction commitments for industrialized countries. After more than two years of negotiations, the Kyoto Protocol was finally adopted during the COP3, held in Kyoto on 11 December 1997.

8. The Content of the Kyoto Protocol

The Emissions Trading Scheme constitutes an example of the flexible economic mechanisms established in the Kyoto Protocol. Therefore, while this thesis does not intend to analyse and discuss exhaustively the Kyoto Protocol, it can be useful to shortly describe its content and the role of the flexible mechanisms. While sharing the objectives, institutions and principles of the Convention, the Kyoto Protocol commits

Annex I Parties to individual and quantified to limit or reduce their emissions. As established in the Convention, the specific emissions reduction targets apply only to the Parties of the Convention that have become also Parties to the Protocol. The Convention establishes also that the Parties to the Protocol shall be bound by the Protocol's Commitments only after it entered into force.

The Kyoto Protocol entered into force on February 16, 2005, more than seven years after its adoption. In fact, the Protocol's entry into force provision established that the Protocol could enter into force only 90 days after at least 55 Parties of the UNFCCC, representing at least 55% of the total amount of GHG emissions produced in 1990 by the Annex I countries, deposited their instruments of ratification, acceptance, approval or accession. This provision underlines the importance of involving those states responsible for global warming; in fact, without the Participation by Annex I countries in the Protocol, its environmental effectiveness would have been seriously compromised.

While the Convention adopted in 1992 failed to set clear targets for the abatement of greenhouse gas emissions (e.g. Bodansky 1993), the Parties adopting the Kyoto Protocol agreed on quantified emissions limitation and reduction obligations. In detail, the Protocol establishes the duty to reduce the emissions of six GHGs by at least 5.2% below the level of 1990 during the Kyoto 5-year commitment period 2008-2012. The six GHGs listed in Annex A are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro- fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The overall 5.2% emissions reduction target has been differentiated among the Parties according to their ability to reduce greenhouse gases and by considering the possible impact of such a reduction on their economies (Brown 2005). While Australia, Iceland and Norway have been permitted to raise their 1990 emissions levels (respectively 108%, 110% and 101%), other states were permitted to stabilize their emissions gases at the 1990 level (the Russian Federation, New Zealand, and Ukraine) and other countries had to limit their emissions below the 1990 levels. For instance, the former 15 MS of the European Union committed to overall reduce their emissions 8% below 1990 emissions level by 2012.

The Kyoto Protocol states that "Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments" and "Reductions in emissions that are additional to any that would occur in the absence of the certified project activity." However, the concepts of *supplementarity* and *additionality* of these mechanisms with respect to domestic actions were not sufficiently specified in the Protocol and were subsequently clarified during the seventh COP held in Marrakesh in 2001 where the Parties agreed upon the so-called "Marrakesh Accords",[10] which establish the modalities, guidelines and rules for participation in transactions under the flexible mechanisms.

One of the most important and innovative aspects of the Kyoto Protocol has been the introduction of flexible economic mechanisms that countries can adopt to comply with their emissions reduction commitments. The economic principle supporting these mechanisms is that emissions should be reduced where abatement can take place at the minimal marginal costs. In fact, as it is a global problem, climate change can be mitigated by reducing emissions, independently of where emissions abatement takes place. The main purpose of these mechanisms is to grant a certain degree of freedom and economic flexibility in deciding how to comply with their commitments; this is accomplished by recognizing that important efficiency gains can be earned by allowing to Annex I states the possibility to meet their obligations not just individually but jointly (Brown 2005).[11] The Protocol facilitates the concept of the "stabilization of greenhouse gases at the lowest possible cost" by providing for four innovative flexible mechanisms:

– *Joint implementation* (JI): the Kyoto Protocol gives Annex I Parties the possibility to receive emissions reduction credits (ERUs) in the case they finance trans-border emissions reduction investments in other Annex I countries. As stated in the art. 6 of the Protocol *"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 GHGs in any sector of the economy, provided that: […] [a]ny such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur."*
– *Clean Development Mechanisms* (CDM): Annex I countries can receive emissions reduction credits in the case that they finance emissions reduction projects in non-Annex I countries. The UNFCCC has the duty to certify that

[10] *Report of the Conference of the Parties on its Seventh Session, Held at Marrakesh from 29 October to 10 November 2001*, UN Doc. FCCC/CP/2001/13/Add.2 (vol II, January 21, 2002).
[11] The concept of joint implementation is included in the Framework Convention, arts. 3(3), 4(2)(a).

emissions reduction has taken place, giving a corresponding amount of credits that can be used by the investing country to comply with its emissions reduction target. CDM are similar to JI, but they have to take place in developing countries (non-Annex I Parties) in order to promote voluntary cooperation in achieving emissions reductions and to spur sustainable development. As stated in art. 12 of the Protocol: *"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 Art. 3"*.

– *Emissions Trading*: art. 17 allows the ratifying Parties to trade the rights to emit CO_2. Keeping the overall emissions reduction target fixed, countries which have abated more than their target can sell their surplus of abated emissions to other countries, giving them the possibility to comply with their emissions reduction targets.
– *Bubbling*: the Parties can renegotiate and distribute their emissions commitments, keeping the overall emissions reduction target (art.4). The EU applied this mechanism by sharing its target with the European MS. The notification of the *European Burden Sharing Agreement* ensures that the European Member States are legally bound to specific national emissions reduction targets agreed under the burden sharing instead of the official European target established in the Protocol (COM 1999: 230). Also the sub-division of the EU common target among different countries has been done in line with the principle of "common and differentiated responsibilities" by taking into account both the emissions per-capita and the expected economic growth (emissions per GDP).

Table 2 - Kyoto targets and emissions per-capita and per GDP

Countries	Target
Austria	-13%
Belgium	-7.5%
Denmark	-21%
Finland	0%
France	0%
Germany	-21%
Greece	+25%
Ireland	+13%
Italy	-6.5%
Luxembourg	-28%
Netherlands	-6%
Portugal	+27%
U.K.	-12.5%
Spain	+15%
Sweden	+4%

Source: Burden Sharing Agreement

Although the Protocol imposes these obligations and possibilities on states, these can be passed on to industry in domestic legislation, as in the case of the Emissions Trading Scheme, which will be carefully analysed and discussed in the following chapters.

The introduction of international economic mechanisms to promote emissions reduction has been welcomed as a world-wide success. As reported by Carraro et al. (2009), "both the UNFCCC and the Kyoto Protocol have established numerous areas where international consensus has emerged or at least appears to be achievable" (p.2). Among them, we recall:

(1) differentiation; with this term the authors refer to the "principle of common and differentiated responsibilities," which has become part of treaty law under the UNFCCC after it- UNFCC entered into force.

(2) A comprehensive approach to all emission sources: the Kyoto Protocol has addressed the comprehensive approach to all emissions sources by including six greenhouse gases and the possibility to absorb them through "carbon sinks" (Carraro et al. 2009).

(3) flexibility and flexible mechanisms; that is, the importance of carbon or emissions markets.

On an economic front the most important success of the Kyoto consists in the introduction of flexible mechanisms that are likely to promote effective emissions reductions minimizing the cost of compliance. Grubb (2000) identifies different dimensions of flexibility that characterize the Kyoto Protocol. Among them, we recall:

How flexibility: the Kyoto Protocol has designed a number of flexible mechanisms that give ratifying Countries a high degree of freedom to choose the most effective way to comply with the target: either making internal abatements or buying rights to emit. Different economic models have shown that without the introduction of flexible mechanisms which allow other means of compliance than domestic abatement, the cost deriving from the Kyoto Protocol would sharply increase.

Table 3 – Estimated costs of achieving the Kyoto target from various economic models

Model	**Marginal cost of target achieved domestically $/ton**			**% GDP loss with domestic implementation**	**% GDP loss with full trading**
	US	Europe	Japan		
SGM	163			0.4%	0.25%
MERGE	274			1%	"Decline Significantly"
G-Cubed	63	167	252	0.3 – 1.4%	
POLES	82	130-140	240	0.2 – 0.3%	0.3%
GTEM	375	773	751	0.7 – 2%	
WorldScan	38	78	87	-	
Green	149	196	77	0.4 – 0.9%	0.1-0.5%
AIM	166	214	253	<0.5%	

Source: Grubb 2000

Despite the fact that estimates strongly diverge among different economic models, and in some cases the different assumptions and welfare measures make these results not directly comparable, all the models nevertheless agree in sign (if not in size) showing that the GDP loss deriving from the Kyoto emissions reduction target declines significantly when the possibility of trading is added on top of the option of domestic abatement.

Where flexibility: dealing with a global problem, its resolution requires emissions to be abated no matter where abatement takes place, and the Kyoto Protocol identifies some flexible mechanisms that can promote emissions reduction in developing countries. Many economists and political scientists have stressed the importance and the effectiveness of the gradual and dynamic institutional approach that characterizes the Protocol. The initial top-down imposition of an emissions reduction target to developing countries would not have favoured international cooperation, since developing countries could have counted on valid argumentations supporting their refusal to commit to stringent emissions reduction targets. In the light of these considerations, developing countries have been first actively involved in the negotiation in order to become familiar with the hot issue without any duty or obligation. In a second step, in spite of the lack of any mandatory abatement target, they have been involved in the emissions reduction process through the development of voluntary projects. Economic instruments such as CDM can contribute substantially to the target achievement by facilitating the negative externality's internalization by promoting cost-effective emissions reduction projects in developing countries and by overcoming the political inertia in approaching environmental issue at a global level. The CDM has been generally considered a useful and effective international mechanism to induce the achievement of short term goals. [12]

Finally, it is worth mentioning that, in spite of these innovative flexible mechanisms which have been introduced by the Kyoto Protocol, a wide number of opponents have described the Kyoto Protocol as a "deeply flawed agreement that manages to be both economically inefficient and politically impractical" (McKibbin and Wilcoxen 2002, p. 107). The major criticisms of the Kyoto Protocol regard its failure to induce collective action against global warming: developing countries are not committed to any emissions reduction targets and the US did not ratify the Protocol. In fact, in 1997 the US Senate approved unanimously the Byrd-Hagel resolution according to which the US would have ratified the Protocol only under the condition of a "meaningful" participation of developing countries. Considering that developing countries are likely to cover more than half of global emissions before 2020, their participation in a

[12] Concerning the CDM Pizer commented that "there is an unusual alliance of support for project-based crediting in developing countries: Environmental advocates see this as maintaining environmental integrity, businesses see this as a cheaper alternative to domestic compliance, brokers and dealmakers see profit opportunities, developing countries see foreign aid, and industrialized country governments see opportunities to complement domestic mitigation. Given the inevitable need to channel mitigation resources from industrialized to developing countries, more thought should be given to how these mechanisms can be expanded and improved" (Pizer, 2005, pg.2).

collective action against climate change has been considered essential to address the climate change problem effectively and efficiently (Olmstead and Stavins 2006).
Although this thesis does not intend to assess the efficiency of the Kyoto Protocol, it has been crucial to underline from the very beginning the unilateral nature of the European climate policy, which is aimed at achieving a stringent emissions reduction target in an asymmetric geo-political scenario. In fact, despite the fact that the European asymmetric emissions reduction target is taken as a given, as chapter 7 will discuss, the effectiveness of the ETS itself risks being jeopardized by the unilateral and asymmetric nature of the European climate policy.

9. Conclusions

This chapter has shortly reviewed the scientific and economic debate on climate change, and it has described the political and legal process that has brought about the entry into force of the Kyoto Protocol and the adoption of its flexible mechanisms. First, the chapter has introduced the problem of climate change, by clarifying what is meant with the term “global warming” and by identifying its historical anthropogenic causes and its possible and uncertain natural consequences. Then, we have briefly reviewed different approaches that economists have adopted to assess the optimal level of emissions reduction by balancing the costs and benefits of global warming against the costs and benefits of its mitigation. Different results have been reached depending on how scientific uncertainties and economic costs are taken into account and discounted. We have highlighted the different assumptions, methodologies and contrasting results without pretending to assess which are the most reliable. Afterwards, the economic concepts of *negative externality* and *public good* have been introduced, and the problems that have to be faced when the public good to be preserved and the externality to be internalized are *transnational or global* in nature have been summarized. Some of these problems are linked to the global and uncertain nature of climate change itself. In fact, effective international cooperation requires the participation of a high number of asymmetric countries which are called to bear certain costs against uncertain future benefits. We have shown that, in spite of these shortcomings, important steps have been taken at an international level to mitigate climate change. Section 7 has described the political and juridical pathway that has brought to the entry into force of the Kyoto Protocol, the first international treaty aimed at stabilizing the emissions of GHG at a safety level. Finally, section 8 has introduced the content of the Kyoto Protocol, the emissions reduction targets and the flexible mechanisms established to reach them. This part did not intend to draw any conclusions about the efficiency of the emissions reduction targets established in the Kyoto Protocol, or about the efficiency of the Kyoto Protocol itself; nevertheless, such issues were required to introduce the European ETS economic mechanism. Moreover, given that the Kyoto Protocol *de facto* does not impose any emissions reduction commitment on the US and on developing countries (Carraro et al. 2009), this chapter has underlined the unilateral nature of the European climate policy, which is aimed at achieving a stringent emissions reduction target in an asymmetric geo-political scenario. In fact, the effectiveness of the ETS itself risks being jeopardized by the unilateral and asymmetric nature of the European climate policy.

Chapter 3. Toward a Cap and Trade Scheme Solution: Economic and Legal Instruments to Address the Problem of Externality

1. Introduction

Until some decades ago the market institution and its competitive mechanisms have been considered one of the main causes of environmental pollution and degradation, rather than a potentially efficient solution to these problems. Economic growth brings about an increasing pollution of the environment and exploitation of exhaustible natural resources. In particular, the combustion of fossil fuels—mainly oil, gas and coal—is at the base of the economic activities of energy and industrial production, as well as transportation. These fuels end are the major cause of the release of GHGs in the atmosphere. In the past decades, an increasing scientific consensus has emerged in recognizing the anthropogenic causes of the change in climate conditions. The so-called global warming can be considered an external cost of the human activity of production (and consumption) which causes damage and economic losses to third parties spread in time and space who are not likely to be compensated by the polluters. Climate change and global warming have been indicated as the "greatest and widest-ranging market failure ever seen" (Stern et al. 2006).

Unless legal systems introduce specific rules aimed at ensuring an optimal internalization of the costs of pollution within the market, global warming will continue to be a neglected cost that producers and consumers are not required to take into account when performing their activities. As far as private polluters are not required to support the costs of emitting GHGs in the atmosphere, climate changing activities will continue until the private marginal benefits of production and pollution are positive, resulting in a socially inefficient outcome where the marginal private costs of production are not aligned with the marginal social costs and where part of the private costs have to be borne by the society as a whole.

It was Garret Hardin's seminal 1968 art. that argued that when a public resource is freely available to everybody, in the absence of any property rule, each individual will have an incentive to use the resource to maximize its private utility, resulting in a collective over-exploitation and destruction of the resource:

> *Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destruction toward which all men rush, each pursuing his own best interests in a society*

that believes in the freedom of the commons. Freedom of the commons brings ruin to all. (Hardin 1968, p. 1244)

Common goods are likely to experience an over-exploitation of the resource in the short run and an under-investment in its protection and development in the long run. The probability of this tragedy occurring increases as the number of agents who can freely access the resource increases as well because of higher coordination and transaction costs among the parties. The concept of externality and the main arguments that explain the tragedy of the Commons can be easily applied to the case of climate change: the atmosphere has been considered a common and inexhaustible public good whose consumption is neither rival nor excludable. However, the recent increasing relevance in public opinion and in the political debate on the problem of global warming and on the potential risks it might pose to human kind is deepening the awareness that the atmosphere is becoming a scarce good that has been overexploited by self-interested private economic activities, whose protection will be undersupplied by free and unregulated markets.

In this sense, environmental protection can be thought of as a *luxury good:* in the last decades more developed countries have been experiencing an increasing social demand for environmental protection. However, there are not sufficient profit opportunities inducing private economic agents to provide voluntarily the social optimal level of environmental protection. Such an outcome can be considered a market failure: market forces do not spontaneously serve the perceived public interest. As a consequence, public authorities have to intervene with tailored legal instruments aimed at correcting this market failure and ensuring an optimal level of environmental protection. In fact, the Law & Economics approach has developed the principle according to which the law should pursue the public interest in an efficient way, minimizing the social costs of intervention. This increasing awareness has induced more and more States to develop and adopt environmental policies aimed at internalizing the costs of pollution which have differed across countries and years.

Once an optimal goal has been assessed, it becomes necessary to identify the most efficient and cost-effective instrument to reach it at the minimal social costs. In fact, it is possible to think about a legal system as being composed of different branches of law or legal rules which potentially compete by offering different solutions to the problem of environmental externality.

During the last decades, the Law & Economics literature has developed a broad comparative analysis of these legal instruments. The general conclusion that can be reached is that none of these legal rules can be considered *a priori* a first-best solution. The more desirable form of governance which can ensure an optimal externality internalization at the lowest costs needs to be evaluated case by case according to variables that have to be taken into account. That is, depending on different factors that are illustrated in the next sections, one legal rule can be preferred to the other, and, in general, different rules can be either substitute or complementary solutions.

Although this research focuses on the mechanism of Cap and Trade, as it has been implemented by the European legislation in the form of the Emissions Trading Scheme, and therefore is not aimed at bringing an exhaustive comparative analysis of the different competing legal solutions, this chapter intends to develop a taxonomic summary of legal rules and economic instruments that can potentially address the problem of environmental externalities, and in particular the problem of climate change. The aim of this chapter is to highlight the properties and the related advantages and disadvantages that characterize the most important legal rules that have been adopted so far in the field of environmental law. This will be done in order to explain why, among them, the cap and trade system has been chosen within the European legislation as the principal legal and economic instrument to induce a reduction of emissions in a cost-effective way.

The second section presents a taxonomy of the legal and economic instruments aimed at internalizing the external costs of pollution. These competing legal instruments can be classified according to different criteria: the time they intervene, which can be before or after damage has occurred (section 2.1); the extent to which they are economically incentive driven, a variable which depends on both the degree of interventionism and on the degree of flexibility left to the polluter in deciding how to internalize the environmental externalities (section 2.2); and whether they intervene within the market and through the market (section 2.3). The following sections analyse in more detail the different instruments presented in the taxonomy by focusing on their advantages and weaknesses in order to evaluate if they can be tailored to address the problem of climate change. Section 3 introduces liability rules, explaining in which cases a strict liability regime should be preferred to a negligence rule, and vice-versa. According to these argumentations, the section concludes that an ex-pot type of intervention through the legal instrument of liability is not suitable to mitigate the problem of climate change. After describing the features and shortcomings of an ex-post type of legal intervention through private law and liability rules in the field of climate change, the chapter proceeds to describe the different types of environmental public law based on a ex-ante intervention. Section 4 introduces the Command and Control type of direct regulation, explaining the relative weaknesses and the conditions that need to be satisfied in order to be an efficient and cost-effective form of regulation. After explaining why Command and Control is not suitable to address the problem of climate change, section 5 moves on to describe the passage to softer types of direct regulation—the so-called marked-based instruments. In particular, it describes the case of Pigouvian tax, highlighting its properties and relative advantages compared to Command and Control. Section 6 analyses the cap and trade solution, which according to the Coase theorem can induce an optimal internalization of the costs of pollution by assigning the rights to pollute and leaving the regulated agents free to bargain.

Section 7 offers a comparative analysis of the two market-based instruments of taxes and cap and trade. This section is aimed at explaining why in many circumstances, and in particular in Europe, the instrument of tradable permits has been preferred to other forms of regulation, and to a tax system in particular. First, the economic literature has found that, under uncertainty, the shape of the marginal cost and benefit functions, jointly with the time horizon of the regulatory policy, are important variables to be considered in the comparative analysis of prices and quantities types of instruments. In addition and in the context of climate change, the desirability of one economic instrument over the other depends also on its capacity to promote international cooperation to fight global warming and to guarantee national sovereignty over politically strategic issues (section 7.1). Moreover, in spite of being equally efficient, a cap and trade scheme where allowances are initially assigned for free, entails different distributive effects than taxes, and thus, according to the political economy approach toward regulation, private parties tend to prefer cap and trade schemes over taxes and tend to lobby for this form of regulation (section 7.2). These considerations are not exhaustive, but they should be sufficient in explaining why a cap and trade system where allowances have been initially allocated for free on the basis of the historical emissions has been preferred to both the alternatives of a carbon tax system and of a cap and trade system where allowances are auctioned. Section 8 concludes.

2. A Taxonomy of Legal and Economic Instruments Aimed at Internalizing Externalities

The following sections present a taxonomy of the legal instruments developed in the field of environmental law in order to achieve the target of optimal internalization of the pollution externality at the lowest cost. According to their relative advantages and disadvantages, it becomes important to analyse how much these competing legal options can be tailored to address the problem of climate change, where the emissions reduction target is taken as a given and its economic foundations are not questioned.

2.1 *Ex-Ante* and *Ex-Post* Legal Instruments

The first distinction that can be made among different legal and economic instruments is between rules belonging to the branches of private law and public law. Private law, in the form of liability rules, intervenes *ex-post* after damage has occurred. In this case, polluters are free to engage in their activity without any kind of *ex-ante* restriction. Yet in the case that the activity causes damage, then the courts force the polluter to pay compensation to the victim. In this case the ex-post compensation gives the polluter a indirect deterrent incentive to improve the level of care in its productive activity. An alternative way of dealing with the problem of environmental externality is to intervene *ex-ante* through public law. The public law instruments can take different forms—from direct regulation to more market oriented instruments like taxes—and are aimed at influencing the behaviour of the polluter ex-ante according to a proper cost-benefit analysis. This cost-benefit analysis should be performed by the more informed party who can assess and balance costs and benefits at the lowest cost. It is therefore important to adopt the legal rule that allocates the duty of developing a cost-benefit analysis to the more informed party.

2.2 Non-Economic and Economic Instruments

Another distinction that can be made among the different legal rules aimed at internalizing the costs of pollution is between non-economic and economic instruments. The field of non-economic instruments includes the command and control type of regulation. In this case no direct economic incentive is provided to the polluter to induce him or her to adopt the socially desired behaviour. The central role is given to the regulator who first has to collect the required information to assess a cost-benefit analysis of pollution reduction, and then has to set some standards accordingly, like technological or performance benchmarks, that specify ex-ante how the polluter has to behave. After “commanding” the regulated agents to behave in a certain way, the public authority has also the duty to monitor and ensure that the regulated agents’ economic activity is in compliance with the imposed rule or standard. In the case they do not comply, either an administrative or criminal sanction can be applied. In some sense, the enforcement of sanctions in the case of non-compliance gives an ex-post economic incentive to comply with the regulation ex-ante by adopting the specified standard. However, they cannot be considered proper economic instruments, as they have been defined by the relevant literature.

According to Oates (1990), while with a command and control type of regulation the authority specifies how the regulated agent should behave in order to reach the socially desired target, with the adoption of economic instruments the authority limits its role to the definition of some incentives aimed at reaching the desired target. This is done while at the same time leaving the regulated agents free to decide how to behave in reaction to these incentives. Economic instruments are mainly characterized by two aspects: first, they are more flexible than the standard command and control rules, and, second, they are designed to facilitate the indirect alignment of private and social goals through a system of incentives. While the environmental targets are defined ex-ante, these mechanisms mainly leave the regulated subjects free to evaluate which is the more convenient way to reach them. It is interesting to highlight that the free market mechanisms, that have been considered responsible for the environmental externality, nowadays have bee identified as the most efficient way to solve this problem. In fact, given that the collective and free use of the environment is increasingly creating a problem of scarcity, its protection can be achieved by attaching a price to its use. This price is aimed at rationing the exploitation of the environment. This kind of mechanism is perfectly tailored to comply with one of the most important environmental legal principles according to which the polluter should bear the cost of the pollution he or she generates. Indeed, market-based instruments attach—more or less directly—a price to the consumption of the environment that the regulated agents have to pay in order to pollute. These mechanisms have been criticized for being neither educative nor morally correct (Frey 1997) since they give the polluter the legally recognized possibility to buy the right to pollute: as long as polluters pay for the pollution they generate, they are allowed to pollute and to behave in the way they find most convenient. Market-based instruments can be either price-based (i.e., indicating the imposition of tax or subsidies) or quantity-based (i.e., the system of cap and trade). In the latter case, the price paid to pollute derives indirectly from the interaction of the demand supply functions in a trading scheme under the constraint of a quantity restriction (i.e., a cap to the emissions that can be produced). Since private agents usually are more informed about production and abatement costs and benefits than the regulator is, market-based instruments are designed in a way that induces the private agents to reveal their private information. In this sense, market-based instruments "exploit the capability of markets to aggregate information" (Hepburn 2006, p. 228).

All these economic and non-economic instruments can be ordered according to the degree of direct intervention (Ogus 1994)—from the less interventionist ones, for instance, rules which impose some disclosure of information, to the most interventionist ones like the ex-ante assignment of licenses. However, within this classification it is not always possible to draw a clear dividing line among instruments according to the taxonomy that has been presented, at least from an economic perspective.

First, the market-based instruments imply a soft form of regulation characterized by an ex-ante collection of information on behalf of the regulator in order to design the legal instrument, as in the case of a direct command a control type of regulation. Moreover, once the market-based instruments have been established, their implementation entails a form of ex-post control and sanctioning enforcement mechanism in case of non-compliance by the regulated sectors. It can be argued that all the legal instruments entail a form of economic incentive with different degrees of flexibility that are left to the regulated agents. From this perspective, there is not necessarily an exclusive equivalence between the *ex-ante* form of intervention through public law and what is meant by the concept of economic instrument. On the one hand, it has been sustained that the more strengthening forms of command and control types of regulation are not economic at all since they do not leave any degree of flexibility to the regulated subjects. On the other hand, the liability rules, which intervene ex-post in the field of private law and which are not considered an economic instrument by the traditional legal literature, could be considered to a certain extent economic instruments. This consideration is based upon the fact that they do not impose any strict requirement; quite the contrary, the imposition of ex-post damage compensation increases the cost of pollution, thus creating an economic incentive to reduce it, and at the same time it leaves the polluter a high degree freedom and flexibility in deciding how to behave (Faure 2008).

2.3 Within the Market and through the Market Instruments

It has been shown that the instruments aimed at protecting the environment can be distinguished depending on the time they are implemented. This distinction is made in order to induce the polluter to internalize the external costs of pollution: ex-ante public law regulation, which imposes a cost to the polluter before damage has occurred, or ex-post private law and liability rules, which forces the polluter to compensate the victim for the harm inflicted after the damage has occurred. Moreover, the different legal devices can be classified depending on how much they are economically incentive-driven, a variable which depends both on the degree of interventionism and the degree of flexibility left to the polluter in deciding how to internalize the environmental externalities. Finally, it is possible to make a distinction between environmental protection and the internalization of the costs of pollution *within the market* and *through the market* (Clarich 2007).

In the first case, it is the market itself that spontaneously develops private instruments within the market aimed at satisfying the increasing demand for environmental protection or at anticipating the development of any kind of environmental protection measure. It is in the case of self-regulation where the market agents decide to publicly certify the compliance with quality standards that are more stringent than those defined in the legal system. Alternatively, in other cases, private agents facing a higher risk of environmental damage liability may decide to insure themselves against such a risk. This private solution can provide an indirect form of environmental protection: the insurer, who has to bear the cost of the potential environmental damage, has an incentive to control the polluter and to verify whether he or she has adopted all the measures required to minimize the risk of a harmful environmental accident. On the other hand, it is in the private interest of the ensured parties to improve the environmental safety standard which can eventually lead to a reduction of the risk premium they have to pay. The second case, where the environment is protected through the market, has already been introduced as it consists of the establishment of flexible economic mechanisms aimed at giving the polluters market incentives to reduce their polluting activity. In this case, the strategy that maximizes the producer's own profit is at the same time the action that ensures a reduction of the environmental damage.

Another distinction can be made between the type of public regulations that intervenes on the side of the demand within the existing markets with the explicit purpose of correcting their partial failures and the other type of public intervention that is aimed at creating a new form of demand through the establishment of new and artificial markets. In the first category it is possible to mention the example of the public administrations, which—in addition to being direct regulators—are also important consumers who have the faculty of re-orienting the demand toward environmentally friendly services and goods by including specific environmental standards that have to be satisfied in order to win the public contracts. The Cap and Trade system and the Emissions Trading System, in particular, are examples of artificial markets, and they constitute the core of this research. This system will be analysed in detail in the next chapters.

After presenting a taxonomy of the legal and economic instruments aimed at internalizing the cost of environmental externalities, the next sections analyse these instruments in greater detail highlighting the related advantages and disadvantages in order to understand under which circumstances they are suitable to be adopted to mitigate the change of climate conditions in a cost-effective way.

3. Liability Rules

The economic analysis of law is based on the basic idea that legal rules should promote economic efficiency and lead to an optimal social equilibrium by providing efficient incentives to the parties who interact in the society. The parties who interact in the context where liability rules can be applied are at least two: a potential injurer whose harmful activity risks inflicting damage on a potential victim. There are two costs that the law should minimize in a such a case: on one hand, the cost of the damage caused by the harmful activity; on the other hand, the costs of practicing the appropriate amount of precaution in order to prevent the damage from occurring. In fact, when performing a potentially harmful activity, as the level of precaution increases, the risk of causing damage decreases. Yet, there is also to consider that the costs of precaution increase as well.

According to Calabresi (1970), the principal function of law is to ensure an optimal level of precaution to the point where the marginal cost of exercising precaution equals the related marginal benefit. Thus, the law should favour an optimal equilibrium where the social costs of accidents are minimized by adopting a legal rule offering the best incentives to take an optimal level of precaution. This precautionary level should be such that it minimizes the sum of the costs of the expected accidents and the costs of avoiding the accidents. In general, three variables should be considered when deciding the more appropriate rule of law to be applied: the costs related to the number of accidents, which can be thought of as proportional to the level of activity; the costs related to the entity of the damage, which depend on the level of precaution; and finally the administrative costs related to the legal rule which has been adopted and the number of court cases in which it could result.

After having determined the variables that need to be balanced in order to identify the optimal equilibrium, it becomes necessary to determine which legal rule can induce the private agents to achieve this optimal outcome at the lowest cost. The emergence of an environmental liability regime is aimed at granting an optimal level of precaution by pursuing two interrelated goals: compensating the victim for the damage caused by the polluting activity and deterring the polluter from performing inefficient activities in order to avoid the pollution that is not cost-justified (where the marginal costs of pollution exceed the marginal benefits). While lawyers tend to stress the compensation goal of accident law, thus focusing the attention on the injured parties, economists tend to attach greater importance to the deterrent function of a liability rule, thus mainly taking into account the role of the potential polluter and the need to provide them with appropriate incentives.

Of course, these policy goals are interrelated and tend to combine an ex-post vision of the law, which grants compensation to the victim after the accident has occurred, with an ex-ante role of the law aimed at deterring socially undesirable activities.

As it has been previously argued, the perspective under which a liability rule is analysed by the Law & Economics approach tends to stress its market oriented approach (e.g. Faure 2008). In fact, under a liability regime, the polluters are either required to take a pre-defined level of precaution or to grant compensation in the case that damage occurs, but the law does not force the polluters to take precise measures aimed at reducing pollution and the risk of accidents. Polluters remain free to decide how to behave as long as they comply with the environmental principle according to which they should bear the cost of pollution, in this case paying damages to the victim.

The legislator can apply two different liability rules: strict liability and the negligence rule. According to strict liability, the injurer has always to compensate the victim for the damage inflicted and independently of the level of precaution he or she took when performing the activity. Under a negligence rule, when an accident occurs the injurer has to compensate the victim only if the damage has resulted from an activity performed with an insufficient level of precaution.

The type of liability rule that can grant an optimal level of precaution, where the marginal cost of taking precaution equals the marginal benefit of reducing the probability of a damage, depends on the nature of the potential accident—whether it is a unilateral or a bilateral accident. We speak about a unilateral accident when the potential injured party cannot adapt his or her behaviour in order to influence the risk of the accident, while the probability of bilateral accident depends on, and can be influenced by, both the potential injurer and the potential victim’s behaviour.

The Law & Economics literature has reached the general conclusion that, while a negligence rule is more tailored to be applied in case of bilateral accidents, a strict liability rule is efficient only in the case of a unilateral accident. The explanation can be quite intuitive: a strict liability rule allocates all the risk of an accident to the tort-feasor, who in the case of a unilateral accident is also the only agent who can influence the probability of causing the accident. On the contrary, a negligence rule spreads the risk and the costs of the accident between the injurer and the victim; therefore, it should be applied in the case of bilateral accidents where the behaviour of both the involved parties can influence the risk, the cost and the probability of the accident.

Negligence rule and strict liability differ not only in the conditions under which the injurer is required to compensate the victim in the case of an accident, but also in the manner by which they allocate the duty of performing a cost-benefit analysis to different parties. Under a strict liability regime, the cost-benefit analysis is performed directly by the potential injurer who balances internally the costs he or she should afford when taking precaution with the probability of incurring harmful damage and of paying the costs of the victim’s compensation. In this case of unilateral accident, strict liability is an efficient rule because it allocates the duty to balance costs and benefits to the most informed party. In fact, the potential injurer is the only agent who can influence the probability and the amount of the damage; hence, he or she knows better than any other the costs of taking precaution and the costs of the damage. Under a strict liability regime, the court does not have to set any standard. Nor does it have to assess any cost-benefit analysis since the injurer is always liable (lower information cost). It does, however, have to determine the relation of causality between the damage and the dangerous activity performed by the polluter, which could involve substantial costs as the number of court cases increases (Shavell 1980).

The information costs sustained by the public institutions increase substantially in the case of negligence rule, which is more suitable for bilateral accidents. Bilateral accidents are an example of interdependent choices since the probability of the accident depends on the level of precaution taken by both the potential injurer and injured party. In order to define what optimal incentives to the parties are, the law must take into account this aspect of interdependent strategies and choices: normally, by giving a direct incentive to one party there arises the risk of creating an indirect disincentive to the other party. For instance, by making the potential injurer strictly liable in the case of bilateral accidents, the law would not give the potential victim any incentive to take some level of precaution. A strict liability rule would exacerbate, rather than balance, this trade-off, by inducing the potential injurer to take an excessive level of precaution (over-deterrence) while at the same time giving an incentive to the potential victim to take an insufficient level of precaution (under-deterrence). The risks and the costs would not be allocated efficiently, and the level of precaution generated by a strict liability applied to the case of bilateral accidents would not be optimal. On the contrary, a negligence rule is considered an effective mechanism to spread risks and costs among the two parties. The negligence rule entails higher administrative costs since the judge has to collect information and perform a cost-benefit analysis to determine directly the optimal level of precaution. Once this threshold has been officially defined, the negligence rule implies that, in the case that an accident occurs, the injurer will have to compensate the victim for the damage inflicted only if he or she took an insufficient level of precaution (lower than the threshold). While if the injurer is performing a dangerous activity in compliance with the negligence standard, then the costs of the accident will be borne by the victim who is not entitled to any compensation. Of course, differently from the strict liability, by granting only limited protection to the potential victim, the negligence rule provides incentives not only to the potential injurer but also to the potential victim to take some level of precaution. If the negligence standard is set by the regulator at an optimal level, also the level of precaution to be taken will be allocated between the two parties in an efficient way.

The negligence rule has also some side effects. First, while it creates incentives with respect to diligence in performing a potentially harmful activity, the negligence rule does not give any incentive regarding the frequency of the activity. The probability of an accident occurring depends on both the level of precaution and the frequency of performing the activity. However, under a negligence rule the potential injurer who takes an optimal level of precaution is free to perform the dangerous activity as many times as he or she wants without incurring any risk of being considered liable in the case that the accident occurs. Second, a negligence rule is efficient only if the judge has sufficient information to balance the costs and benefits in order to set the standard of precaution at an optimal level. Only in this case are the risks and the incentives to take precaution correctly allocated between the two parties. On the contrary, an official standard lower (or higher) than the optimal level of precaution will elicit under-deterrence (or over-deterrence) from the potential injurer and over-deterrence (or under-deterrence) from the potential victim. The third major point to be considered is that the negligence rule is efficient only if the judge is able to measure the level of precaution taken by the injurer and to compare it with the negligence standard defined ex-ante.

In the case of environmental pollution negligence cannot be an efficient rule. First, pollution represents a case of unilateral accident where the potential victim is not able to modify the risk of an accident through his or her own behaviour. Secondly, the legislator normally faces substantial information asymmetries impeding him or her from setting the negligence standard at an optimal level which in turn balances the marginal costs and benefits linked to the potentially harmful activity.

Moreover, it has been generally recognized that, although strict liability is superior to negligence in the cases of unilateral environmental pollution, also a strict liability regime would fail to be an efficient instrument to internalize the cost of pollution, particularly in the case of climate change. It has been shown that the main feature of a liability regime—whether strict liability or negligence—is to intervene ex-post or after damage has occurred and to require the polluter to compensate the victim. This mechanism in turn creates a deterrence effect. In particular, in the case of unilateral accident and under a rule of strict liability all the costs are shifted to the injurer. It is duty of the polluter, who is retained always liable, to perform a cost-benefit analysis aimed at defining the optimal level of care. This mechanism is effective if the judge is able to assess a causal relationship between the damage and the harmful activity performed by the polluter. In the case of climate change, this assessment risks constituting a *probatio diabolica*: the effects of climate change are uncertain and, moreover, they are spread in time and space, thus making it difficult to collect substantial evidence of the causal relationship between the damage incurred by the victim and the polluting activity of the potential injurer.

Other fundamental aspects make an ex-post kind of intervention a costly and hardly effective instrument to mitigate the risk of climate change. First, climate change is characterized by a multitude of potential injurers and by a plenitude of potential victims. Proving the causal link between the harmful activity and the damage becomes increasingly difficult as the number of potential victims and injurers increases. Second, climate change is characterized both by a long passage of time before the effects of releasing emissions in the atmosphere become visible and by wide-spread effects in space. Moreover, the risk of insolvency should be mentioned: climate change involves a high risk of destruction, and the potential damage results so high that the potential injurer would not be able to compensate the victim for it. Being that the feasible compensation is lower than the magnitude of the potential damage, an ex-post intervention would cause under-deterrence on the part of the polluter.

Given the features characterizing climate change, it is possible to conclude that ex-post intervention through a liability regime is not the most suitable legal instrument to promote an optimal internalization of the global warming externality. However, in spite of these shortcomings, it should also be mentioned that the last decades have experienced a rising number of liability claims against states responsible for global warming, showing that the application of a liability regime to the case of climate change is costly but not impossible (Faure and Nolkaemper 2007).

4. Command and Control Type of Regulation

The shortcomings that have been previously listed constitute a strong argument in favour of an ex-ante legal approach toward the problem of climate change. In fact, in addition to the ex-post liability regime developed in the field of private law, environmental law is characterized also by an ex-ante type of regulation which has been developed in the field of public law. In the particular case of climate change and GHGs emissions, whose risks have been recognized only recently, a type of ex-ante public legal regulation has been preferred instead of a private law liability regime, given the latter's shortcomings previously described.

Environmental public law was initially developed through a Command and Control type of regulation, for instance either by forbidding certain dangerous activities, by requiring some particular behaviour or by imposing some quality standards. As reflected in the name itself, this form of regulation is developed in the two following steps which both require the collection of a large amount of information on behalf of the regulator. First, the regulator has to perform a cost-benefit analysis in order to assess the optimal level of activity where the marginal costs of pollution are aligned with the respective marginal benefits. Among them the regulator should know the cost linked to the activity and the cost of the foregone activity; it should also know the cost of alternative technologies which can reduce the externality and the cost of the externality, determined by the difference between the marginal private and social cost functions. Moreover the authority has to know also the social benefits of the activity in order to assess the optimal level of pollution. The collection of all this information tends to be highly costly since private parties rarely find it convenient to disclose spontaneously the private information they have. To the contrary, private agents might be tempted to adopt a strategic behaviour by hiding their private information or revealing biased information that would favour their competitive position against potential competitors. Therefore, when applying Command and Control, the regulatory mechanism should be designed in order to give private agents an incentive to reveal their private information, and to reveal them correctly.

Moreover, not only should the information costs be considered to assess the desirability of this type of highly interventionist form of regulation, but also the administrative and enforcement costs, which are the costs of implementing the regulatory standard and of imposing sanctions in case of non-compliance after the regulation has been commanded. Thus, two necessary conditions for Command and

Control to work effectively are, first, an optimal standard ex-ante and, then, optimal enforcement ex-post through the application of optimal civil or penal sanctions. In fact, the polluter tends to balance the cost of investing required to comply with the imposed standard with the cost of incurring a sanction in the case of non-compliance weighted by the probability of being discovered; this probability decreases as the number of regulated agents increases.

The disadvantages of Command and Control have been extensively described by the economic literature (Kolstad et al. 1990). Its other major shortcomings lie in the fact that this form of regulation fails to give efficient incentives to invest in research to develop new technologies beyond the standard set by the regulator. Moreover the major criticism of Command and Control concerns its incapacity to induce an equalization of the marginal abatement costs among different polluters. In fact, standards cannot be specifically tailored to the regulated agents and they tend to be quite general. Due to these two qualities the standards fail to exploit the differences in abatement opportunities among private parties.

While the economic literature has mainly focused on the shortcomings and disadvantages of this strong form of interventionism and therefore been more in favour of a more market-oriented type of regulation, it is important to stress also the advantages of Command and Control. First, direct regulation promotes certainty in the market: agents know that as long as they comply with the standard they cannot be held liable (like in the case of negligence), and thus they receive clear information and incentives to undertake long-term investment in order to improve their technology. This condition is particularly important for the energy and industrial sectors which are characterized by long-term intensive investments. Moreover, it is important to highlight under which conditions Command and Control type of regulation results effective. Obviously, it can be effective when the cost of commanding and controlling are low enough, costs which implies a limited number of polluting sources to regulate. Moreover, the more homogeneous the regulated sectors are, the easier it is to equalize their abatement costs; thus, the second requirement for an effective regulation is determined by the low variability among the regulated sectors. Finally, in order to promote dynamic efficiency it should be possible to adapt and update the imposed standard whenever new information and technologies are available.

Stavins (2004) argues that when "costs are similar among sources, command-and-control instruments may perform equivalent to (or better than) market-based instruments, depending on transactions costs, administrative costs, possibilities for strategic behavior, political costs, and the nature of the pollutants" (p.9). Indeed, the literature has also reported empirical evidence of many cases where Command and Control has resulted in an effective type of regulation (Oates 1990).

An obvious case when Command and Control is the most effective form of regulation is when the marginal costs of a dangerous activity always exceed its marginal benefits, thus implying that this activity should be always forbidden. However it does not seem the case with climate change: obviously there are great benefits deriving from the industrial and energetic production. These benefits have to be balanced with the highly uncertain costs of releasing GHGs in the atmosphere.

5. From Command and Control to Market Based Incentives: the Case of Taxes

Only in the last decades has the theoretical and institutional debate tended to stress not only the market failure in granting an optimal level of environmental protection, but also the failures and deficiencies of public regulation. An excessive rigidity and uniformity of the rules create inefficiencies which fail to take into account different geographical and technological situations. Overly rigid regulatory constraints do not foster innovation and tend to protect the status quo. As will be discussed below, a large amount of literature of political economy has shown that the regulated sectors prefer to lobby for the imposition of a command and control regulation which tends to protect the competitiveness of the incumbent firms against the potential competition of new and more efficient entrants (Buchanan and Tullock 1975). In fact, the imposition of a direct form of regulation historically tended to put more costs on the new entrants, thus preserving the inefficient competitive position of the incumbent firms which are successful in their lobbying activity (Kehoane et al. 1996).

In the last two decades, the theoretical debate has moved toward the possibility of adopting more market-oriented types of regulation which are more flexible and thus able to grant an internalization of the costs of pollution at lower costs. The first instrument that can be adopted instead of Command and Control is a pollution tax, as it was formulated and presented by the English economist Arthur Pigou in 1920. While in the case of direct regulation, the authority has to perform a cost-benefit analysis in order to set the optimal standard, in this alternative scenario the regulator (only) has to collect the information necessary to set a tax equal to the negative externality, which is determined by the difference between social and private marginal costs. Thus, contrary to the previous case of Command and Control, the public authority does not have to collect any information concerning the benefits. Like in the Command and Control system, under the tax system the regulator has to build a system of ex-post control to safeguard against tax evasion which entails some costs. However, some economies of scope can be done with the existing national tax framework, implying lower administrative costs and a lower risk of tax evasion compared to the case of Command and Control.

Once the pollution tax is set, the duty to perform a cost-benefit analysis of pollution is shifted to the private agent, who is also the most informed party and thus in a better position to balance the benefits and costs of polluting. Differently from the previous case, the regulated sector does not face any strict constraint, and as long as he pays the environmental tax, he can produce and pollute without any limitation. Without the imposition of any taxes, the polluter will continue to produce (and to emit GHGs in the atmosphere) as long as its marginal benefits from pollution are greater than zero. Conversely, if a tax is set at a level which equals the cost of the externality, the regulated agent will produce and pollute up to the optimal equilibrium where the marginal costs (increased by the tax) and benefits of pollution are balanced and equalized.

Thus, differently from the Command and Control case, a Pigouvian tax gives the polluters an indirect incentive to reveal its private information about its benefits and strategies: once the tax is established, the private agent is called to decide between changing the technology, reducing the production or continuing to produce and to pay the tax. In general, while in the short run the imposition of a tax tends to cause a reduction of production and pollution up to the static efficient outcome, in the long term the tax gives an indirect incentive to invest in cleaner technologies with a lower carbon intensity, thus promoting also dynamic efficiency.

When the tax is set at an optimal level this soft form of regulation generates optimal deterrence: not all the externality is eliminated but just the inefficient externality above the point where the social marginal costs of production exceed the social marginal benefits. Moreover, when a tax is set at an optimal level, it can exploit the differences in abatement costs among the different tax payers, creating in the long run an equalization of the abatement costs that cannot be easily achieved by a Command and Control direct regulation.

The tax solution shows the trade-off between quantity and price: on one hand, the price to be paid is known and stable; the lack of price volatility is an important incentive that can help private agents to formulate long-term strategies aimed at investing in and developing less carbon-intensive technologies. On the other hand, the quantity of emissions that will be released in the atmosphere is not known and cannot be fixed. Under a tax system, the polluter can pollute as much as he or she wants as long as he or she continues to pay the tax, and the regulator cannot put a cap on the overall emissions level. Thus, in order to reach an efficient outcome it is crucial to set a tax that is proportional to the level of externality, and this process may be difficult.

First, it is possible that the cost of the externality is not fixed (i.e., private and social marginal costs vary at the same rate, so they are parallel functions with a fixed distance, that is the externality), but it can also vary at an increasing marginal rate. Both marginal production costs and the marginal cost of the externality can be increasing, but they can vary at different rates. For instance, as production increases both the marginal cost of producing and the marginal cost of emitting an extra-ton of GHG in the atmosphere increase; however, the latter can increase faster (or slower) than the former. In this case, the difference between the private and the social marginal cost function is not fixed but rather increases (decreases) as the level of production increases. In this case, the environmental pollution externality can be internalized efficiently only by applying a variable pollution tax. This tax should equal the increasing difference between the private and social marginal cost functions; however, such a tax is difficult to apply because of the prohibitive costs of detailed pollution data requirements. Fixed pollution taxes are more pragmatic and easier instruments to apply, but in this case they would constitute a second best solution as they fail to induce the internalization of the externality at an efficient level.

Another problem of the pollution tax is related to the question “what to tax?” In theory the tax should be proportional to the amount of GHGs released in the atmosphere, but this is a variable that is difficult to monitor on a small scale suggesting that it might be more convenient to link the tax at another variable that can be considered a proxy of the emissions. Since emissions derive mainly from the combustion of fossil fuels, one might tax directly the input at the top of the production process. This kind of substitute tax provides an indirect incentive to improve the technology: by introducing more efficient technologies, which can produce the same amount of output with a lower amount of input, the polluter has to pay less taxes and indirectly the amount of emissions produced decreases as well. However, this tax fails to provide any incentive to promote pure, less carbon-intensive technologies that present the same input/output ratio. For instance, some kind of emissions may be captured by installing a filter which entails some investment costs. In this case, the energy intensity and efficiency of the technology would not be strictly improved since the same amount of input would continue to be required in order to produce the same amount of output. In this case, the producer would continue to face the same tax burden in spite of the installation of the filter which would lower the plant carbon intensity (i.e., less emissions released per ton of production, or per ton of input). Other technologies, like the Carbon Capture and Storage can reduce the amount of emissions that is produced, but they require the employment of a higher amount of energy. This means that the technology carbon intensity improves, but its energy efficiency expressed by the input/output ratio would worsen (more input is required to produce the same amount of input) and the tax burden would increase despite emissions are reduced. In these cases, taxing just the input (i.e., fossil fuel tax) or taxing just the output (i.e., consumption tax) risk to not provide optimal incentives to develop pure, less carbon-intensive technologies.

Moreover, the enhancement of dynamic efficiency requires the adaptation of the tax rate after the introduction of new technologies that can reduce the rate at which the pollution externality changes at the margin. If a new technology which abates the marginal social costs of pollution is introduced and the regulator continues to impose the old tax rate which is referred to as the old marginal social cost, it would result in an inefficient equilibrium where the externality is reduced to a level where the marginal cost of abatement exceeds the marginal social benefit. Conversely, if the tax rate is not adapted and the regulated agents know it, no incentive is provided to develop this kind of technology.

Like in the previous cases, the imposition of an efficient tax requires some information that might be difficult to collect. Thus it becomes difficult to impose an optimal tax, and there is the risk of inducing over or under-deterrence. However, it could be argued that the first goal of a Pigouvian tax is to establish a system aimed at reducing the market failure in a context where externalities are difficult to assess with precision. Under this perspective, taxes do not have to be perfect, but they can be thought of as a second best solution; such a solution is aimed at providing incentives to improve production and consumption in order to reduce the market failure and grant higher environmental protection. According to the environmental principle of prevention (i.e., preventing environmental danger rather than reacting to environmental harm that already has taken place) and to the principle of precaution (which states that in front of an environmental risk the lack of scientific certainty and consensus about the possible consequences is not sufficient to postpone intervention aimed at lowering that risk), it might be more effective to move to a second best solution by applying an imperfect tax rather than doing nothing until an optimal tax is determined with certainty.

6. From Pigouvian Taxes to a Coasian Cap and Trading Solution

While the Pigouvian tax is considered a price solution to the problem of the externality, the establishment of an artificial market of emissions property rights is considered a "symmetric" quantity solution. Dales (1968) can be considered the founding father of the tradable emissions rights scheme, but his work can be traced back to the property rights school in economics, according to which externalities are a consequence of a lack of property rights and can be avoided through the establishment of a system aimed at creating and protecting property rights (Demsetz 1967). In addition, it would not be too ambitious to assert that the idea of substituting a price system with a quantity system of property rights can already be found in the seminal article of Ronald Coase "The Problem of Social Costs" (1960). The environmental externality has for a long time been considered a consequence of the unilateral polluter's harmful activity. Coase changed this approach moving toward a bilateral causation approach, by stressing the reciprocal nature of the harm. While in the traditional framework, direct protection should be given to the victim of pollution, Coase argues that the protection of one party—the victim—inevitably imposes an indirect cost on the other party who then ends up facing some limitations on its freedom to produce. Once the bilateral nature of the harm has been recognized, Coase's famous theorem shows that, as long as the transaction costs related to the private bargaining solution are zero, the establishment of a system of property rights is an effective legal and economic instrument to achieve an efficient outcome where the externality is internalized up to an optimal level. Transaction costs can be considered as the costs of designing, bargaining and enforcing a contract. They also entail information costs and strategic costs incurred by the opportunistic behaviour that the parties might be in place to adopt. When transaction costs are negligible, an efficient allocation of resources results from private bargaining regardless of the initial legal assignment of property rights.

This conclusion is very powerful and challenging: since efficiency is pursued through private bargaining independently on the initial allocation of property rights, the tradable emissions rights can be initially assigned according to other criteria and priorities that are different from efficiency. Since efficiency is reached anyway, the regulator can assign property rights in order to reach, in addition to efficiency, and not instead of efficiency, other goals like fairness or distributive justice.

The conditions set forth by the conclusion of the positive version of the Coase theorem can be met under the necessary conditions of zero transaction costs. The obvious normative implication is that, when transaction costs are positive, then the initial assignment of property rights might be crucial to granting an efficient allocation and use of resources. When transaction costs are positive, first the policy maker should design legal rules aimed at reducing them and then leave private parties to bargain about property rights among themselves until the efficient equilibrium is reached. For instance, the legal rules should be set in order to induce private agents to reveal their information and to reduce the adoption of strategic behaviour. If transaction costs cannot be lowered through legal intervention, then it becomes crucial to collect information in order to assign the property rights directly to the party who values them most and who can use them in the most efficient way.

When transaction costs are high and cannot be lowered, then it becomes necessary to question the desirability of the property rights solution, which should be preferred only if it entails lower transaction costs than the administrative costs of an ex-post intervention through a liability regime.

In the light of the principle of the Coase theorem, this section analyses the property of a mechanism of tradable permits under the assumption of zero transaction costs, highlighting conditions that have to be satisfied in order to grant an efficient allocation of resources through bargaining.

First, it is necessary to recall an important difference between the scheme of tradable permits and the classic Coasian framework. While Coase describes a system where the victim and the injurer are called to privately bargain property rights according to their private information about costs and benefits, a system of tradable emissions rights focuses only on the polluters (i.e., the victims of pollution are not called to participate actively within the scheme). In this scheme the regulator puts a cap on the emissions and distributes (according to a particular criterion) an equivalent number of tradable emissions rights among the polluters. Then, Coasian bargaining of tradable permits ensures the achievement of a optimal social equilibrium at the lowest marginal abatement cost, where the agents' marginal costs are equalized and the market price of the permits equals the cost of the externality. Unlike other cases, such a market for pollution tradable permits is an artificially designed market, whose supply and demand functions depend on the volume of allowances artificially created and allocated by the regulator. A functioning market requires the existence of scarce goods. Without scarcity there is no market; permits would not have any positive market value and the system would fail to give polluters any incentive to reduce their emissions:

> *Emissions trading can help achieve a given level of emission caps efficiently by setting an appropriate price, but this requires that policymakers set the caps consistent with the desired – and scientifically credible – level of environmental performance* (Capoor and Ambrosi 2007, p. 6).

Thus at least two conditions need to be satisfied for a cap and trade system to work effectively: (1) the total level of permits to be allocated in the market (the cap) should equal the optimal amount of GHGs to be emitted, determined by the point where the social marginal cost equals the social marginal benefit of polluting, and (2) monitoring shall be effective in guaranteeing that economic agents do not produce more emissions than the number of permits they own. Under this perspective it is possible to compare a cap and trade system to a soft form of Command and Control: in both cases the regulator has to collect information to set a limit, and in both cases a form of ex-post control is necessary to ensure compliance with the regulation. However, the Cap and Trade system is a more market-oriented form of regulation. First, the regulator does not have to know the private marginal costs of abatement of the regulated firms; it (only) has to know the marginal cost and benefit of emissions in order to set the emissions cap at an optimal level that ensures scarcity. After the cap is set at an appropriate level, the mechanisms grant flexibility leaving the private parties to decide how to comply with the law according to their private information concerning marginal abatement costs and benefits.

When these conditions are satisfied, cap and trade is an effective system because, given the permits scarcity in the market, if one polluter wants to cover its emissions gap (i.e., the difference between emissions and permits initially allocated) by acquiring permits in the market, then another economic operator will have to abate these emissions on behalf of the first polluter in order to sell him or her the permits needed. Moreover, the market allowances' free bargaining will make sure that tradable permits will be allocated to those who value them the most, while emissions will be reduced by those who can do it at the lowest marginal abatement cost. Indeed, in a cap and trade system, economic agents can comply with the regulation either by "*making or buying*": they can cover their emissions gap either by abating internally the emissions they produce (i.e., make) or alternatively by acquiring in the market the permits they need to cover their gap (i.e., buy). Compared to a more centralized Command and Control type of regulation, a cap and trade system is a market-oriented mechanism giving economic agents higher strategic investment freedom in deciding how to comply with the environmental regulation; plants operating on the energy efficiency frontier, whose marginal abatement costs are higher than the permits' market price, will find it more convenient to buy permits in the market, while less efficient plants will opt for abating emissions internally and selling their permits' surplus at a price higher than their MAC. According to this perspective, a cap and trade system is not only effective, but also efficient: emissions will be reduced where the marginal abatement costs are the lowest, thus at the minimal marginal social costs; as a consequence, the permits' price will equal the lowest marginal abatement costs and in the long run the marginal abatement costs among different polluters will be equalized.

Flexible economic instruments, such as a system of tradable permits, are likely to result in significant efficiency gains, since the social optimum equilibrium can be reached by minimizing the costs of compliance. This is true for the potential buyers with high marginal abatement costs and who can select the cheaper option of acquiring permits in the market instead of reducing emissions internally. It is also true for selling agents who can balance their costs in abating emissions internally with the revenues from selling the permits surplus they own. These economic principles have been included in the European legislation; in fact, as stated in the EC Directive 87/2003/EC art.1, the EU ETS has been established "in order to promote reductions of GHG emissions in a cost-effective and economically efficient manner."

However, the EU ETS effectiveness and efficiency in inducing emissions reduction has not been proved yet and, on the contrary, the partial results (in terms of CO_2 price and emissions reduction in Europe) reached some years after the ETS implementation seem to suggest that the ETS is far from being an effective mechanism. The next chapters will analyze the legal design of the ETS in order to assess to what extent it can be considered an effective mechanism and, in the case inefficiencies have been discovered, to assess to what extent they can be considered a result of its legal and institutional framework. The analysis will focus mainly on the two variables that influence the correct functioning of a cap and trade scheme. First, the stringency of the ETS cap is discussed and, secondly, the criterion adopted to allocate free permits, which has been mainly grandfathering.

7. Comparative Analysis of Market Based Incentives: Prices vs. Quantities

The previous sections have explained why and under which circumstances market-based instruments should be preferred to a Command and Control type of regulation: they are incentive driven, they are more flexible, they can achieve an optimal internalization of the externality at lower marginal costs, and they require lower administrative and information costs. This chapter has underlined both the advantages and weaknesses linked to each form of regulation. However, it has failed to explain why in many circumstances, and in particular in Europe, the instrument of tradable permits has been preferred to other forms of regulation, and to a tax system in particular, to address the problem of climate change and to induce a reduction of emissions necessary to comply with the Kyoto target. The substantial symmetry between these market-based instruments has been previously highlighted by the economic literature (Weitzman 1974). Under a tax system, the regulator fixes the price, and under this constraint, the private parties determine the quantity of emissions; while the price is fixed and known, the quantity of emissions is uncertain. On the other hand, under a cap and trade scheme the regulator sets the quantity of emissions, while private parties in the market determine the price corresponding to the cost of the externality, thereby raising the problem of price volatility. Moreover, it has been shown that, without uncertainty, taxes and permits are fully equivalent if the government can update these instruments after the introduction of more efficient technologies has occurred (Denicolò 1999).

However, in both cases the regulator has to collect a certain amount of information to set either a tax equal to the externality, or to cap the emissions at an optimal level; in both cases, if the tax or the cap is not set an optimal level, the regulation will induce under-deterrence and the achievement of a non-optimal equilibrium where the marginal costs of pollution differ from the marginal benefits. Thus, while under circumstances in which there is perfect information both instruments should ensure the achievement of an optimal equilibrium, under circumstances of uncertainty there might be a divergence of results. In his comparative analysis, Weitzman (1974) demonstrates that when there is a lack of information regarding the marginal abatement costs, the desirability of one instrument over the other depends on the shape of the marginal benefit function. In other words, when the costs are uncertain, a tax system is less (or more) desirable than an alternative cap and trade system when the marginal benefits of reducing the externality are relatively steep (or flat) compared with the shape of the marginal cost function.

Hepburn (2006) applies these results to the case of climate change: in theory a carbon tax should be preferred to a cap and trade scheme if the marginal costs of abating emissions increase very fast and new technologies have to be developed in order to induce further emissions reduction and if the marginal benefits from abatement are relatively flat. Actually it seems the case considering that climate change depends on the stock of emissions in the atmosphere, which is determined by the flow of emissions produced each year. This condition implies that the reduction of emissions in the short term has little impact on mitigating climate change. This does not imply that the reduction of emissions does not bring any environmental benefits—which can be high— but only that such benefits become evident only after the reduction of a substantial amount of emissions.

Thus, while according to the shape of the marginal cost and benefit function, a carbon tax should be preferred to a system of tradable emissions rights, Hoel and Karp (2002) show that the preference for a system of cap and trade increases by increasing the time horizon of the regulatory policy.

The shape of the marginal cost and benefit function jointly with the time horizon of the regulatory policy are important variables to be considered in the comparative analysis of prices and quantities types of instruments. The main conclusion to be drawn after applying the Weitzman analysis to the case of climate change is that a tax system should be preferred under a relatively short time horizon of the policy and in the case that the marginal abatement costs increases quickly, nevertheless the benefits of emissions reduction are quite insensitive to emissions over a short period. Being that all these clauses are verified in the real context, it becomes natural to ask why a tradable permits scheme has been preferred to a carbon tax system. Other factors need to be taken into account in order to explain the emergence of a cap and trade system over the alternative option of a carbon tax.

7.1 International Issues

First, it is important to recall that climate change is a global problem which requires a global approach promoted by international cooperation. National policies have to be coordinated and in compliance with supranational law, namely EU directives, and international law. The choice of the regulatory instrument can depend on and be influenced by international agreements. Yet, it is also important to determine the regulatory instrument that can promote international cooperation in the most effective way. One can argue that according to this perspective a tax system presents two shortcomings. First, fiscal policy typically belongs to the realm of national sovereignty. As some of the most important and influential political and economical instruments, individual nations are rarely willing to give up their fiscal independence and freedom by delegating the right to develop a common fiscal policy to supranational institutions like the European Union. In 1992, the European Commission advanced the possibility of introducing a carbon tax system among MS. Given that they would involve lower administrative costs, taxes were thought to be more effective than a command and control direct regulation and cheaper than a cap and trade system; however, different countries, among them Great Britain, strongly blocked this proposal, fearing that this would constitute the first legal precedent allowing the European Commission to develop a supranational fiscal policy in other fields different from the environmental one. In a context where the supranational power does not have the faculty to set a centralized and harmonized fiscal policy among different European MS, it would be possible to think of a second-best alternative where each MS could fix its own carbon tax, thus maintaining national sovereignty over this strategic political instrument. However, and the examples from other fields abound, it is easy to argue that the cost of creating a harmonized and effective fiscal policy increases as the number of national sovereign authorities to be coordinated increases as well. Like in the case of the Prisoner Dilemma, despite the fact that the cooperation outcome would be superior, each MS faces a strong incentive to impose a lower tax rate that would attract foreign investments. The risk of normative opportunism and fiscal arbitrage increases as the number of MS to be coordinated increases beyond the European borders.

The risk of triggering competition to the bottom cannot be neglected, implying that a carbon tax is not an effective—as far as mechanisms promoting global cooperation go—to face and mitigate the problem of Climate Change.

Under this perspective, the system of tradable permits, as it has been designed in the Kyoto Protocol, seems to be a more effective instrument in promoting a different kind of cooperation that combines a top-down approach typical of the direct regulation with a bottom-up approach that characterizes voluntary agreements. For the purpose of this research it is sufficient to mention that on one hand we are experiencing an increasing tendency to link the different cap and trade schemes that have emerged all over the world. The coordination and connection of different trading schemes is likely to bring about some important efficiency gains. A cap and trade scheme is developed according to the idea that room for bargaining and consecutive efficiency gains increase as the heterogeneity of the bargaining parties' marginal abatement costs increases as well. Thus by linking different cap and trade schemes both the scope of the market and the number of private agents who can bargain tradable permits increase. As the variability in marginal abatement costs is likely to increase as well, it is possible to conclude that the extension of a cap and trade scheme results in important efficiency gains which in turn facilitate international cooperation.

The second important feature that facilitates cooperation is determined by the flexible mechanisms established in the Kyoto Protocol, like the joint implementation and the clean development mechanisms, which can induce global cooperation from the bottom through the establishment of a system of voluntary agreements among private parties monitored and certified by supranational institutions. According to the Kyoto Protocol and to the previous Rio Declaration, the non-Annex I countries (i.e., less developed countries which did not contribute to generating the problem of climate change) were not required to ratify the Kyoto Protocol and to commit to any emissions reduction target. On one hand, this decision seems to be coherent with a principle of justice and fairness: less developed countries did not cause global warming so they should not face the cost burden deriving from the duty to mitigate climate change. On the other hand, this decision does not seem economically efficient since the firms operating in developing countries are more carbon intensive, thus presenting lower marginal abatement costs and higher abatement opportunities. As a result, despite posing some problems concerning distributive justice, the same amount of emissions could be reduced more effectively, at lower marginal costs, by intervening in those countries characterized by obsolete technologies and low marginal abatement costs. This would be an alternative to reducing these emissions in developed countries which are characterized on average by a cleaner energy resources mix and more efficient technologies and thus producing at a lower carbon intensity rate than developing countries.

According to this perspective, nowadays the definition of international project-based crediting mechanisms, such as the *Clean Development Mechanism* (CDM), seems to be the most concrete answer to the problem of global cooperation and, in addition, to the promotion of emissions abatement at lowest marginal costs. The Linking Directive 2004/101/CE defines a link between the countries participating in the European Union Emissions Trading Scheme (EU ETS) and other countries that did not ratify the Kyoto Protocol. The Directive establishes that firms operating in the ETS can obtain "certified emission reductions" (CERs) by carrying out emissions reduction projects in the countries that did not ratify the Protocol (non-Annex 1 countries). It also allows firms to use those credits to cover their exceeding emissions into the ETS. The credits obtained by CDM projects (CERs) are equivalent to the Emissions Unit Allowances (EUAs), and they correspond to one ton of CO2. In practice, it means that CERs can increase the total number of available permits and thus contribute in a substantial way to the achievement of Kyoto targets. In fact, the inclusion of credits deriving from CDM projects is strongly contributing to the *Emissions Trading Scheme*'s development. Point Carbon estimated that in 2005 CDM certificates covered the biggest part of the market, in terms of exchanged volumes but not in terms of monetary value. Compared to 362 millions of EUAs exchanged, for a total value of 7. 2 bill. €, in 2005 CDM projects have been signed (emissions reduction purchase agreements, ERPAs) for a total amount of 397 millions of CO2 tons. However, the total value of these project corresponds *only* to 1.9 bill €. In fact, the CER's lower value is due to the higher risk that international CDM projects must discount. Different factors can explain the risk involving CDM projects: the Linking Directive establishes that CERs can be used only starting from the second ETS phase (2008 – 2012); current CDM have been signed so far without any effective (i.e., physical) available credits transactions (i.e., forward and futures); project- based transactions pay a higher risk premium because these credits can be assigned only if the project is positively achieved; and finally most of these long-term projects are implemented in countries that face high political instability. Given that the Kyoto emissions reduction target is the main goal to be achieved, Law & Economics tends to evaluate positively such Coasian bargaining solutions. In fact, instruments such as the CDM can contribute substantially to achieving this target by both inducing the negative externality's internalization by promoting cost-effective emissions reduction projects and by overcoming the political inertia in approaching environmental issues at a global level. Pizer defines the CDM as a useful international mechanism to induce the achievement of short-term goals: "there is an unusual alliance of support for project-based crediting in developing countries: Environmental advocates see this as maintaining environmental integrity, businesses see this as a cheaper alternative to domestic compliance, brokers and dealmakers see profit opportunities, developing countries see foreign aid, and industrialized country governments see opportunities to complement domestic mitigation. Given the inevitable need to channel mitigation resources from industrialized to developing countries, more thought should be given to how these mechanisms can be expanded and improved" (Pizer, 2005, p.2). To summarize, in an international context, a cap and trade instrument is likely to be superior to a carbon tax on different grounds: first it involves higher political acceptability than carbon taxes on behalf of MS which are not willing to give up their sovereignty in this strategic field. Second, while taxes are subjected to the risk of fiscal arbitrage which might cause a race to the bottom, a cap and trade system is more likely to favour and induce international cooperation according to both a top-down approach (i.e., a linking of different cap and trade schemes) and a bottom-up approach (i.e., voluntary agreements in the form of certified emissions reductions).

7.2 Political Economy Approach and Private Preferences toward a Cap and Trade System

Another important reason that could explain the general preference in Europe toward a cap and trade scheme over a tax system comes from the "political economic theory of regulation" developed within the Chicago School by prominent scholars as George Stigler, Richard Posner, Sam Peltzman and Gary Becker. In brief, rather than focusing on the potential failures of the market, the Chicago School tends to stress the failure of regulation, which is likely to be *captured* and influenced by private interests. According to this approach, it is unrealistic to assume that once the risk of a market failure is detected, the government intervenes in order to regulate the market and to correct its failure in order to pursue the public interest. Quite the opposite, it is not the government which imposes a regulation on the firms, but rather the firms, aggregated in the form of private interest groups, that are likely to demand regulation. The reason why regulation is more likely to be demand-driven, rather than supply-driven, is that private interest groups tend to use it as a strategic instrument as a way of creating a barrier to entry in the market and as a way of preserving their competitiveness: when asking for regulation, private groups will lobby in favour of a regulation type whose benefits are going to be highly concentrated within the group, while its costs are going to be imposed and widely dispersed outside the interest group.

This general theory is supported by empirical evidence. Keohane et al. (1998) observe that at the time of deciding which economic and legal instrument should be chosen in order to achieve the desired level of environmental protection in a cost-effective way, the positive political decisions developed in the United States have strongly diverged from the recommendations of normative economic theory. In the last decades, Command and Control has been adopted more extensively than market-based instruments, despite the fact that economic theory unequivocally demonstrates the economic superiority of the latter over the former type of regulation. This superiority is due to the fact that the latter type can ensure environmental protection at lower marginal costs and it promotes dynamic efficiency by providing more effective incentives to develop more efficient technologies. Moreover, many authors (McCubbins et al. 1989, Maloney & Brady 1988, Nelson et al 1993) underline that when environmental standards have been adopted, they have tended to penalize, rather than reward, more efficient firms since the requirements to reduce marginal amounts of pollution have generally been more stringent for new pollution sources—and on average characterized by modern and more efficient technologies—than for incumbent firms. This has therefore created a distortive incentive to keep old and more polluting plants in operation.

The evidence that the standards for new sources have been on average more stringent than the standards applied to incumbent firms is coherent with the analysis of Tullock and Buchanan, according to which incumbent firms tend to prefer Command and

Control over taxes because the imposition of standards can work as a barrier to entry in the market.

Revesez and Stavins (2004) observe that market-based instruments have been increasingly adopted and that the form of tradable permits has been extensively preferred to the adoption of taxes, despite the fact that economic theory suggests that they are equally efficient and their appropriateness depends on case specific factors, such as the shape of marginal cost and benefit functions. Under a political economy perspective, the reason why public authorities have generally preferred tradable permits over taxes can be found in their different distributive effects. It has been previously argued that, under some circumstances, both taxes and tradable permits are efficient, flexible mechanisms that induce an optimal internalization of the pollution cost. However, while a tax system implies a transfer of money from the private to the public sector, in a cap and trade scheme, where allowances are initially allocated for free (as in the European case of ETS), this potential tax revenue is kept by the private parties, implying opposite impacts on public finance. As it will be more thoroughly analysed in chapter 6, under distributive terms a cap and trade scheme can be thought of as a tax system able to generate tax revenue. However, if the permits are initially grandfathered to the regulated installations, this tax revenue is kept by the private installations. On the other hand, under auctioning the tax revenue is shifted to the public finance, implying the same distributional effects as a tax system. Auctioning permits or imposing a carbon tax implies that firms are required to pay not only for the emissions they abate but also for the pollution they generate. Grandfathering, contrarily, means that the emission rights are allocated for free to polluters according to their historical level of emissions. This implies that emitters only have to pay for the costs of emission reduction and not for their emissions as in the case of auctioning. Consequently, compared to auctioning, the advantage of grandfathering is that it increases the political acceptability of an emissions trading scheme (e.g. Baumol and Oates, 1998; Tietenberg et al., 1999). For this reason, grandfathering proves the prevalent method of allocating emission allowances (e.g. Revesz and Stavins, 2004). In addition, firms may also have an incentive to pollute in order to receive more allowances (e.g. Egenhofer and Fujiwara, 2005). Although this can be prevented by choosing a historical base year that polluters cannot influence anymore, companies will try to lobby in favour of a different or updated base year if this provides them with more allowances.

A system of cap and trade where allowances are initially grandfathered according to historical emissions is likely to be preferred to both a tax system and to a cap and trade system where allowances are auctioned because, on one hand, it entails lower compliance costs, and on the other hand it tends to increase the costs of potential new entrants that would not be entitled to any free allocation (i.e., they do not have any historical emissions). As a result, regulation works as a barrier to enter the market.

8. Conclusions

This chapter has provided a taxonomy of different legal and economic instruments aimed at internalizing the cost of pollution in an effective way. Different instruments have been briefly discussed and their related advantages and weaknesses have been highlighted through a comparative analysis. First the ex-post liability regime within the field of private law has been presented. Then the ex-ante forms of regulation have been discussed: first, the direct regulation in the form of Command and Control, and then the more market-oriented types of regulation. Pigouvian taxes and Coasian cap and trade schemes have been explained and compared, and their efficiency and different distributive effects have been evaluated, as has their capacity to promote international cooperation in order to address the difficult task of mitigating climate change at a global level.

Under a perspective of political economy, it has been argued that a cap and trade scheme has been preferred to other instruments as a main mechanism to promote the reduction of emissions in Europe because it ensures higher political acceptability in the eyes of the regulated sectors.

Despite not presenting an exhaustive analysis, this chapter has attempted to introduce the instrument of cap and trade which constitutes the core of this research. In fact, rather than developing an exhaustive comparative analysis between regulatory instruments, the thesis focuses on how to improve the ETS that has been chosen (for one reason or for another) as the main regulatory instrument to address the problem of climate change.

This decision is supported by pragmatic evaluations. It would be possible to discuss whether and under which circumstances a tax system is superior to a cap and trade scheme or vice-versa; however, this thesis has been developed in the light of the legal, formal and binding decision of establishing a market for tradable permits (Directive 87/2003/EC) in Europe. While this scheme is far from perfect and entails some costs that could be avoided by a more effective legal design, under a path dependency perspective one could argue that the costs of abandoning this institutional framework in order to switch to another regulatory mechanism aimed at pursuing the same emissions reduction target would be probably higher than the costs linked with the improvement of this existing mechanism. Therefore, given that the ETS has been chosen as the principal regulatory instrument in Europe, the aim of this research is to analyse how effective this mechanism is in reaching the emissions reduction target, whose efficiency is not questioned. The general aim of this thesis is hence to focus on the biggest experiment of a cap and trade system ever established in order to identify the eventual inefficiencies deriving from the legal design of the ETS framework and to indicate how the law should be reformed in order to improve the overall functioning of the ETS.

Chapter 4. Legal and Economic Aspects of the European Emissions Trading Scheme

1. Introduction

Taking both the European emissions reduction targets as given, and without questioning the European decision of opting for a cap and trade scheme among different possible regulatory options, this research starts by observing how the ETS is performing and develops an economic analysis of the institutional and legal framework of ETS. The general purpose of this thesis is to investigate whether the ETS has been designed in an effective way and, in the case that fallacies are identified, to offer some normative prescriptions to improve the ETS' effectiveness by reforming its institutional framework according to economic principles.

This chapter is aimed at introducing the economic and legal background of the ETS. Starting with a brief reminder of the important experience of the American SO_2 emissions trading program, section 2 of this chapter describes the origin of the EU ETS within the legal framework of the Kyoto Protocol and the role it covers within the European climate policy. The ETS is based upon the institution of emissions allowances, artificially created by the public authority and assigned to the regulated agents that are free to trade them within the ETS. Therefore, the legal nature of the allowances within the field of property law is briefly discussed.

Section 3 contextualizes the ETS in a temporal and special framework. The length of the ETS regulation and its subdivision in different trading periods are specified together with its scope: the amount of emissions and sources that fall within the ETS. This specification is important to underline that the ETS regulates only a subset of the GHGs and emissions sources covered by the Kyoto Protocol. This difference suggests that compliance with the ETS European legislation does not necessarily imply compliance with the Kyoto emissions reduction target.

Section 4 introduces the National Allocation Plans (NAPs): the public document that MS have to design and submit to the European Commission. NAPs specify how many allowances the MS intend to allocate to their national ETS sectors and installations, as well as the criterion according to which they intend to distribute those allowances. This section underlines the responsibilities delegated at a decentralized level. It is necessary to introduce the role that MS have to carry out within the ETS. This topic is discussed in the fifth section which describes the areas where the application of the principle of subsidiarity, jointly with the lack of clear guidelines, has led to different interpretations and implementations of the common European Directive across MS, thus limiting the internal harmonization within the ETS. Four areas have been identified: the definition of the national ETS cap, and thus the emissions reduction burden imposed on the national ETS sectors; the criterion to distribute the allowances among ETS national installations; the definition of the installations that should fall within the ETS; and the possibility of bringing some ex-post adjustments, like the case of closures and the definition of the baseline year according to which allowances are grandfathered. Most of the issues that are introduced in this paragraph will be extensively discussed in the next chapters in order to assess whether and to what extent the delegation of many duties to MS according to the principle of subsidiarity has compromised the internal harmonization of the ETS and, if so, whether it has limited the effectiveness of the ETS.

Section 6 intends to use a practical case to illustrate how the ETS can impact the secondary market—in this case, the electricity generation market—by inducing a reduction of emissions through a switch to less carbon-intensive fuels. First, the properties and specificities of the electricity markets are shortly recalled (sections 6.1). Then section 6.2 describes the process according to which quantities and prices are set at equilibrium, while section 6.3 explains how such equilibrium might change after CO_2 emissions have been monetized within the ETS. The indicator of the CO_2 theoretical coal-to-gas switch price is introduced.

2. The Launching of the EU ETS and the Nature of the Emissions Allowances

The mitigation of climate change constitutes one of the most important, ambitious and shared European goals. First, in 2002 the former fifteen MS of the European Union ratified the Kyoto Protocol, committing to reduce their emissions by 8% below the 1990 level by 2012. Then, in 2007 the European Commission expressed its firm intention to strengthen this goal, and in December 2008 the European MS finally approved the Climate Package, committing themselves to a unilateral 20% reduction of GHG emissions below the 1990 level by 2020.

In the light of these ambitious commitments, a cap and trade scheme—namely, the European Union Emissions Trading Scheme (EU ETS)—has been established to promote a reduction of GHGs emissions required to comply with the Kyoto target in an efficient and cost-effective way.

The ETS constitutes the most important pillar of the European climate policy. It was established in 2003 by the European Directive 87/2003/EC when entry into force of the Kyoto Protocol was still uncertain, and it became operational in January 2005.

This scheme is now up and running. More or less similar emissions trading schemes have been already in use in Denmark (since 2001) and the United Kingdom (UK) (since 2002). Also outside the EU, various countries, such as Norway, Japan and Canada, intend to build national tradable emission rights systems, which could eventually be linked to the EU scheme provided that they mutually recognize their transferable units. The Norwegian government, for instance, decided in early 2006 to approve such a link.

More than 11,000 energy and industrial installations—which are collectively responsible for almost half of the European GHG emissions—participate in the ETS, which thereby constitutes the largest multi-country and multi-sector experiment of a Cap and Trade scheme for GHGs in the world. The EU ETS has been developed in the light of some previous important experiences, particularly the Sulphur Dioxide (SO_2) allowance program, launched in the United States in 1990 to promote the national reduction of sulphur dioxide gases, which are responsible for the environmental problem of acid rains. Moreover, the possibility of building a multi-national cap and trade scheme to reduce GHG emissions had already been foreseen in 1997 by the Kyoto Protocol. In fact, Art. 17 of the Kyoto Protocol establishes that the ratifying Parties "may participate in emissions trading for the purposes of fulfilling their commitments […]. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments." The Annex on emissions trading in the subsequent Marrakech Accords enabled governments to authorize legal entities to transfer and/or acquire emissions under Art. 17.

The European scheme is interesting in the light of the American experience with market-based instruments because the EU has copied most design features of the US SO_2 emissions trading scheme (e.g. Christiansen and Wettestad, 2003; Damro and Méndez, 2003). In particular, both programs allocate allowances for free and proportionally to historical emissions, instead of auctioning them. In the European context, Art. 10 of the aforementioned Directive ensures that every MS has allocated at least 95 per cent of its allowances free of charge in the period 2005-2007 and at least 90 per cent for the period 2008-2012. Moreover, both the SO_2 emissions trading program in the US and the CO_2 emissions trading scheme in the EU define tradable emission rights as *allowances*. Art. 3 of the European Directive states that "allowance means an allowance to emit one tonne of carbon dioxide equivalent during a specified period, which shall be valid only for the purposes of meeting the requirements of this Directive and shall be transferable in accordance with the provisions of this Directive." In the SO_2 emissions trading scheme in the US, an allowance is defined as follows: "The term 'allowance' means an authorization, allocated to an affected unit by the Administration under this title, to emit, during or after a specified calendar year, one ton of sulphur dioxide [...] Allowances allocated under this title may be transferred among designated representatives of the owners or operators of affected sources under this title and any other person who holds such allowances (...)" (CAAA, 1990, Title IV Acid Deposition Control, section 402 (3) and section 403 (b) respectively).

Although most economists see tradable emission rights as property rights, and although it is clear that these allowances have common features with the property that is freely alienable and tradable, the Directive that establishes the Scheme of emissions trading does not specify the precise legal nature of the allowances that can be traded within the ETS. Therefore, it becomes important to clarify the nature of the European Union Allowances. Art. 9 of the ETS Directive establishes that MS have to create a limited number of allowances to be distributed among national sectors and installations; this is done with an appropriate national allocation plan. This article implies that allowances are issued exclusively to each installation that is entitled to receive a certain number of individually identifiable allowances. Art. 12(1) of the Directive establishes that allowances can be freely exchanged within a trading period, whereas art. 12(3) establishes that by April 30^{th} of each year the regulated sectors have to surrender to the competent authority a number of allowances equivalent to the verified emissions produced each year. Otherwise, they must pay a penalty as described by Art. 16.

These articles ensure the creation of allowances that are unique, exclusive and transferable through trading between private parties. All these features characterize the concept of private property according to which allowance holders have a right to the exclusive use of this asset while third parties have the duty to not interfere with this property. However, Anttonen et al. (2007) argue that "although an allowance holder may be said to have property rights, this does not translate into allowances constituting private property" (p.98). In fact, the EU ETS presents some features that are typical of central and direct regulation: first, the public authority determines top-down a limit to emit GHGs; then the central authority assigns some permits to produce emissions that the parties can freely trade, but that they have to surrender each year; next, the authority monitors the produced emissions and verifies that the amount of surrendered allowances equals the amount of produced emissions. The processes of licensing, monitoring, verification, enforcement and penalty are all similar to those of the Command and Control type of regulation. All these features may lead one to speak about *regulatory property* rather than private property.

It is worth mentioning that the lack of an official clarification concerning the legal nature of the emissions trading allowances has induced different MS to attribute a different role to them—one with different features. A survey developed among some MS highlights that while the Finnish Government Bill classifies the European Union Allowances as intangible rights which are comparable in nature with intellectual property rights—including, patents, trademarks and licenses—the Swedish Authority attributes a different nature to the allowances; it classifies the allowances as financial instruments, thereby coming to an opposite conclusion concerning the applicability of the securities laws to the carbon allowances (Anttonen et al. 2007). The United Kingdom's approach tends to combine these different views: in the *Re Celtic Extraction* case, the Court found that a waste management license given exclusively to the Celtic Extraction Ltd under the Environmental Protection Act could be categorized as property for the purposes of the Insolvency Act. This was because the Court of Appeals established that the conditions required to have the status of property had been satisfied. Similarly, the United Kingdom recognizes the possibility to use the allowances as security assets. Under this legal regime, allowances constitute an intangible property as in the case of intellectual property. They can, however, simultaneously be used as a security in the assets of the operator holding them, which can be also mortgaged. Although allowances are intangible rights, they constitute a tangible part of the installations' assets.

In the case of the American SO_2 allowance program, a legal provision was adopted to specify that 'allowance' does not constitute a property right [in section 403(f) of the CAAA]. This formulation was chosen to avoid compensation payments to polluters for 'taking' allowances when the government lowers the annual emission caps. Both in the US and in the EU, an emission right is basically defined as an allowance that authorizes a legal entity to emit a certain amount of pollution during a specified period. This is not so much a permanent, private property right, as it is an authorization that can be terminated or limited by the government. Therefore, the Law & Economics literature prefers to characterize allowances as mixed, hybrid or regulatory property rights (e.g. Rose, 1999; Yandle, 1999). Emission rights contain elements of both public and private property rights: allowances are non-permanent, government-mandated rights that combine state control over the emission quotas with private freedom for polluters to choose how to comply (sometimes referred to as 'command-without-control'). Moreover, although allowances are not property rights *themselves*, property rights *in* allowances are, in fact, recognized since emitters can receive, hold and transfer them while excluding all others—except for the government—from interfering with their possession, use and disposition of them (Cole, 1999: 113-4).

3. The Length and Scope of the EU ETS

The EU ETS was designed in 2003, and it was officially launched in January 2005. The EC Directive divides the duration of the Cap and Trade system in different trading periods. The first one is a three-year pilot phase (2005–2007), while the second phase started in January 2008 and lasts 5 years (2008-2012). This second five-year phase coincides with the first commitment period of the Kyoto Protocol. The second ETS Directive approved in 2009 amends the first ETS Directive and establishes that a third trading period will start on 2013 and will last eight years, until 2020. This third phase goes beyond the Kyoto Protocol deadline and coincides with the EU emissions reduction self-committed period as it has been specified in the European Climate Package, finally approved at the end of 2008.

It is possible to observe that the three ETS trading periods with different lengths have been developed within a learning-by-doing framework. In fact, the ETS remains one of the world's first experiments of cap and trade schemes for greenhouse emissions allowances. The Scheme was developed in an uncertain context (as it could not count on previous experiences) and was lacking a great deal of important information (for instance, CO_2 emissions data). In this scenario the European Commission tried to balance the difficult trade-off between building a credible policy aimed at favoring long-term investments (which would call for long trading periods) while at the same time avoiding too strict regulation that would require ex-post adjustments (and which call for shorter trading periods to be adjusted phase by phase).

At the beginning of any phase, the ETS installations are entitled to receive a yearly amount of permits that they can freely trade within the same ETS trading period. Thus, the first ETS Directive establishes that during the first and second trading period banking and borrowing of allowances are only allowed on a year to year basis within a trading period; conversely, trading of allowances has been forbidden across different trading periods. In fact, the EC Directive decided against the inter-period transfer of permits (art.13): permits are allocated phase by phase, and they cannot be banked and transferred from one phase to another. Thus, at the end of one phase, the number of exceeding permits that have not been delivered is cancelled and removed from the ETS.

The effective functioning of the ETS requires also the establishment of a system of monitoring and verification of the emissions produced each year by the installations operating in the ETS, as well as a system of enforcement of penalties in the case on non-compliance. Art. 12 of the EC Directive 87/2003 specifies that by 30 April of each year the ETS installations have to surrender a number of permits equivalent to the amount of emissions produced during the preceding year.

Art. 14 of the ETS Directive delegates to MS the duty to monitor the ETS installations, while Art. 15 requires that the emissions reports are verified in accordance with the criteria established in Annex V of the Directive. Further guidelines for monitoring and reporting published by the European Commission on 29 January 2004 state that:

> *The operator shall submit the emissions report, a copy of its permit for each of its installations, plus any other relevant information to the verifier. The verifier shall assess whether the monitoring methodology applied by the operator complies with the installation's monitoring methodology as approved by the competent authority, the principles for monitoring and reporting presented in section 3, and the guidelines laid down in this and subsequent Annexes. On the basis of this assessment the verifier shall conclude as to whether the data within the emissions report*

contains omissions, misrepresentations or errors that lead to material misstatement of the reported information.

Thus, MS have first the duty to verify whether the emissions have been reported by the ETS installations in compliance with the monitoring and reporting methodology established by the competent authority; moreover, MS have to verify whether material errors have been made, where "materiality" is defined as:

The professional judgment of the verifier as to whether an individual or aggregation of omissions, misinterpretations or errors that affects the information reported for an installation will reasonably influence the intended users' decisions. As a broad guide, a verifier will tend to class a misstatement in the total emissions figure as being material if it leads to aggregate omissions, misinterpretations or errors in the total emissions figure being greater than five percent.

Moreover, Art. 16 establishes that the ETS operators who do not surrender sufficient allowances to cover their emissions are liable for the payment of an excess emissions penalty. In the first ETS phase spanning 2005-2007 this penalty equaled 40 Euros for each ton of carbon dioxide equivalent emitted by that installation for which the operator did not surrender allowances, while for the second phase 2008 – 2012 the penalty equals 100 Euros for each unsurrendered permit. It is important to notice that, according to the EC Directive, the payment of this penalty does not release the operator from the obligation to surrender the amount of allowances equal to those excess emissions that have not been covered.

For the purposes of this research it is important to highlight also the scope of the EU ETS, stressing from the beginning the differences between the GHG emissions and the emissions sources regulated respectively by the EU ETS and the Kyoto Protocol.

The MS that ratified the Kyoto Protocol committed to reduce all the GHGs produced by all the emitting sources located in the Protocol-ratifying Parties; the GHGs included in the Kyoto Protocol are CO_2, CH_4, N_2O, SF_6, PFCs and HFC, which are produced by all the emitting sources, mainly energy and industry sectors, and transport, household and tertiary services, and agriculture.

On the contrary, the Directive 2003/87/EC regulates (at least during the first ETS phase 2005 – 2007)[13] only the CO_2 emissions produced by the installations located in the EU MS belonging to one of these broad energy and industrial sectors listed in the Annex I of the Directive:

- Energy activities and combustion installations with a rated thermal input exceeding 20 MW;
- Mineral oil refineries;
- Coke ovens;
- Production and processing of ferrous metals (iron and steel);
- Mineral industry (such as cement, glass and ceramic production);
- Pulp and paper.

These emitters are defined as “ETS sectors”, while the emitters not regulated by the EC Directive (mainly, agriculture, household, tertiary services, and transport) are defined as “non-ETS sectors”.

In the light of these considerations, it should be clear that the EU ETS includes and regulates only part of the overall GHG emissions and emissions sources covered by the Kyoto Protocol.

The important consequence to be kept in mind is that complying with the ETS regulation does not necessarily mean complying with the Kyoto emissions reduction target. In fact, the ETS intends to cover only part of the national emissions gap (determined by the difference between national emissions and the national emissions reduction target as defined by the European burden sharing agreement), while other national policies have been developed in order to promote the reduction of emissions in the remaining non-ETS sectors. Obviously the achievement of the national emissions reduction target requires coordination between the European climate policy implemented within the ETS and the national climate policies in order to ensure that the sum of the emissions reduction burdens imposed on the ETS and non-ETS sectors is equal to the emissions gap that each country has to cover.

The choice of circumscribing the EU ETS to only a part of total GHGs and emissions sources regulated by the Kyoto Protocol has some implications. On one hand, this choice raises an information problem. GHGs emissions have been historically monitored mainly at a national level; thus, before the establishment of the ETS, public

[13] The second ETS Phase 2008 – 2012 regulates all the six greenhouse gas emissions, while for the end of the second phase the EU ETS will cover also the aviation sector

authorities did not know exactly the amount of emissions produced by the ETS installations (ETS share). *De facto*, the initial amount of emissions had to be regulated by the ETS; it was uncertain and could only be estimated. In particular, the European Commission reported that before its establishment the EU ETS most likely covered almost 45% of the overall European emissions (CEC 2005a: 7), or about 30% of the European overall GHG emissions (CEC, 2005b). On the other hand, this circumscription is aimed at containing the respective monitoring and transaction costs. Indeed, being mainly released by fossil fuels combustion, CO_2 is the easiest GHG to monitor and, in fact, most countries had already developed *emissions by fossil fuels* monitoring systems to levy national energy taxes even before the establishment of the ETS (Kemfert et al, 2006). Moreover, administrative, regulatory and transaction costs would have sharply increased if the EU ETS had been extended from the almost 12,000 installations actually covered to all the European emissions sources, comprising transportation and residential sources which are widely dispersed and fragmented.

4. The National Allocation Plans

According to art. 9 of EC Directive 2003/87, every MS has the duty to develop for each ETS phase a national allocation plan (NAP) "stating the total quantity of allowances that it intends to allocate for that period and how it proposes to allocate them." By tallying all the permits reported in the NAPs that each MS intends to allocate to their national ETS installations, we can derive the level of the ETS cap. The NAPs are the basic documents that have to be analyzed in order to assess whether the EU ETS can be considered an effective economic instrument to induce CO_2 emissions reduction. In fact, the NAPs provide the basic information required to evaluate to what extent MS rely on the mechanism of tradable permits—compared to other national and European climate policies— to achieve their respective Kyoto target (e.g. Betz et all 2006). In fact, the amount of emissions the ETS sectors have to reduce is determined by the difference between the emissions they produce and the ETS cap. Thus, when MS decide how many permits should be allocated to their national installations covered by the ETS, they indirectly establish how the national emissions reduction burden derived from the ratification of the Kyoto Protocol is shared among ETS and non-ETS sectors.

The EC Directive establishes that the NAPs designed by MS must be submitted to the EC for final approval. The Commission has to analyze each NAP, accepting, modifying or rejecting it according to the allocative criteria set out in the EC Directive's Annex III.

For the purpose of this research, it can be useful to recall and analyse some of the criteria listed in the Annex III of the European Directive. Among all the criteria established in the EC Directive Annex III, the Commission has to assess the NAPs also according to these principles:

- Consistency with the MS' EU Burden-Sharing Agreement and national climate change program (Criterion 1);
- Consistency with assessments of historical and projected emission trends towards achieving the required emission targets (Criterion 2);
- Consistency with potential to reduce emissions (Criterion 3);
- Non-discrimination and non-favoring of certain companies or sectors (Criterion 5);

Criterion 3 asserts that emissions shall be reduced efficiently where the marginal abatement costs (MACs) are lower; however, it is the most vague and least objective criterion because the ETS sectors and installations' MACs are not publicly known. As a consequence, Criterion 3 grants the regulator high discretion in deciding how many permits shall be allocated to the ETS sectors, and consequently how the emissions reduction target should be divided among ETS and non-ETS sectors. The other criteria suggest that the ETS cap should be consistent with MS emissions reduction targets and take into consideration the emissions reduction policies applied in the non-ETS sectors (e.g., Betz and Stato, 2006).

Despite that the Directive has set some general rules to establish how many (and how) permits shall be allocated, MS still have a high degree of freedom in determining the number of permits to be allocated to their national ETS installations. After some criticism about the Annex III criteria vagueness has been raised, the Commission has published non-binding guidelines on how it will interpret these criteria in its NAP assessment (CEC 2004a, CEC 2005b). Also in the communication on the 2008-2012 NAPs assessment, the EC confirmed the principle according to which "to determine the required reduction, the proportion of overall emissions that the trading scheme represents is relevant in comparison with emissions from sources not covered by the Directive" (CEC (2006a): 7). It means that the ETS cap should take into account how the emissions reduction burden will consequently be divided between ETS and non-ETS sectors.

5. The Role of the Member States

It has been previously argued that the cap and trade scheme, and the EU ETS in particular, presents many typical aspects of a direct form of regulation. These are mainly the top-down imposition of a limit on the emission of GHGs and the ex-post phases of monitoring and the enforcement of penalties in the case of non-compliance, with the duty to surrender an amount of allowances that is equal to emissions and that has been produced and verified by the competent authority. However, in Europe the central regulatory approach that characterizes the cap and trade scheme has been combined with the principle of subsidiarity, expressed in Art. 5 of the Treaty establishing the European Economic Community, according to which the central authority should limit itself to perform only those tasks that cannot be performed effectively at a decentralized and local level. From the previous sections it should be clear that, at least during the first and second trading periods of the ETS, many responsibilities have been decentralized and delegated to the MS. Indeed, the ETS Directive specifies that MS have the duty to implement the EU ETS at a national level, both on the ex-ante side, when the initial number of permits has to be determined in the NAP and distributed among the national ETS installations, and on the ex-post side, when national authorities have to monitor the amount of emissions produced by national installations, and collect them in a registry to be submitted at a central level. Thus, the administrative function of the MS is absolutely necessary for the implementation of the EU ETS.

The delegation of many regulatory duties to the MS according to the subsidiarity principle has led to a different interpretation and implementation of the common European Directive. Indeed, in this decentralized context it becomes important to investigate whether and to what extent the application of the principle of subsidiarity within the ETS combined with the lack of clear and objective rules has limited the internal harmonization within the ETS, and if this is the case, whether this practice has limited somehow the effectiveness of the ETS. For this purpose, it can be useful from the very beginning to briefly indicate in which areas some divergences in the implementation of the ETS have emerged among MS, while a deeper analysis will be offered in the next chapters.

First and foremost, the criteria adopted to assess the amount of allowances to assign (and thus the emissions reduction burden imposed on national installations) and the criteria to determine how to distribute these allowances among the regulated agents have diverged among MS. In particular, this research attempts to assess to what extent this divergence has occurred among MS and to understand whether this lack of harmonization has influenced the capacity of the wider European scheme to promote a cost-effective reduction of emissions in order to comply with the Kyoto Protocol. One of the other divergences that have emerged across MS regards the definition of the scope of application of the Directive within national borders. In particular, it was not clear which installations should have fallen within the ETS. For instance, the meaning and the interpretation of the words “combustion installation” has diverged across MS. As explained above, the Annex I of the Directive establishes that the installations with a thermal capacity of combustion higher than 20 MW have to be subjected to the ETS. The first NAPs highlighted that many differences existed concerning how this term should have been interpreted. While some countries have adopted quite a general definition, according to which any combustion installation, regardless of the sector they belong to, have to be included in the ETS, even in those cases where those installations did not belong to the energy sector and their principal purpose was not to supply heat or power. In contrast, other MS, like the United Kingdom, have adopted a narrower interpretation, deciding to include in the ETS only those combustion installations belonging to the energy sector and of which the principal purpose was to generate power or heat. As a consequence, similar plants operating in the same relevant market have been subjected to the EU ETS in one country but not in another. The potential distributive effects in the secondary markets are quite clear: some installations could have had a competitive disadvantage artificially created by the European legislation in the case that they were subjected to a costly regulation, while their competitors could have been exempted simply because they were located in a different region.

When this different interpretation of the term “combustion installation” has become manifest, the European Commission has clarified this concept in order to grant higher internal harmonization within the ETS. In the communication “Further Guidance on Allocation Plans for the 2008 to 2012 Trading Period of the EU Emission Trading Scheme,” the Commission stated that any process resulting in the oxidization of fuels should have been considered a combustion installation, and therefore it should have been regulated by the ETS in the case its thermal capacity was exceeding 20 MW.

Another divergence that has emerged among MS regards the possibility of bringing some ex-post adjustments to their NAPs. Some countries have attempted to increase the total number of allowances to be allocated to national installations, while others proposed—and succeeded—to change the criteria according to which allowances should have been assigned to new entrants, to installations intending to close their plants and to incumbent installations among different trading periods. In such a cases, MS have adopted a strategic and opportunistic behaviour aimed at preventing their own national industries to afford environmental costs that would worsen their competitiveness. However, ex-post adjustments risk to prevent a harmonized implementation of the EU ETS among MS and, by creating legal uncertainty, they might deter the regulated installations from undertaking long-term strategies and investments in a low-carbon economy. Moreover, they risk giving the ETS installations – especially firms with market power—an incentive to influence future regulation to their own advantage. More generally, a reversible regulation risks becoming an endogenous variable that firms internalize into their profit maximizing function, and this might distort the firms' incentive to undertake optimal investments in emissions abatement.

In conclusion, although some divergences in implementing the EU ETS across different MS might be desirable under the principle of subsidiarity, it becomes important to question whether and to what extent the administrative independence of MS has degenerated into the formulation of short-term opportunistic national policies. Furthermore, we might question if such policies thus deter firms from performing the emissions abatement required to comply with the Kyoto target and from preventing the achievement of a level of harmonization required to ensure the effectiveness of the ETS. One of the purposes of this research is to investigate if, how and to what extent the legal design of the ETS framework based on a principle of subsidiarity has promoted effective incentives to reduce emissions in an efficient and cost-effective way.

6. The ETS and Economic Incentives to Reduce Emissions: The Case of Electricity Generation

So far, it has been argued that the implementation of a cap and trade system where emissions are capped and the regulated operators are free to bargain for the right to emit will result in an efficient reduction of emissions. This emissions reduction is due to the fact that through free trading, allowances will be allocated to those who value them most. Conversely, emissions will be reduced by those who can abate them at the lowest marginal costs. While in the long run market-based instruments should ensure dynamic efficiency by promoting research and the development of cleaner and more efficient technologies, in the short run—when such technologies cannot be developed and adopted—economic instruments like the cap and trade scheme can induce the reduction of emissions by increasing the final price of polluting products. Thus, these instruments intervene indirectly in both the demand side by re-addressing the consumption preferences toward less carbon-intensive (and cheaper) products, and on the supply side by inducing a production switch toward less carbon-intensive technologies and fuels that after the implementation of the EU ETS will become relatively more economical.

This section intends to illustrate these concepts with a practical case by showing the potential impact of the EU ETS on the electricity sector in terms of final prices, fuel adoption and reduction of emissions. The electricity market represents an interesting case worth examining because it accounts for more than 50% of the sectors regulated by the ETS and because it is characterized by a high variety of fuels and technologies with different carbon intensities. As a result, it presents huge abatement opportunities via fuel switching.

First, the properties and specificities of the electricity and electricity markets will be shortly recalled (sections 6.1). Then section 6.2 will describe the process according to which quantities and prices are set at equilibrium, while section 6.3 shows how such equilibrium might change after CO_2 emissions have been monetized within the ETS.

6.1 Some Features to Know about Electricity

In addition of being one of the most important primary goods sustaining economic production and consumption, electricity is characterized by some particular features that are reflected in the structure of the electricity generation market and in the way prices and quantities are set at equilibrium.

First of all, electricity has a double nature: On the demand side, electricity is a completely homogeneous good without any type of quality specification. On the supply side, electricity looks like a highly heterogeneous product, since it can be generated by a wide variety of technologies and fuels, which diverge depending on their fixed and variable costs, thermal capacity, carbon intensity, energy efficiency, and their degree of continuity and so forth. It is important to recall that, due to their intrinsic differences, these technologies cannot always be substituted for one another and, in some cases, they are completely alternative sources. For instance, nuclear generation plants are characterized by very high fixed costs, low variable costs and high start-up costs; as a result, they can generate electricity at very low marginal costs for long ranges of time, and in turn, they are tailored to satisfy the base load demand. On the contrary, it would be very costly and inefficient to start up a nuclear plant just to satisfy the peak load demand during a short time. This function can be better covered by technologies characterized by very low start up and fixed costs, which can also be called into operation for a short time. These technologies however, tend to produce electricity at a high marginal cost.

Alternatively, there are also technologies, like coal and gas fired plants, that have similar characteristics and that can be substituted and called into operation alternatively depending on their marginal costs, which mainly depend on the variable prices of fuels established in the energy market exchanges.

The second feature characterizing the electricity market is the inelasticity of the demand: electricity is a primary and indispensible good; moreover, it is difficult to substitute with alternative goods. As a consequence, the demand for electricity results quite rigid and variations in prices are not likely to greatly influence the quantity consumed. This implies that electricity can be sold even at very high prices, for instance in the case of supply shortage.

The third important peculiarity of the electricity good is its non-storability. Electricity can be stored only in small quantities and at substantial economic costs. This implies that electricity cannot be acquired at low prices when the market experiences oversupply in order to be sold at higher prices during the shortage periods. According to the basic principles of thermodynamics, the amount of electricity that is put into the transmission has to be completely acquired and consumed. In a certain moment if the demand of electricity is not satisfied due to a supply shortage, the whole electricity system will experience a general blackout. Conversely, if the supply of electricity into the grid exceeds the amount of electricity acquired, the system ends up being overloaded and faces a high risk of fusion.

This peculiarity requires a high level of coordination and monitoring aimed at ensuring that in each instant of time the amount of electricity supplied equals the amount of electricity acquired. For this reason, in the electricity market a regulator has the role of ensuring a continual balancing between demand and the supply of electricity, whose wholesale equilibrium price and quantity is established in the exchange market each hour per day. The electricity planning and monitoring system entails high coordination costs that are also required to avoid the risk of bottlenecks in the electricity network due to a supply of electricity beyond the capacity of the grid.

6.2 The Functioning of the Electricity Market

Due to all the peculiarities of electricity, its market develops in different steps. First, the day before the delivery of electricity the equilibrium quantities and prices are determined hour by hour in a wholesale market. Quantities and prices can differ not only in time, but also in space because of the potential existence of different geographical zones, which are separated by transmission bottlenecks. The day after, at the time of delivery, the prices and quantities are adjusted in order to ensure a perfect match between demand and supply and to avoid any risk of imbalance between demand and supply that might arise from any possible inconvenience (e.g., unexpected bottlenecks, unavailability of a plant that was called into operation and so forth).

Generation prices that are contracted at the exchange markets may thus differ from the retail price that consumers pay in practice also for other reasons. These reasons include the lack of competition in the final retail market or the presence of financial instruments (long-term contracts) aimed at sharing the risk and reducing the electricity price volatility, which mainly depends on the variable trend of the fuel prices.

In order to analyse the impact of the ETS on electricity markets, prices and related emissions, it is better to refer to generation prices rather than retail prices, which might be influenced also by other variables which are not relevant for our research purposes. Moreover, rather than looking at future prices, this analysis focuses on spot prices which are influenced by fuel prices, plant availability, weather, temperature and climate conditions (which influence both the demand that some seasonal and daily cycles present and the availability of renewable plants) and, after the establishment of the ETS, also by CO_2 prices.

Competition in electricity markets works differently from that in the economic models of Cournot, where firms compete in quantities, and from that in the model of Bertrand, where firms compete in prices. In order to determine the quantity to be supplied in each hour of the day—the equilibrium price at which plants are called to generate electricity— all the generators submit a bid function (i.e., supply bid function competition) each hour of the day to a central dispatcher. This bid function contains one or more possible combinations of quantities and prices: for each owned plant the generator specifies the minimum price at which he or she is willing to supply energy, jointly with the maximum amount of electricity he or she is able to produce in that specific hour. The combinations of quantity and supply can differ depending on the plants' available capacity and marginal production costs (Green and Newbery 1993, Borenstein et al 1999, OECD 2003). Once all the bids have been submitted, the central dispatcher collects and classifies them in order of their capacity to build the hourly *merit order* supply function: the supply function is determined by ordering the different bids according to the price at which they can be supplied. The merit order criterion is aimed at minimizing the total cost for each level of production. The result is a supply step function where plants are called to operate according to their increasing marginal costs, i.e., generally nuclear, lignite, coal, gas, heavy fuel oil and light fuel oil (Feher and Harbord 1993, Armstrong et al. 1994). The demand curve, on the contrary, is determined by ordering all the potential demanders according to the maximum price they are willing to pay (i.e., the so-called reserve price).

Once the dispatcher builds the supply and demand curves for each hour, the point where they cross determines the equilibrium quantity and price. Such a price is called the System Marginal Price because it corresponds to the price offered by the last marginal plant called to produce, the so-called marginal plant. Therefore, the market price is set by the marginal bidder who produces electricity in the least efficient way at the highest marginal cost and the same price is paid to all the other operators called to produce and who had offered a quantity at a price lower than the System Marginal Price. The merit order criterion determines which units are going to be dispatched in any hour, and, of course, the bigger the gap between the price bid and the market price, the higher the profitability of the operator. This criterion gives electricity generators an incentive to develop more efficient technologies since the probability of being called to supply electricity and the relative profitability increases as the marginal costs of production decrease with respect to the marginal plant called into operation.

6.3 The Merit Order Function after the ETS

While in the long run emissions can be reduced by investing in cleaner efficient technologies, in the short term, when R&D investments cannot bring any substantial emissions reduction, emissions can be reduced basically either by producing less or by using less carbon-intensive fuels and technologies. Particularly, in the energy market, emissions can be reduced in the short run by switching electricity generation from coal to gas burning. Indeed, coal is a more carbon intensive fuel than gas.

Therefore, in order to establish ex-post how effective the ETS has been in promoting emissions reduction in a cost effective way, it can be useful to investigate whether the CO_2 price has been sufficiently high to induce a fuel switch from coal to gas within a plant that can burn both fuels or, equivalently, to promote a switch in the merit order function between the coal plants and the gas fired plants. Before a price has been attached to the emissions of CO2, *ceteris paribus* and depending on the level of demand, a coal plant could be called to generate electricity instead of a gas fire plant—or vice versa—depending on their relative prices. According to the historical trend of gas and coal prices, generating electricity using coal has been on average cheaper than burning gas, and, consequently, it has been more convenient to produce electricity burning coal and emitting more CO_2 rather than switching to gas and reducing GHG emissions. Coal plants have usually preceded gas fire plants in the merit order supply function; however, after the ETS was established, the economical benefits of burning gas or coal now depends, among other factors, on the price to be paid for any CO_2 ton released into the atmosphere. Coal is more carbon-intensive than gas, so as the CO_2 price increases, gas becomes relatively more economical than coal. In fact, it has been previously recalled that ETS installations can adopt a *make or buy* strategy: plants operating in the power generation sector can alternatively decide to burn the more carbon-intensive coal and buy in the ETS the additional permits they need to cover their *emissions gap*. Alternatively, they can switch production from coal to gas, emitting a lower amount of GHGs and thus lowering the number of permits to acquire in the ETS. Hence, as it will be argued more extensively in the next chapters, in spite of being initially assigned at no charge, grandfathered permits have an opportunity cost equivalent to their market price which firms have to internalize and pass through to the final price that is proposed in the supply bid function. Different arguments have been generally provided by private industry to explain why the value of allowances assigned at no cost cannot be incorporated in the final price. First, European installations are not able to increase the final price because they would loose market share to extra-EU firms that are not subject to any environmental cost and that would offer the same good at a lower price. Second, the elasticity of the demand works as a natural limit to the ability of increasing final prices since consumption would shift to more economical products. These arguments can be valid for many industrial sectors, and will be analysed more extensively when describing the risk of carbon leakage. They do not, however, hold in the case of electricity markets simply because, due to transmissions constraints, electricity generators are naturally protected against international competition (imports constitute a limited percentage of the consumed electricity). Moreover, the demand of electricity is particularly rigid and inelastic when it comes to increases in prices.

Once it has been recognized that freely allocated allowances have an opportunity cost determined by the potential revenue that could have been earned by reducing emissions and selling the exceeding amount of allowances at the ETS market price, it becomes clear that, after the ETS has been launched, the economical benefit of burning gas instead of coal depends, among other factors, on the price to be paid for any ton of CO_2 released into the atmosphere.

Depending on the gas and coal fuel prices and on how expensive it is to cover the production of an extra-ton of CO_2 with the acquisition of an allowance in the ETS, firms that have the technological possibility of an internal fuel switch will decide whether to burn coal or switch to gas. At the same time, the central dispatcher will evaluate if, once the costs of CO_2 are incorporated in the final electricity prices, coal plants are still more efficient than gas plants, thus preceding them in the merit order supply function, or vice versa.

Based on the real gas and coal prices, it is possible to calculate the theoretical price of the allowances that would make generating power from a 38% efficiency coal generator and from a 53% efficiency gas generator comparable. This indicator is called *theoretical coal-to-gas indifference switch price*. Then, whenever the real CO_2 price exceeds the *coal-to-gas switch price*, burning gas is more economical than using coal. This means that the ETS is effective in giving an incentive to switch to less-carbon intensive fuels. As a consequence, the amount of emissions released per megawatt hour (MWh) of electricity generated decreases, and it would be possible to conclude that the ETS is creating effective incentives for reducing emissions in the electricity generation market by promoting a switch of production toward less carbon intensive fuels. Vice-versa, whenever the CO_2 price—determined within the ETS and depending on the dynamics of the allowances' demand and supply functions—is lower than the theoretical coal-to-gas switch price, it implies that the ETS has failed to give an incentive to reduce emissions via fuel switching. Finally, a theoretical switch price lower than zero implies that, according to the real gas and coal prices, burning gas would be the most economical option even in the absence of a trading scheme that attaches a price to the emissions of GHGs. If this were the case, burning coal instead of gas would be more economical only if the CO_2 prices were negative.

In addition to analyzing the effects of the CO_2 prices on the economic benefits of adopting one technology over the other, the economic literature has also investigated the impact of the CO_2 prices on the final market prices and on the firms' profitability. Sijm et al (2006) define the CO2 costs' pass through as "the average increase in power price over a certain period due to the increase in the CO2 price of an emission allowance" (p. 4). However, many empirical studies have demonstrated that after the first year of the ETS, the correlation between electricity and CO_2 price was lower than 1, implying that pass through occurred at a rate lower than 100%. Many scholars have tried to explain the potential reasons behind this divergence. Sijm et al (2006) argue that, while the generators *add-on* the full opportunity costs of CO_2 allowances into the electricity price, still the increase of the final market price could be lower than the allowances opportunity costs for different reasons. First, it is possible – but not probable – that higher power prices reduce the demand, thus moving the market equilibrium up to a point where the marginal price would be set by a cheaper generator. In this case, the electricity price marginal increase is lower than the CO_2 opportunity cost because of the response of the market demand. This phenomenon can also be explained in the case that the real CO_2 price incorporated in the generation marginal costs is higher than the theoretical coal-to-gas switch price, a situation that then induces a switch of the plants' merit order in the supply curve. Moreover, the electricity price might increase less proportionally than the CO_2 price in the case that markets are not competitive. This argumentation will be further discussed in the next chapters, but intuitively it can be useful to consider that in perfectly competitive markets—where the market price equals the production marginal costs—a variation in marginal costs is always reflected in an equivalent variation in prices. Meanwhile, in non-competitive markets, prices might increase less proportionally than the cost increase because they are already kept at an artificially high level, and it would be not profitable to increase them by the same amount of the increase in marginal costs (Kate and Niels 2005; Levy 2005; Derek and Fezzi 2007).

7. Conclusions

This section has introduced the economic and legal background concerning the ETS that is important to know for the purpose of this research. First, the origins of the ETS have been introduced, and the nature of the European Union allowances has been discussed within the field of private property law. While different MS have given different interpretations of the emissions allowances, highlighting on one hand their similarities with intangible intellectual property and, on the other, their nature of financial instruments which can be adopted as securities. This chapter has stressed that allowances are different from a permanent and private property right; rather, they are the result of an authorization that can be terminated or limited by the government. Therefore, the law and economics literature prefers to characterize allowances as mixed, hybrid or regulatory property rights. Moreover, the length and scope have been introduced in order to explain the substantial differences that emerge between the ETS and the Kyoto Protocol, suggesting that compliance with the ETS European legislation does not necessarily imply compliance with the Kyoto Protocol commitment. Then this section has discussed the role of MS, which—according to the principle of subsidiarity— are called to design a national allocation plan where the amount of allowances to be assigned at a national level and the criteria of distributing them have to be specified and submitted to the European Commission. In many areas the delegation of the decision-making procedure at a decentralized level has limited the harmonization of the market for tradable permits. This research is aimed precisely at investigating to what extent this lack of internal harmonization can distort the ETS' effectiveness in promoting emissions reduction in an efficient and cost-effective way.

Finally, this section has described the potential impact of the EU ETS on the electricity market, illustrating with a practical example how the monetization of the CO_2 can promote the reduction of emissions in the generation of electricity by inducing a switch from most polluting to less- carbon intensive technologies and fuels. For this purpose, the indicator of CO_2 theoretical coal-to-gas switch price is introduced. The purpose of this section has been to provide the background information required to develop an analysis of the ETS' effectiveness in the next chapters.

Chapter 5. Analysis of the Effectiveness of the EU ETS: Assessing the Stringency of the ETS Cap[14]

1. Introduction

With the 2002 ratification of the Kyoto Protocol, the former fifteen MS of the European Union committed to reduce European GHG emissions to 8% below the 1990 emissions level by 2012. In this context, the European Directive 87/2003/EC has established a system of tradable allowances (the European Emissions Trading Scheme – EU ETS) in order to promote "reductions of GHG emissions in a cost-effective and economically efficient manner"(EC, 2003: Art. 1). The EU ETS covers only part of the GHG polluting sources; thus, compliance with the terms of the first ETS Directive does not necessarily imply compliance with the Kyoto targets.

The general purpose of this chapter is to bring new insight to the wide-spread debate aimed at assessing the effectiveness of the ETS in promoting emissions reduction in a cost-effective way, as stated in the ETS Directive. In particular, this chapter analyses the extent to which MS are effectively relying on the ETS to comply with their Kyoto commitments. This analysis is then used to determine whether the emissions reduction burden deriving from the ratification of the Kyoto Protocol has been divided between ETS and non-ETS sectors in a cost-effective way. Therefore, this chapter focuses mainly on the ETS cap and on its stringency, where the ETS cap indicates the proportion of emissions that the ETS sectors are legally required to abate and, consequently, the amount of emissions that the non-trading sectors have to reduce to comply with Kyoto commitments. The stringency of the ETS cap is assessed by investigating whether allowances have been over-allocated during the first and second ETS trading periods. Different methodologies have been suggested to measure the size of allowances over-allocation and to assess the effectiveness of the EU ETS. Notably Ellerman and Buchner (2006) have compared the ETS verified emissions with the Business as Usual (BAU) emissions (i.e., the theoretical amount of projected emissions that should have been produced in the absence of the ETS) showing that during the first ETS year both the ETS cap and the emissions produced by the ETS sectors were lower than the emissions that would have been produced in the absence of the ETS. The authors conclude that permits have not been over-allocated and that

[14] Part of this chapter has been published as a research article in the international review *Climate Policy*. For major details see: S. Clò (2009), "An analysis of the EU Emissions Trading Effectiveness," *Climate Policy*, 9, 227–241.

the ETS is effective in promoting emissions reduction.

Based on a different methodology, this chapter reaches different conclusions. Over-allocation is defined here as occurring when the ETS cap exceeds a theoretical ETS cap that would impose an emissions reduction burden on the ETS sectors proportional to the share of European emissions they produce. This chapter finally analyses the inefficiencies, which emerge in the MS where over-allocation is detected. There is no doubt that the emissions produced by the ETS sectors have been lower than their counterfactual BaU emissions, as Ellerman and Buchner clearly show, and thus emissions have been reduced to a certain extent since the establishment of the ETS.

Nevertheless, this analysis shows that during the first and second trading periods of the ETS over-allocation took place, implying that so far the ETS has not been sufficiently effective in inducing the emissions reduction required to comply with the Kyoto Protocol emissions reduction target. Moreover, this ETS cap stringency analysis clarifies how the Kyoto emissions reduction burden has been divided between ETS and non-ETS sectors, highlighting to what extent the EU and different MS rely on the ETS flexible economic mechanism to comply with the Kyoto target.

This analysis assesses whether the emissions reduction burden has been split among ETS and non-ETS sectors in a cost-effective way and then identifies which inefficiencies emerge when permits are over-allocated to the ETS sectors.

The chapter is structured as follows. Section 2 describes the partial results achieved by the ETS during its first phase (2005–2007), while section 3 presents the methodology that Buchner and Ellerman (2006) adopted to assess whether allowances had been over-allocated. Then section 4 briefly describes the content of the second NAPs. In section 5, the stringency of the ETS cap is assessed according to an alternative methodology; then, the required data and sources of information are discussed. Section 6 assesses the ETS first and second phase cap stringency at a national and European level, determining which MS over-allocated allowances. In section 7, the inefficiencies linked with over-allocating allowances are analysed. Finally, section 8 concludes.

2. Interpreting the EU ETS Results During the First Trading Period

On January 2005, after the EU ETS was officially launched, allowances could be purchased at a price of 7 Euro per ton (monthly average). In the following months, the price constantly increased, exceeding the 20€/ton threshold. In 2006, the market for tradable permits experienced a liquidity explosion: the permit volume traded between January and April 2006 was higher than the overall quantity of permits traded in 2005, and the CO_2 price progressively increased to its maximum peak—the highest ever registered during the ETS first trading period. In spite of bullish expectations across the European exchanges,[15] after peaking at 29.7 €/ton, in April 2006 the CO_2 price suddenly diminished by 20 €/ton in correlation with the publication of the EC "Verified Emissions data", according to which in 2005 the ETS sectors emitted 80 million tons of CO_2 less than the amount of assigned permits.

[15] On April 21st the EUAs price was 29.1 Euro/ton, and Pointcarbon, the recognized world-leader carbon market analyst, published in its Carbon Market Europe weekly reports an editorial by the UBS Investment Research's executive director entitled "CO_2 price still too low".

Table 4 - 2005 Allocated Permits and Verified Emissions (Mt CO_2)

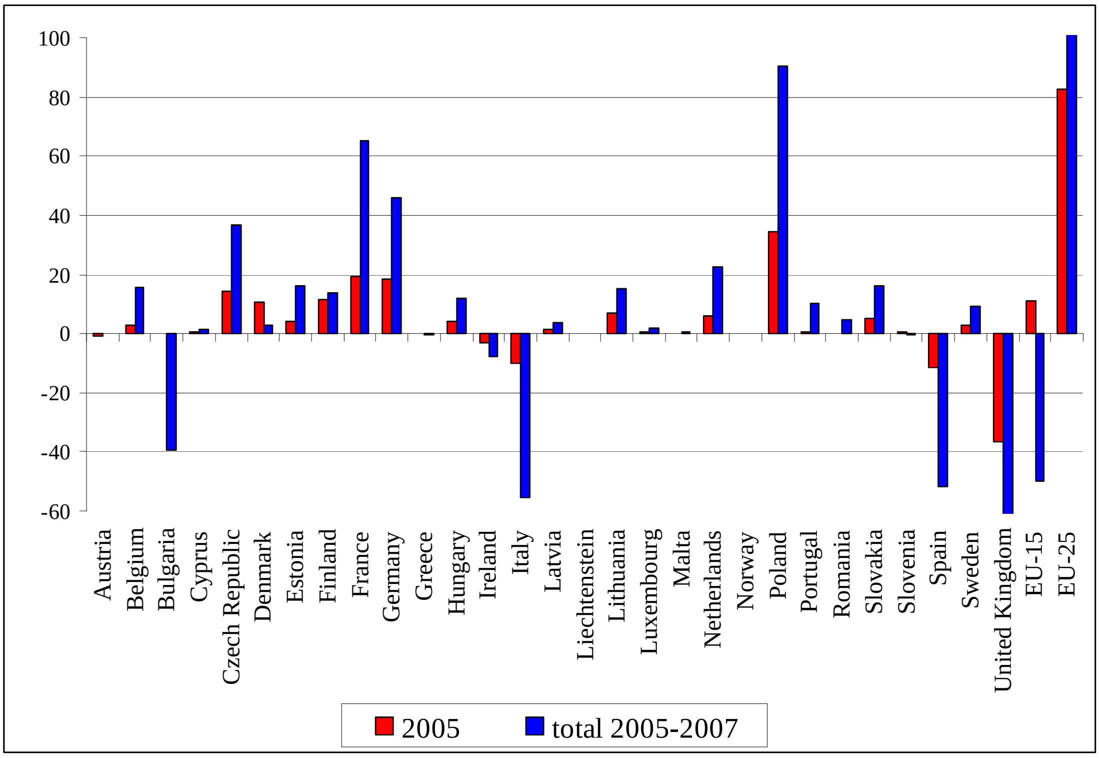
	2005 Permits Allocation	2005 ETS Verified Emissions	Gross Short[16]	Gross Long[17]	Net Long (+)/Net Short (-)
Austria	32.4	33.4	3.3	2.3	-1
Belgium	58.3	55.4	9.9	12.9	3
Cz Republic	96.9	82.5	0.16	14.6	14.4
Denmark	37.3	26.5	0.1	10.9	10.8
Estonia	16.7	12.6	0	4.1	4.1
Finland	44.7	33.1	0	12	12
France	150.4	131.3	4.2	23.3	19.1
Germany	495	474	25.2	46.2	21
Greece	71.1	71.3	5.3	5.2	-0.1
Hungary	30.2	26	1.2	5.4	4.2
Ireland	19.2	22.4	4.2	1.1	-3.1
Italy	215.8	225.3	28.4	18.9	-9.5
Latvia	4.1	2.9	0	1.2	1.2
Lithuania	13.5	6.6	0	6.9	6.9
Luxembourg	3.2	2.6	0	0	0
Netherlands	86.5	80.4	6	12.2	6.1
Poland	235.6	205.4	0.5	28.6	28.1
Portugal	36.9	36.4	1.8	2.2	0.4
Slovakia	30.5	25.2	0	5.2	5.2
Slovenia	9.1	8.7	0.1	0.5	0.4
Spain	172.1	182.9	34.8	24	-10.8
Sweden	22.3	19.3	3.1	6.1	3
UK	206	242.5	50.9	14.5	-36.4
Total	2,087.8	2,006.6	179	259	**79**

Source: European Commission 2006; Ellerman and Buchner 2006

[16] Gross short is the sum of the permits' shortage taking into account exclusively those plants that in 2005 produced more emissions than the permits they had

[17] Gross long is the sum of all the permits surplus just taking into account those plants that in 2005 produced less emissions than the permits they initially owned

Figure 7 - Difference Allocation - Verified Emissions (Mt CO2)

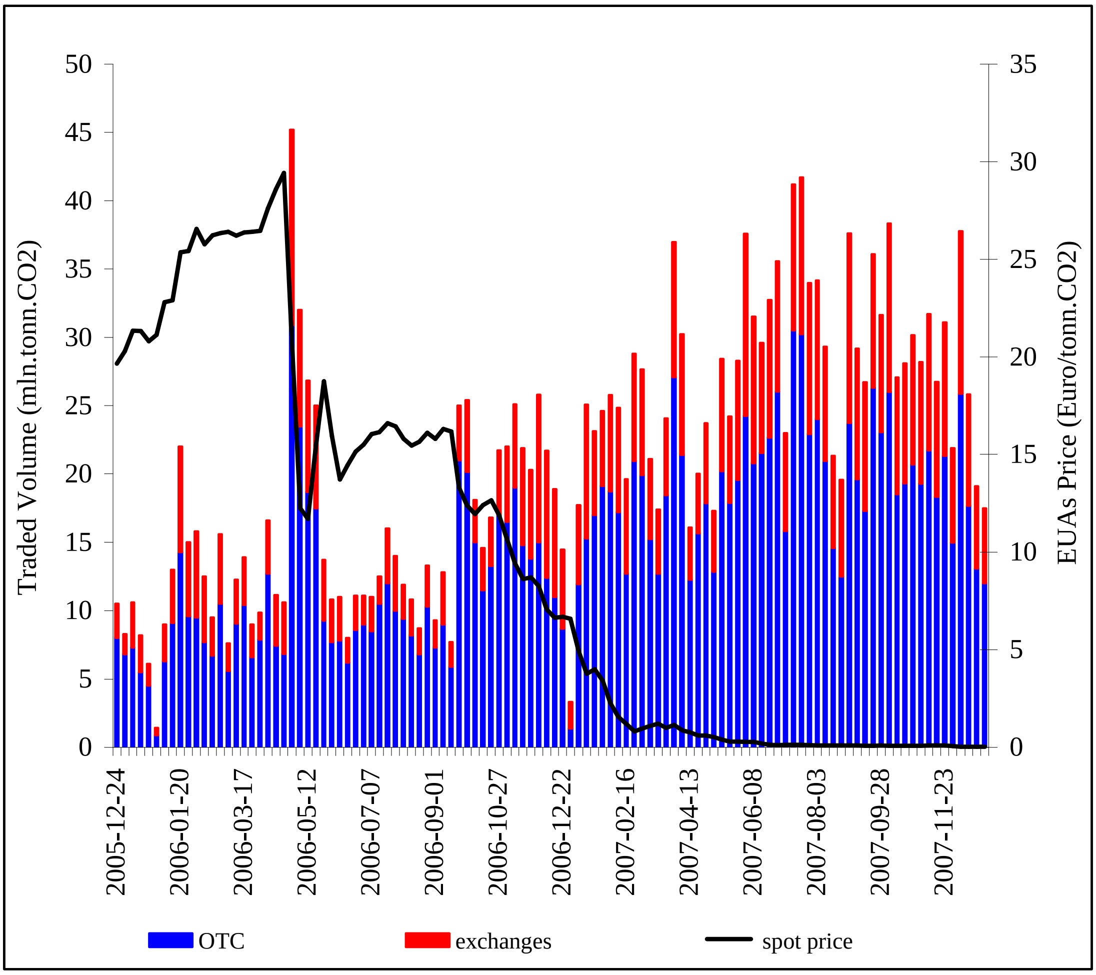


Source: CITL

After this unexpected crash, the spot price of allowances fluctuated in a volatile range between 14 and 19€ until September 2006. As shown in table 4, this price volatility can be explained by the significant room for bargaining that was still of interest to the ETS operators; indeed, in spite of the aggregate permit surplus in the market, different players were still in a gross short position, thus having to acquire some permits in order to cover their long position and comply with the ETS Directive (figure 7).

Given this huge excess of permits combined with the impossibility of banking allowances to the next trading period, after September 2006 the CO_2 price started to fall progressively toward zero, where it stayed until the end of the first phase. Figure below depicts the CO_2 spot price trend during the first ETS phase.

Figure 8 – CO_2 Spot Price and Traded Volume during the 1° ETS Trading Period



Source: elaboration from PointCarbon

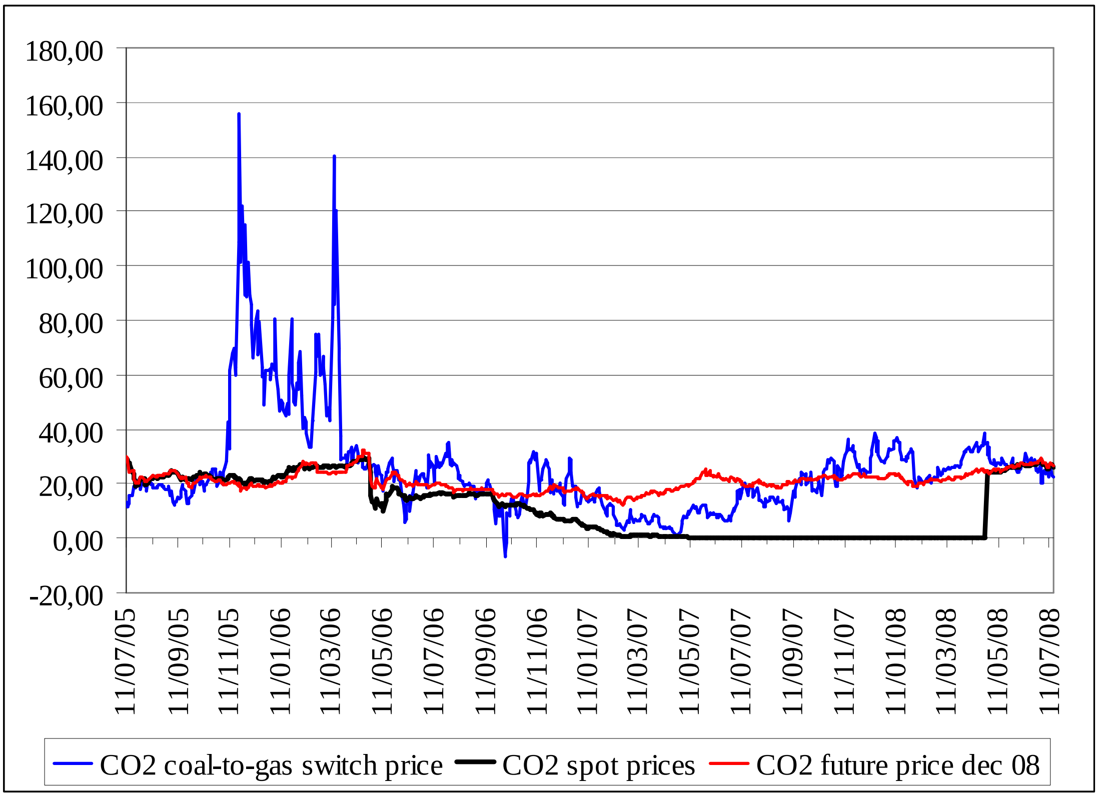
The unexpected collapse of the CO_2 price toward zero has compromised the ETS effectiveness in promoting emissions reduction in a cost effective-way. In spite of being quite intuitive, this assertion needs to be supported by appropriate data and arguments. First, it can be argued that the CO_2 price established in the ETS can be considered a proxy of the cost of the environmental externality that the industrial and energy installations are required to internalize in the marginal production cost. However, as long as the CO_2 price tends toward zero, then this implies that the European climate policy is failing to induce any internalization of the external costs of climate change. Second, the incentive to reduce emissions that is given by the ETS and by the CO_2 price can be roughly estimated by comparing the CO_2 price with the *CO_2 theoretical coal-to-gas switch price.*

As explained in the previous chapter, emissions can be reduced in the short run by switching production from more polluting to less carbon-intensive fuels and technologies. In the energy market, electricity can be generated alternatively by coal plants and by cycle combined gas turbine (CCGT) fired plants. Gas plants are leaner than coal plants because they are more efficient (i.e. they have a higher thermal performance) and because they burn a less carbon-intensive fuel; however, coal plants tend to be more economical, since coal is on average cheaper than gas. Therefore, private companies tend to prefer coal over gas, while the central dispatcher tends to call into operation first the coal plants. This in turn results in a higher level of emissions. The establishment of the ETS can have a significant impact on the merit order between gas and coal plants: after the CO_2 emissions have been monetized and the electricity generators have been required to internalize this cost, coal plants—which are more carbon intensive—have to pay a higher environmental cost, worsening their competitiveness against gas plants.

Based on the historical prices of coal and gas weighted by the plants thermal efficiencies and by the fuels CO_2 emissions factors, it is possible to calculate the theoretical CO_2 price that would make the generation of electricity through the burning of gas or fuels equally preferable. Then, the comparison between the real CO_2 price and the theoretical CO_2 switch price allows us to infer whether the ETS has succeeded in giving electricity generators an incentive to reduce emissions by switching from coal to less carbon-intensive fuels. In fact, whenever the real CO_2 price is lower than the theoretical CO_2 coal-to-gas switch price, then generating electricity by using coal instead of gas is more economical. As a result, in this case it is clear the ETS has failed to give substantial incentives to reduce emissions. On the contrary, when the real CO_2 price is higher than the theoretical CO_2 switch price, then the electricity generators will find it more economical to use gas instead of coal, and the electricity merit order supply function will experience a shift between the gas and coal plants. In this case, the ETS has succeeded in giving substantial incentives to reduce emissions, promoting a win-win strategy: after the CO_2 emissions have been monetized, the less carbon intensive technology becomes also the most efficient one. The switch toward less carbon-intensive fuels is both economically rational and environmentally compatible.

The following figure compares the real and the theoretical CO_2 prices, while Appendix I illustrates how the theoretical CO_2 coal-to-gas price has been calculated and reports the data that has been used to develop this comparative analysis.

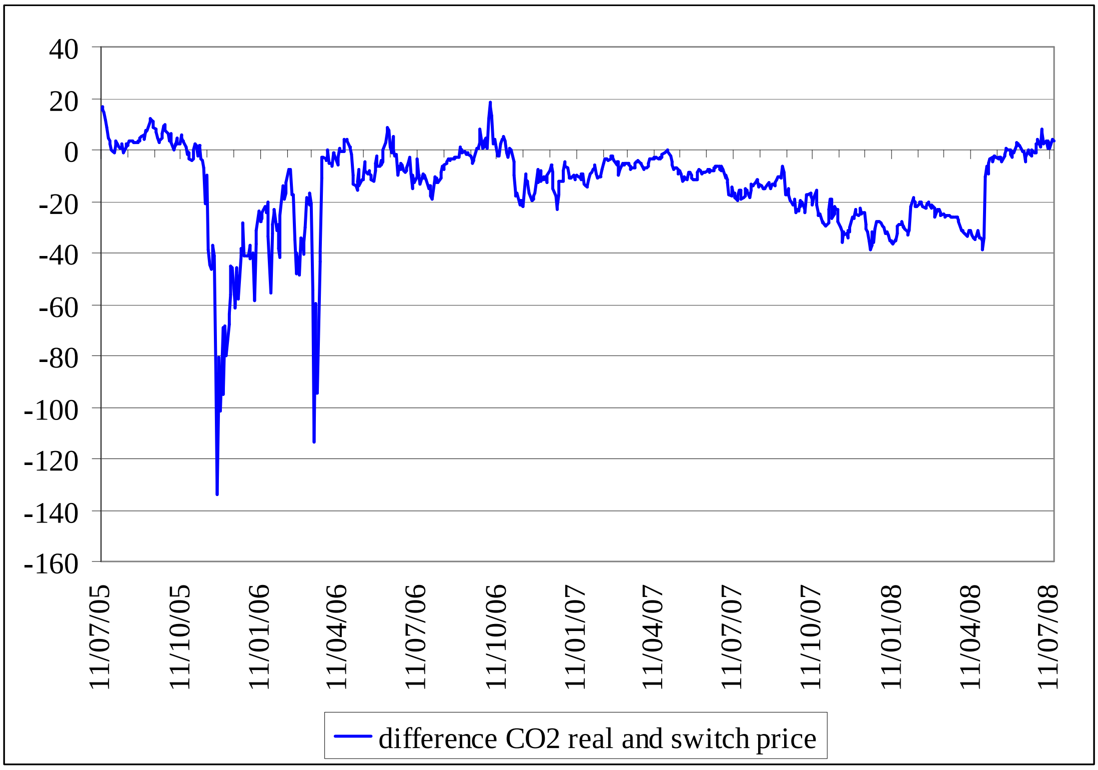
Figure 9 – Theoretical Coal to Gas CO_2 Switch Price and CO_2 Real Spot and Future Prices (€/Mwh)



Source: own elaboration

The following figure reports the difference between the CO_2 real and the theoretical coal to gas switch prices: whenever the difference line is greater than zero, then the ETS has induced emissions abatement through a fuel switch, while in the opposite case, the ETS has failed to give sufficient incentive to promote emissions abatement in the electricity market.

Figure 10 – Difference between CO_2 Real and the Theoretical Coal to Gas Switch Prices (€/MWh)



Source: own elaboration

According to this comparative analysis, in the period that goes from the second half of 2005 through the first half of 2008 the real price is higher than the switch price only during a few periods (summer 2005, October 2006—which, however, presents a negative switch price implying that gas was more economical even without taking into account the cost of CO_2 emissions—and after April 2008 when the 2007 allowances were finally surrendered and the first ETS trading period was officially closed). During all the periods then CO_2 prices crashed toward zero, the ETS did not give any incentive to abate emissions.

3. Assessing Over-allocation: The Ellerman and Buchner Analysis

The CO_2 price collapse toward zero and the 80 million tonnes gap between the ETS cap and the amount of emissions produced by the ETS sectors seem to suggest that during the first ETS trading period the ETS regulation did not work properly.

However, *prima facie*, there is no evidence showing that the 80 million permit surplus is effectively a consequence of the over-allocation of permits by the competent regulatory authorities. In theory, emissions abatement on behalf of the ETS sectors could explain the 80 million gap between the ETS emissions and the ETS cap.

In the latter case, it would be possible to assert that the ETS is promoting an emissions abatement on behalf of the ETS installations, whereas the CO_2 price drop is just a consequence of the correct functioning of ETS market fundamentals. Therefore, an assessment of the ETS cap stringency is required to understand if over-allocation took place, to assess the effectiveness of the ETS in inducing emissions reduction and to evaluate to what extent the ETS sectors are contributing, with respect to non-ETS sectors, to the Kyoto target's achievement.

"Over-allocation" is not a clearly defined concept: while the term implies that too many allowances have been allocated, it does not give any precise indication regarding how many excess allowances have been given out. To assess whether, and to what extent, over-allocation has occurred, a benchmark needs to be defined; that is, a theoretical cap that reflects the optimal amount of allowances should be assigned. Any amount above this cap implies over-allocation. Once such a benchmark has been determined, it becomes possible to establish whether over-allocation took place and, if this is the case, to assess its magnitude.

Different studies evaluate whether allowances have been over-allocated. Notably, Buchner and Ellerman (2006) have chosen as their benchmark the level of 2005 "Business as Usual" (BaU) emissions: the hypothetical amount of emissions that would have been produced in 2005 by the ETS sectors if the EU ETS had not been established. The authors explain this choice by arguing that "all would agree that handing out more allowances than BaU emissions would constitute over-allocation" (Buchner and Ellerman, 2006: 6). This observation is unquestionably true; however, as the authors themselves recognize, the chosen benchmark is a counterfactual value that can never be observed and that can only be estimated (e.g. Grubb and Ferrario 2006). The authors assume that, in the hypothetical absence of the ETS, the amount of emissions produced by the ETS sectors would have increased at an annual rate determined by the product of the real GDP growth rate and the annual rate of change of carbon intensity. The authors estimate the level of ETS BaU emissions by multiplying the estimated baseline of the ETS historical emissions, as reported in the MS NAPs,[18] by the annual GDP growth rate observed in each MS between 2002 and

[18] Official and reliable data of the ETS emissions was published only after the ETS' establishment; the amount of emissions produced by the ETS installations before the ETS was launched is unknown and can only be estimated.

2005; finally, they adjust this value with the CO_2 intensity change rate that was experienced between 2000 and 2004 in each MS (Appendix II). The authors estimate that the counterfactual 2005 BaU emissions produced by the ETS installations would have been 143 million higher than the amount of CO_2 emissions produced in 2005.

Obviously, the size of permit over-allocation, determined by the difference between the 2005 ETS BAU emissions and the level of allocated permits in the same year, differs depending on how BaU emissions are calculated: being an estimation that can never be observed, the counterfactual risks being biased in both upward and downward directions.[19] Of course, Ellerman and Buchner are perfectly aware of this problem, and, after taking into account the possible biases, they adjust the counterfactual concluding that, compared to the BaU emissions scenario, ETS 2005 verified that "emissions were reduced by an amount that was probably larger than 50 million tonnes and less than 200 million tonnes" (p. 34).

Moreover, in 2005, the number of allocated permits was lower than the level of BaU emissions projections (Appendix II). Thus, according to the benchmark chosen by Ellerman and Buchner, over-allocation should not have taken place. In the following citation, Parsons et al (2009) returns to this topic, arguing that:

> *the gradual drop in the spot price for the first phase (…) led to many ill-informed statements that the European system had been "overallocated" allowances and that the EU-ETS was a failure in reducing carbon emissions. The zero price is not a reflection of the allocation. Instead, it reflects the seam between 2007 and 2008 built into the EU-ETS's use of discrete phases without any banking or borrowing allowed between the phases. The cap remained what it had always been, and aggregate emissions were below the cap due to some combination of error in estimating baseline emissions, abatement and the randomness of actual emissions. So, in the first phase, the EU-ETS succeeded in capping emissions exactly where it had started out to cap emissions, and there was no failure from the perspective of the*

[19] For instance, the ETS historical emissions baseline reported in the MS' NAPs might be upwardly biased as the data collected in the NAP were prominently voluntary submissions by the industries. The fact that the allowances were grandfathered proportionally to historical emissions gives industries an incentive to resolve uncertainties in favour of higher emissions: the more emissions were produced in the past, the higher the number of allocated permits would have been (Ellerman Buchner 2006)

original system's goal. (p.9)

There is no question that, after the establishment of the ETS, emissions have been reduced compared with the BaU scenario, and the idea that prices dropped toward zero mainly because of the impossibility of banking allowances from one trading phase to the next has been widely accepted; however, this information is not sufficient to evaluate the effectiveness of the ETS in any exhaustive manner. Parsons et al (2009) conclude that *the ETS succeeds in capping emissions* and that *there was no failure from the perspective of the original system's goal,* but they do not assess how much the ETS is contributing to the achievement of the Kyoto Protocol target. Rather than estimating how much of the emissions has been abated after the establishment of the ETS, this chapter aims at understanding how much the ETS is contributing to emissions reduction compared with the non-ETS sectors, and to what extent MS are relying on the ETS to achieve their Kyoto emissions reduction targets in a cost-effective way. With these goals, the following section introduces an alternative methodology to assess over-allocation.

4. The ETS Cap for the Second Trading Period

The European Directive 2003/87/EC divides the ETS in different phases: beginning in 2008, a five-year phase follows the first three-year pilot phase (2005-2007). Art. 9 of the EU ETS Directive specifies that "for each period [...] each MS shall develop a national plan stating the total quantity of allowances that it intends to allocate for that period." Moreover, Art. 13 establishes that "allowances shall be valid for emissions during the period [...] for which they are issued." These articles imply that for any new phase MS have to specify with a new NAP the amount of the permits they intend to allocate to each plant every year within that specific ETS phase (e.g. Neuhoff, Martinez and Stato 2006). Therefore, the emissions rights surplus registered during the first ETS phase (2005-2007) cannot be banked and transferred from this phase to the next one. Thanks to this temporal subdivision, national and European legislators had the possibility to ensure permit scarcity for the second phase independently of the permit surplus registered during the first phase.

After these NAPs were submitted, the EC imposed in total a permit cut of 245 million per annum.

Table 5 - 2008-2012 Proposed and Approved National Allocation Plans

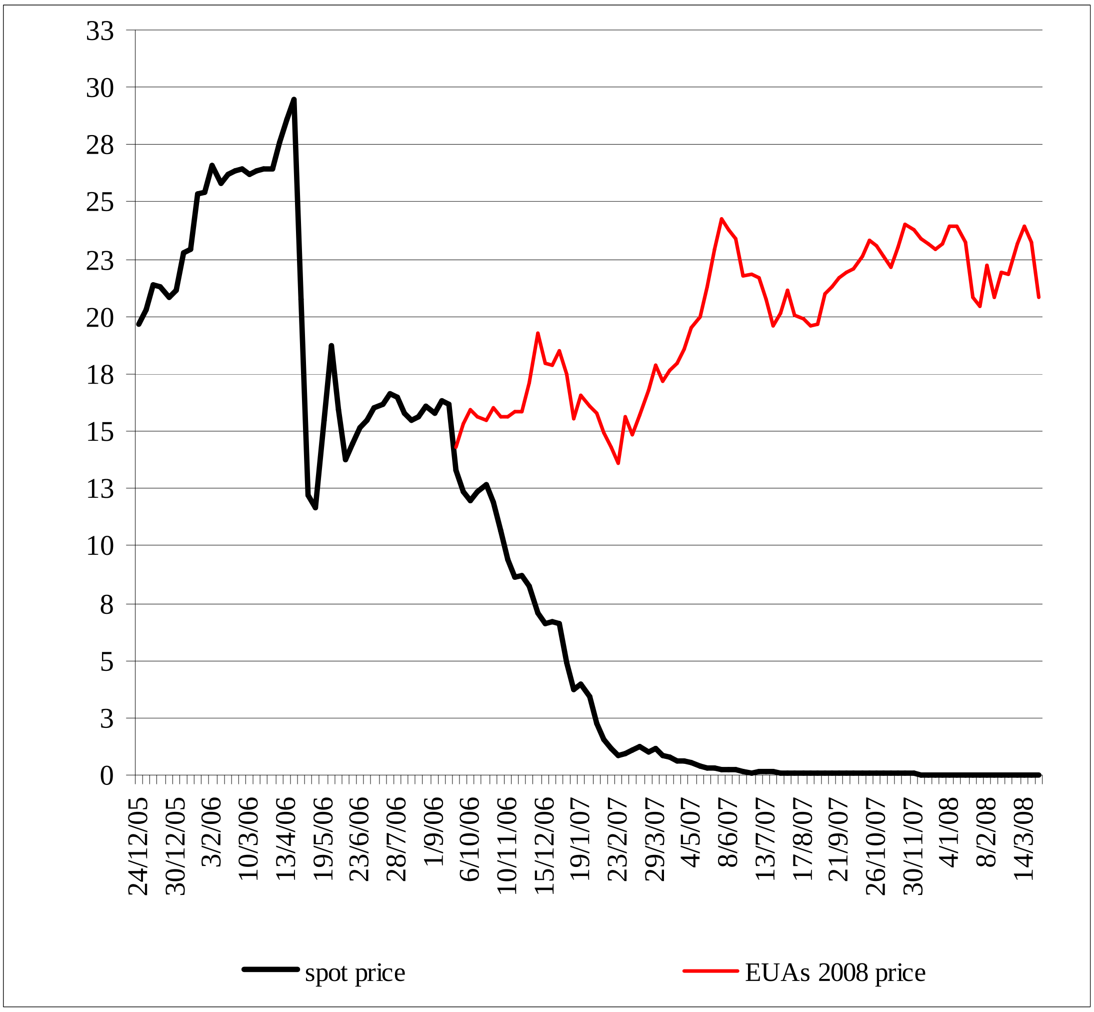
	First Period Cap	2008 – 2012 Proposed Cap	2008 – 2012 Approved Cap	EC Cut to 2008- 2012 Proposed NAPs (Mt Co2)	EC Cut to 2008- 2012 Proposed NAPs (%)
Austria	33	32.8	30.7	-2.1	-6.4
Belgium	62.1	63.3	58.5	-4.8	-7.6
Bulgaria	42.3	67.6	42.3	-25.3	-37.4
Cyprus	5.7	7.12	5.48	-1.64	-23
Czech Rep.	97.6	101.9	86.8	-15.1	-14.8
Denmark	33.5	24.5	24.5	0	0
Estonia	19	24.38	12.72	-11.66	-47.8
Finland	45.5	39.6	37.6	-2	-5.1
France	156.5	132.8	132.8	0	0
Germany	499	482	453.1	-28.9	-6.0
Greece	74.4	75.5	69.1	-6.4	-8.5
Hungary	31.3	30.7	26.9	-3.8	-12.4
Ireland	22.3	22.6	22.3	-0.3	-1.3
Italy	223.1	209	195.8	-13.2	-6.3
Latvia	4.6	7.7	3.43	-4.4	-57.1
Lithuania	12.3	16.6	8.8	-7.8	-47.0
Luxembourg	3.4	3.95	2.5	-1.25	-31.6
Malta	2.9	2.96	2.1	-0.86	-29.1
Netherlands	95.3	90.4	85.8	-4.6	-5.1
Poland	239.1	284.6	208.5	-76.1	-26.7
Portugal	38.9	35.9	34.8	-1.1	-3.1
Romania	74.8	95.7	75.9	-19.8	-20.7
Slovakia	30.5	41.3	30.9	-10.4	-25.2
Slovenia	8.8	8.3	8.3	0	0
Spain	174.4	152.7	152.3	-0.4	-0.3
Sweden	22.9	25.2	22.8	-2.4	-9.5
UK	245.3	246.2	246.2	0	0
SUM	2,298.5	2,325.31	2,079.85	-245.46	-10.7

Source: CEC 2007c

While the 2008-2012 cap proposed by MS (2,320 million permits) would have allocated almost 200 million permits more than the amount of ETS 2005 verified emissions (2,122 million), the cap approved by the European Commission (2,080 millions permits) is lower than both the first period cap and the 2005 ETS emissions.

It is interesting to observe that the EC's stricter intervention in the second phase NAPs had a significant influence on the trend of the CO_2 future prices relative to December 2008. As shown in the figure below, after September 2006, while spot prices started their path toward zero, future prices started to increase above the threshold of 20 Euros per ton of CO_2.

Figure 11 – Trend of CO2 Spot and Future Prices during the First ETS Trading Period (€/ton)



Source: own elaboration on Pointcarbon

However, this consideration is not sufficient to conclude that over-allocation has not occurred during the second phase. The ETS 1st and 2nd cap data just presented will be compared with a new benchmark that is different from the BaU emissions level proposed by Ellerman and Buchner. In the next section, we propose an alternative methodology built to assess the stringency of the ETS 1st and 2nd cap.

5. A Benchmark for Evaluating the Stringency of the ETS Cap

The 2008–2012 NAPs submitted to the European Commission have proposed that almost 200 million allowances more than the amount of ETS 2005 verified emissions should be allocated during the second phase. However, in order to ensure that allowances have a scarcity value, the EC has reduced the proposed cap by 245 million allowances per annum (–10.5%) to a level that is lower than both the first period cap and the 2005 ETS emissions (Table 5). To assess whether over-allocation took place, both the ETS first and second phase caps are going to be compared to a theoretical benchmark.

The ETS 2005 BAU emissions benchmark does not give us any further information about how far European MS are from their emissions reduction target and to what extent European MS are relying on the ETS—compared to other national climate policies—to achieve their emissions reduction target.

Therefore, the alternative theoretical benchmark to assess the ETS cap stringency should refer to the emissions reduction target MS shall achieve by 2012.

The Kyoto target cannot be a benchmark since it applies to the overall European GHG emissions, whereas the ETS covers only part of them. A criterion is required to identify which part of the target can be directly compared to the ETS cap.

The first-best candidate is the *cost-effectiveness criterion*, which equalizes the marginal abatement curves (MACs) between trading and non-trading sectors, ensuring that emissions are reduced cost-effectively at the minimal marginal cost and independently of the efficiency of the Kyoto target, whose assessment goes beyond the scope of this analysis.

In the extreme case that the non-ETS sectors did not have any abatement possibility (i.e., MAC tending toward infinite), then the cost-effectiveness approach would call for all the emissions reduction burden to be borne by the ETS sectors. Vice versa, if the ETS sectors had no abatement possibility (i.e., MAC tending toward infinite), then it would be efficient to impose the entire emissions reduction burden on the non-ETS sectors, dispensing the ETS from any emissions reduction obligation.

If ETS and non-ETS sectors had the same MACs then the emissions reduction burden would be equally split between ETS and non-ETS sectors.

However, the ETS and non-ETS sectors' aggregate MAC data are not publicly available and the ETS cost-effective cap cannot be determined with precision.

A second-best option is the *proportional reduction approach*, according to which emissions of the trading and non-trading sectors should be reduced proportionally to their emissions share—down 8% compared with 1990 levels—to meet the overall EU target. The ETS proportional cap would impose on the ETS and non-ETS sectors an emissions reduction burden proportional to the EU target and to the amount of pollution they generate.

According to the EC, this approach is effective and consistent with the EU target (EC, 2008). Indeed, the Commission has declared that it “considers it necessary for a MS with a gap to close to use the second-period allocation plan to achieve at least a fair proportion of the outstanding effort, i.e. a part reflecting the share of EU ETS installations in total greenhouse gas emissions” (EC, 2006a: 5).

5.1. Data Required and Sources of Information

The theoretical benchmark consistent with the proportionality criterion (hereafter *the ETS proportional Kyoto target*) is calculated by multiplying the MS (EU) emissions reduction target by the share of emissions produced by the ETS sectors at the national and European level (ETS share).

*ETS proportional Kyoto target = EU Kyoto target * EU ETS share*

While national emissions reduction targets, as defined by the European Burden Sharing Agreement (BSA), are publicly available (Table 6), until 2007 the share of ETS European and national emissions could only be estimated.

Table 6 - Burden Sharing Agreement and Distance from the Kyoto Target (Mton CO_2)

	Base Year Emissions	Burden Sharing Agreement	Kyoto Target	2005 GHG Emissions	Distance from the Target
Austria	78.9	– 13%	68.68	93.3	-24.62
Belgium	146.9	– 7.5 %	135.87	143.8	-7.93
Czech Rep.	196.3	– 8%	180.58	145.6	34.98
Denmark	69.3	– 21%	54.77	63.9	-9.13
Estonia	42.6	– 8%	39.23	20.7	18.53
Finland	71.1	0%	71.1	69.3	1.8
France	567.1	0%	567.09	553.4	13.69
Germany	1,230	– 21%	971.67	1,001.5	-29.83
Greece	111.1	+ 25%	138.82	139.2	-0.38
Hungary	122.2	– 6%	114.89	80.5	34.39
Ireland	55.8	+ 13%	63	69.9	-6.87
Italy	519.6	– 6.5 %	485.83	582.2	-96.37
Latvia	25.9	– 8%	23.82	10.9	12.92
Lithuania	50.9	– 8%	46.86	22.6	24.26
Luxemburg	12.7	– 28%	9.14	12.7	-3.56
Netherlands	214.3	– 6%	201.45	212.1	-10.65
Poland	565.3	– 6%	531.34	399	132.34
Portugal	60.0	+ 27%	76.15	85.5	-9.35
Slovakia	73.2	– 8%	67.36	48.7	18.66
Slovenia	20.2	– 8%	18.6	20.3	-1.7
Spain	289.4	+ 15%	332.79	440.6	-107.81
Sweden	72.5	+ 4%	75.35	67	8.35
UK	767.9	– 12.5 %	671.9	657.4	14.5
EU-15	4,266.4	– 8%	3,925.11	4,192	-266.89
EU-23	5,363.2	No common target	4,946.3	4,940.1	6.22

Source: EEA 2006: 61, EEA 2007

Before the EU ETS establishment, emissions data were mainly aggregated at a national and sector level; official and exact data concerning the pre-2005 ETS emissions share are not available. Nevertheless, different attempts have been made to estimate these values.

Georgopoulou et al. (2006) estimated the pre-2005 ETS emissions share for each MS by dividing the ETS historical emissions baseline (as reported in the NAPs) by the national GHG emissions (as reported by the European Environment Agency - EEA).

As recognized by Georgopoulou et al. (2006), this estimation might be biased: ETS historical emissions data have been collected in the NAPs from self-reported submissions on behalf of ETS installations, which had an incentive to postpone emissions abatement and to signal higher emissions in order to receive more grandfathered allowances.[20]

Finally, in 2007, both the 2005 ETS and the overall GHG (trading and non-trading sectors) emissions data were published. For the first time the exact share of European and national emissions produced by the ETS sectors in the same year can be calculated from official and publicly available data. Indeed, according to Art. 14 of Directive 2003/87/EC (EC, 2003), every year (t) MS have the duty to monitor and to report the amount of emissions produced in the previous year (t–1) by each ETS installation. The collected data are aggregated at a national level and officially published by the EC. Moreover, according to Council Decision 280/2004/EC (EC, 2004), each year (t) the EEA has to report the amount of national GHG emissions produced by each MS in the year before last (t–2). The EEA inventory reports (EEA, 2004, 2007) cover all the trading and non-trading sectors, as well as the GHG emissions.

On June 2007, the EEA published the "Annual European Community GHG inventory 1990–2005 and inventory report 2007" reporting the overall 2005 GHG emissions data for each EU MS. Therefore, two years after the ETS establishment we can refer to reliable, official and publicly available data regarding the ETS emissions and national GHG emissions produced in the same year. For the first time it has become possible to calculate the precise ETS share and its marginal change year by year. However, albeit precise, the 2005 ETS share cannot take into account the potential emissions reduction that occurred after the establishment of the ETS.

[20] So far their analysis has been considered one of the most reliable assessments of the ETS emissions share calculated before the EU ETS establishment; also Neuhoff et al (2006), from the Cambridge Electricity Policy Research Group, has referred to this ratio to assess the ETS emissions projections 2008 – 2012.

Table 7 - The ETS Share (Mt CO_2 eq.)[21]

	(1) 2002 ETS emissions	(2) 2002 GHG emissions	(3) Pre-005 ETS share	(4) 2005 ETS emissions	(5) 2005 GHG emissions	(6) 2005 ETS share
Austria	30.2	86.4	35%	33.4	93.3	36%
Belgium	63	145.3	47.5%	55.4	143.8	39%
Cz Rep	89	142.9	60.3%	82.5	145.6	57%
Denmark	30.9	69	44..8%	26.5	63.9	41%
Estonia	12	19.5	61.5%	12.6	20.7	61%
Finland	40.9	77.2	53%	33.1	69.3	48%
France	132.4	554.1	23.5%	131.3	553.4	24%
Germany	501	1,015.2	49.3%	474	1,001.5	47%
Greece	71	133.6	52.8%	71.3	139.2	51%
Hungary	29.4	80.8	36.4%	26	80.5	32%
Ireland	20.6	69.4	29.7%	22.4	69.9	32%
Italy	228.1	555	41.4%	225.3	582.2	39%
Latvia	3.7	10.6	37.6%	2.9	10.9	27%
Lithuania	8.5	19.6	35.7%	6.6	22.6	29%
Lux	2.6	10.8	24.2%	2.6	12.7	20%
NL	81.7	213.5	38.2%	80.4	212.1	38%
Poland	219.8	370.2	57.1%	205.4	399	51%
Portugal	36.6	86.1	42.5%	36.4	85.5	43%
Slovakia	26.7	50.9	52.4%	25.2	48.7	52%
Slovenia	20.6	69.5	48.9%	87	20.3	43%
Spain	174.5	398.6	43.8%	182.9	440.6	42%
Sweden	9.8	20.1	29.1%	19.3	67	29%
UK	276.7	643.7	42.5%	242.5	657.4	37%
EU 15	1,663.8	4,078	41%	1,636.8	4,192	38%
EU- 23	2,073.5	4,842	43%	2,006.7	4,940.1	41%

Sources: NAPs 2008-2012, EEA 2004a, Georgedopoulou et al. 2006, EC 2006, EEA 2007

Given the potential problems of both pre-2005 and 2005 ETS shares (Table 7), referring to only one of them might lead to an imprecise assessment of over-allocation. Instead of choosing between the pre-2005 and the 2005 ETS share, both of them are considered, resulting in two benchmarks:

1. Benchmark 1: The *Pre-2005 ETS Proportional Kyoto Target,* determined by multiplying the MS Kyoto target by the pre-2005 ETS share (Appendix III).

[21] The pre-2005 ETS share (Georgedopoulou et al) is determined by the ratio "2002 ETS emissions/ 2002 total GHG (ETS+non-ETS) emissions, while the 2005 ETS share determined in this article is calculated by the ratio: "2005 ETS verified emissions/2005 total GHG (ETS+non-ETS) emissions"

2. Benchmark 2: The *2005 ETS Proportional Kyoto Target* is derived by multiplying for any MS its Kyoto target by the 2005 ETS share (Appendix III).

These two benchmarks limit the ETS proportional target range.
Assessing over-allocation in relation to a range rather than to a single benchmark generates more robust conclusions. Moreover, the unrealistic assumption of ETS constant emissions share (e.g. Betz et al. 2006; Georgedopoulou et al. 2006; Schleich et al. 2007) can be relaxed.

6. Assessing the ETS Cap Stringency

6.1 EU-15

To comply with the Kyoto Protocol, the old EU-15 MS have to emit 3,925 Mt CO_2 eq. by 2012. Given that the EU-15 ETS sectors emitted respectively 41% (pre-2005 ETS share) and 39% (2005 ETS share) of the overall EU-15 GHG emissions, the EU-15 ETS proportional caps limiting the *ETS Kyoto proportional target range* equal respectively 1,609 and 1,491 Mt. The stringency of the EU-15 ETS caps can then be derived.
<u>2005-2007 First Cap:</u> during the first phase the EU-15 MS allocated 1,729 million permits, corresponding to 44% of the EU-15 target. This cap exceeds both benchmarks limiting the *EU-15 ETS Kyoto proportional range*. It is possible to conclude unambiguously that over-allocation took place: the EU-15 MS have assigned to the ETS sectors an amount of allowances more proportional than their ETS share.
<u>2008-2012 Proposed Cap:</u> with the new 2008-2012 NAPs, the EU-15 MS proposed to allocate 1,636 million permits, almost 42% of the EU-15 target. This cap also exceeds both benchmarks limiting the EU-15 ETS proportional range. Also for the second phase, the EU-15 MS intended to over-allocate permits.
<u>2008-2012 Approved Cap:</u> the 2008-2012 EU-15 ETS cap approved by the EC (1,568 million permits or 40% of the EU-15 Kyoto target) is in between the two benchmarks limiting the EU-15 ETS proportional range. When compared to the pre-2005 ETS proportional Kyoto target, over-allocation would not be detected. On the contrary, when compared to the stricter benchmark—the 2005 ETS proportional target—the

2008-2012 approved cap would constitute over-allocation. In this case, no univocal conclusion about the EU-15 second phase cap can be derived.

6.2 EU-23

Based on the pre-2005 and 2005 ETS emissions data, the EU-23 ETS sectors have emitted respectively 43% and 41% of the overall EU-23 GHG emissions.[22] The EU-23 ETS proportional Kyoto target range can be calculated.

<u>2005-2007 First Cap:</u> during the 2005-2007 first ETS phase, the EU-23 MS allocated 2,172 million permits, almost 44% of the virtual EU-23 Kyoto target.[23] Being higher than both the pre-2005 and 2005 EU-23 ETS shares, this cap constitutes over-allocation.

<u>2008-2012 Proposed Cap:</u> the amount of permits the EU-23 MS proposed to allocate to the ETS sectors (2,151) exceeds the *ETS proportional target range*. Indeed, the proposed 2008-2012 cap equals 43.5% of the EU-23 virtual Kyoto target. This percentage exceeds both the pre-2005 and 2005 EU-23 ETS shares. Without the EC intervention, the EU-23 MS would have over-allocated permits also in the second ETS phase.

<u>2008-2012 Approved Cap</u>: on average permits have not been over-allocated during the second phase. Indeed, the final 2008-2012 cap approved by the EC (1,955 million permits, or 39.5% of the EU-23 Kyoto target) is lower than both the benchmarks limiting the EU-23 proportional Kyoto range.

6.3 Member States

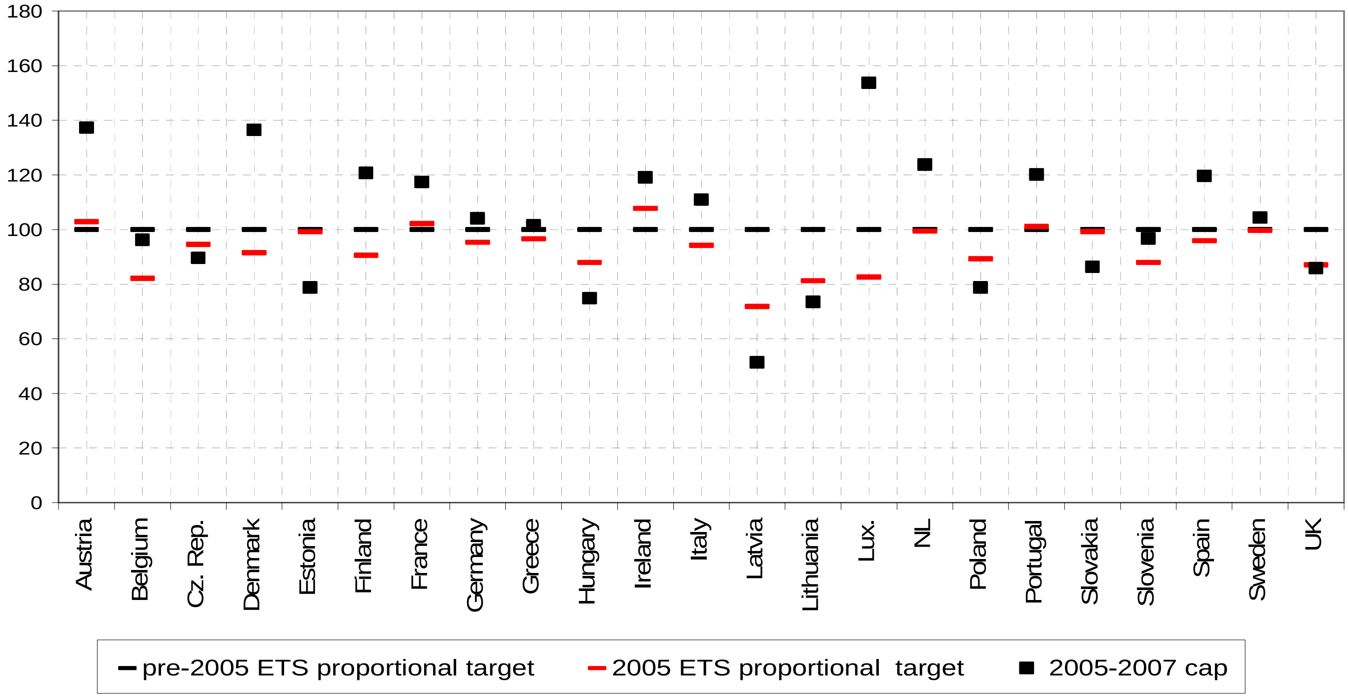
This section analyses which MS over-allocated permits during the first and second phases. Two different values are presented: the first one compares the amount of permits allocated by any MS during the first phase (2005-2007) to the relative ETS proportional target range (figure 12). The second value compares the proposed and approved second phase ETS cap to the same range. To simplify this comparison, the pre-2005 ETS proportional Kyoto targets have been normalized; then the 2005 ETS proportional Kyoto target and the amount of ETS permits allocated during the two phases have been recalculated accordingly (Appendix III).

---

[22] Cyprus and Malta do not have a target; therefore, they are not taken into account, while Romania and Bulgaria are excluded from this analysis since they joined the ETS after its beginning.

[23] The EU 23 MS do not have a common target. This virtual target is derived by aggregating national targets.

Figure 12 - ETS Proportional Target Range and ETS 2005-2007 Cap (Normalized Values)



Source: own elaboration

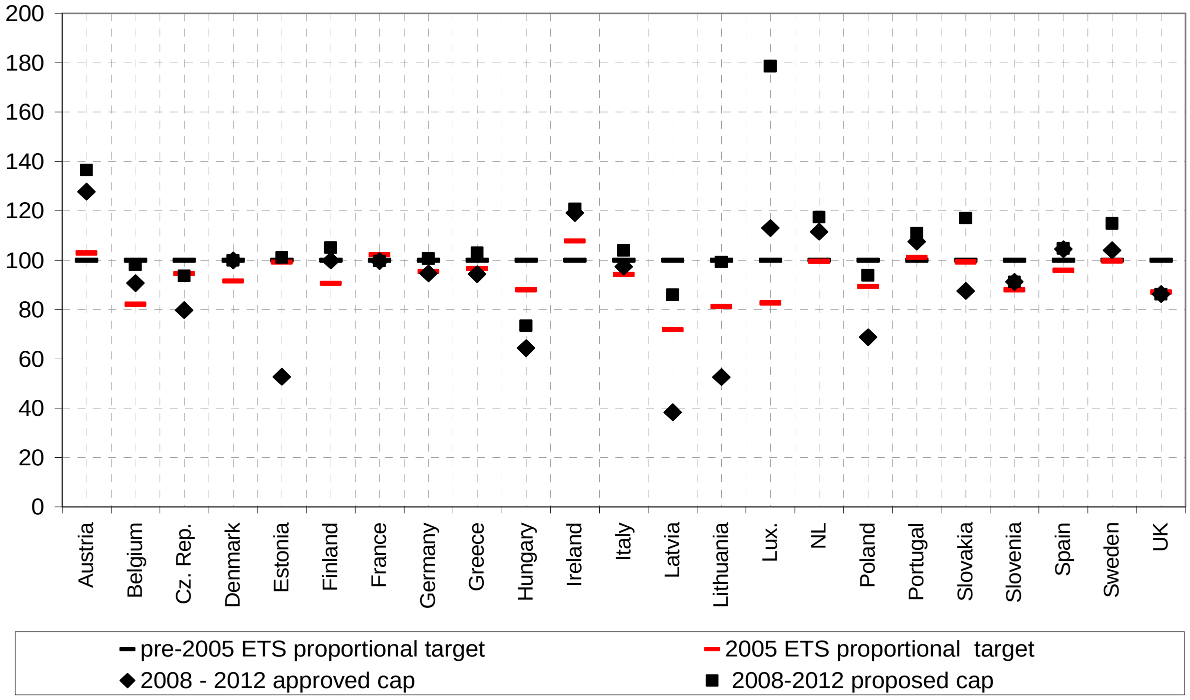
For the first ETS phase (2005-2007), MS can be classified into three categories:

1. MS whose cap exceeds the ETS Kyoto proportional range;
2. MS whose cap is within the range;
3. MS whose cap is below the range.

The first category includes all the former EU-15 MS except the UK and Belgium. All these MS assigned a number of permits that is more proportional than both the pre-2005 and 2005 ETS shares. These MS over-allocated permits to their ETS national sectors. The same conclusion holds for the second category (Belgium and Slovenia) when the MS' ETS cap is compared to the respective range's upper benchmark, while the opposite would be true when compared to the range's lower limit. In this case, no univocal conclusion is derived.

Finally, the MS belonging to the third category allocated an amount of permits that is more proportional than both their pre-2005 and 2005 ETS emissions share. In this case, over-allocation did not take place. Not surprisingly, except for the United Kingdom, this category includes all the new MS.

Figure 13 - ETS Proportional Target Range and the ETS 2008-2012 Cap (Normalized Values)



Source: own elaboration

Figure 13 shows that before the EC intervention most of the EU MS proposed to over-allocate allowances also during the ETS second phase. MS can be classified into five categories:

1. MS whose both proposed and approved caps exceed their relative ETS proportional range (Austria, Ireland, Luxemburg, the Netherlands, Portugal, Spain and Sweden). Over-allocation occurred despite the EC intervention;
2. MS that proposed to over-allocate permits, but which had to reduce their cap to a point included in the range (Finland, Germany, Greece, and Italy). In this case, after the EC intervention, over-allocation did not take place. Thus, the cut imposed by the EC differs among MS;
3. MS (Belgium, Denmark and Slovenia) whose both proposed and approved caps are included in their respective ETS proportional Kyoto ranges;
4. MS that proposed to allocate an amount of permits lower than their respective range (France and the UK). France and the UK's proposed caps have been approved by the EC without any imposition of a cut;

5. MS whose proposed caps have been reduced below their respective ETS range (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Slovakia). Apart from Slovakia, these proposed caps either were already included or below their respective ranges. All these MS challenged the EC's imposition of a cut before the European Court of Justice.

7. Consequences of Permit Over-allocation

The ETS cap indicates, directly, the maximum amount of GHGs the ETS sectors can totally emit and, indirectly, to what extent MS rely on the ETS flexible mechanism to reach the Kyoto target. Indeed, when MS determine in their National Allocation Plan the total amount of permits to be assigned among the ETS participants, they implicitly define to what extent the ETS sectors will contribute, with respect to the other non-ETS sectors, to the abatement of pollution in order to comply with their national emissions' reduction target established in the Kyoto Protocol.

By construction, over-allocation implies that the ETS sectors have to bear an emissions reduction burden less proportional than the percentage of produced emissions. Therefore, where over-allocation has been detected MS will reach their emissions reduction target only if another agent—mainly non-ETS sectors—reduces the emissions that the ETS sectors are not legally required to abate. In this case, the main side effect of permit over-allocation is a shift of the reduction burden from ETS to non-ETS sectors.

Non-ETS sectors have to bear an additional cost, which—according to the proportionality criterion—should be borne by the ETS sectors. This constitutes a form of cross-subsidization that is not cost-effective. According to different studies, the ETS sectors have on average lower MACs than non-ETS sectors (e.g. Criqui and Kitous 2003; Böhringer et al., 2005; Peterson, 2006). Moreover, the EC has established that 60% of the effort concerning the 2020 European emissions reduction target (20% less emissions than the 1990 level) must be achieved in the ETS sectors reflecting "the larger cost-effective potential in particular in the electricity sector compared to non-ETS sectors."[24]

According to the cost-effectiveness approach, the ETS sectors should bear a higher emissions reduction burden than non-ETS sectors, and not vice-versa.

[24] EC 2008

So far it has been assumed that the emissions the ETS sectors are not required to abate will be reduced by the non-ETS sectors; however, it is also possible that a third agent different from ETS and non-ETS sectors will bear this burden. This third agent is most likely the national governments. Governments can reduce emissions through the direct acquisition of international credits deriving from Clean Development Mechanism projects. Schleich et al. estimated in the beginning of 2007 that 11 of the EU-15 MS' national governments intended to purchase directly a number of credits deriving from international projects (Clean Development and Joint Implementation Kyoto flexible Mechanisms) equal to 109 MTon CO_2 annually,[25] "which represents a share of 7.3% of the Assigned Amount of these EU-15 MS" (Schleich et al. 2007, p.4). As Neuhoff et al. (2006) indicate, permit over-allocation to ETS sectors implies that these sectors will have a lower need to recur to international credits, which will be acquired in order to comply with national emissions reduction targets; thus, Finance Ministers and tax-payers would end up paying for these directly, transforming the international Kyoto flexible mechanism into a largely public-funded market. Also in this alternative case, permit over-allocation implies a form of indirect subsidy to the ETS sectors, which is not cost-effective since the government would have to abate on behalf of the non-ETS sectors and instead of the ETS sectors in order to comply with the Kyoto target.

In the final case where nobody abates in place of the ETS sectors, MS would fail to comply with their emissions reduction target; this possible scenario is not evaluated as "efficient or inefficient". Indeed, this thesis considers the emissions reduction targets as a given without questioning the efficiency of the targets themselves. It does, however, do this as it focuses on the tradable permits' cost-effectiveness to reach such given targets. Yet, should the EU fail to achieve the Kyoto target, its political credibility would be seriously affected. Moreover, the ETS cap stringency analysis has highlighted that the size of over-allocation differs among MS because of both the lack of harmonized allocative criteria and the EC non-homogeneous evaluation of the submitted NAPs. As a consequence, despite being subjected to the same European regulation, national firms and sectors competing in the same European market face different reduction efforts and costs. The lack of a level playing field for ETS

---

[25] Intended governmental use of Kyoto Mechanisms (in $MtCO_2e/a$): Austria 9, Belgium 7, Denmark 4.2, Finland 2.4, Ireland 3.6, Italy 19, Luxembourg 4.7, the Netherlands 20, Portugal 5.8, Spain 31.8 and Sweden 1.1.

operators distorts competition in the European market under Articles 81 and 82 of the EC Treaty. Moreover, the implications of State under Art. 87 become relevant (e.g. Johnston 2006; Weishaar 2007).

8. Conclusions

This chapter has investigated to what extent the EU and different MS are effectively relying on the ETS to comply with the Kyoto Protocol commitment. The ETS cap stringency has been assessed by comparing the total number of allocated permits to a theoretical ETS cap that would impose on the ETS sectors an emissions reduction burden proportional to the percentage of European emissions they generate. This analysis clearly demonstrates that most MS have an interest in supporting their national industry through permit over-allocation. Despite being economical at a national level, this opportunistic behaviour is not effective. Firstly, to the detriment of the environmental effectiveness of the system, MS have assigned more permits than would be allowed to ensure scarcity on the market. Moreover, by imposing on the ETS sectors an emissions reduction burden less proportional than their emissions share, permit over-allocation determines the transfer of the emissions reduction effort from trading to non-trading sectors, which is not cost effective. In fact, the ETS sectors, having on average lower MACs than non-ETS sectors, should bear a higher emissions reduction burden.

Most importantly, this analysis shows that the size of over-allocation differs among MS. As a consequence, despite being subjected to the same European regulation, national firms and sectors competing in the same European market face different reduction efforts and costs. This lack of a level playing field distorts competition, creating undesirable economic consequences at the expense of an effective EU common market integration. The approach chosen to asses the ETS cap stringency highlights that the ETS, despite being the most important EU environmental mechanism, is not sufficient to ensure compliance with the Kyoto target. Rather, it must be coordinated with the national policies aimed at inducing emissions reduction in the non-ETS sectors. Indeed, compliance with the Emissions reduction target established in the Kyoto Protocol requires that the lower the emissions reduction burden imposed on the ETS sectors is, (the higher the ETS cap is) the stricter non-ETS environmental policies must be, and vice-versa.

Thus, permit over-allocation not only means that ETS sectors will have to abate an amount of emissions that is not cost-effective (i.e., direct consequence), but it also implies that stricter national non-ETS policies need to be promoted in order to comply with the Kyoto target (i.e., indirect consequence).

In conclusion, this analysis highlights that emissions trading is not an effective economic mechanism *per se*. Its effectiveness depends on the scarcity of permits in the market, which can be ensured by harmonized allocative criteria among MS and by a European policy that is homogeneous among MS and consistent with national emissions reduction targets and ETS shares.

Appendix I: Calculation of the Theoretical CO_2 Coal-to-gas Switch Price

The theoretical CO_2 coal-to-gas switch price has been calculated using the day ahead price of National Balancing Point (NBP) gas traded in the British exchange market in pence per therm and the prices of the 1st month contract API#2 coal traded in dollars per ton. The cost of producing electricity by burning either gas or coal has been calculated assuming that coal plants have a 38% thermal efficiency while the Combined Cycle Gas Turbine plants have a 53% thermal efficiency. In addition to the fuel marginal costs, the cost of producing electricity is increased by the price of the CO_2 which has to be weighted with the coal and gas fuels emissions factors for different power generation technologies, assuming that burning coal produces 950 Kilograms of CO_2 per MWh of electricity generated, while burning gas produces 450 Kilograms of CO_2 per MWh of electricity generated.

Coal Plant:

Electricity price (€/Mwh) = coal price ($/ton)/38% + CO_2 *price (€/tonCO2)* 0.95 (ton* CO_2*/MWh)*

Combined Cycle Turbine Gas Plant:

Electricity price (€/Mwh) = gas price (p/therm)/53% + CO_2 *price (€/ton*CO_2*)* 0.95 (ton* CO_2*/MWh)*

If we know the gas price and the coal price, we obtain two equations with one unknown (price of CO_2). Thus, by equating the electricity prices we obtain the theoretical price of CO_2, which would make generating power by burning gas or burning coal an equally preferable process. However, in order to develop this equation it is necessary to convert all the data with the same unit of measurement:

- The price of coal has first to be converted from Ton to Kg (from $/ton to $/kg); then by adopting the coal heat of combustion (7,400 Kcal/kg), it is possible to pass from $/kg to $/Kcal and then to $/Gcal. Finally, we know that 1 Gcal corresponds to 1.16 Mwh, and by converting dollars into Euros, we can express the price of coal as Euros per megawatt hour.
- The price of gas has first to be converted from therm (p/Therm) to British Thermal Units (p/BTU). Then we know that 1 million BTU equals 0.29 MWh (p/MWh). Finally, pence are first converted in pounds, and then, according to

the appropriate exchange rate, they can be converted in Euros. In addition, the price of gas can be expressed in Euros per Megawatt hour.

The theoretical CO_2 price has been calculated on the basis of gas, coal and CO_2 daily prices from mid July 2005 to mid July 2008. Due to the extension of the database, we limit ourselves to reporting some data just to illustrate how the prices have been converted in Euros per megawatt hour and how the theoretical switch CO_2 price has been calculated.

Table 8 – Conversion of Coal Prices from $/ton to €/MWh

COAL 1st Month Contract							
	$/Ton	$/Kg	$/Kcal	$/Gcal	$/MWh	€/Mwh	Exchange dollar/euro
24 Apr 06	63.00	0.06	0.000009	8.51	7.34	6.12	1.2
25 Apr 06	62.65	0.06	0.000008	8.47	7.30	6.08	1.2
26 Apr 06	62.60	0.06	0.000008	8.46	7.29	6.08	1.2
27 Apr 06	62.45	0.06	0.000008	8.44	7.28	6.06	1.2
28 Apr 06	62.40	0.06	0.000008	8.43	7.27	6.06	1.2
01 May 06	62.40	0.06	0.000008	8.43	7.27	5.59	1.3
02 May 06	62.40	0.06	0.000008	8.43	7.27	5.59	1.3
03 May 06	60.50	0.06	0.000008	8.18	7.05	5.42	1.3
04 May 06	60.25	0.06	0.000008	8.14	7.02	5.40	1.3

Source: own elaboration on Fortis Bank data

Table 9 – Conversion of NBP Prices from p/therm to €/MWh

NBP GAS Day Ahead						
	pp/therm	p/Mil. BTU	p/MWh	pounds/Mwh	€/Mwh	Exchange pounds/euro
24 Apr 06	41.4	414.00	1,427.59	14.28	20.54	0.7
25 Apr 06	39.5	395.00	1,362.07	13.62	20.20	0.7
26 Apr 06	39	390.00	1,344.83	13.45	18.23	0.7
27 Apr 06	38	380.00	1,310.34	13.10	19.09	0.7
28 Apr 06	39.15	391.50	1,350.00	13.50	17.86	0.7
01 May 06	39.15	391.50	1,350.00	13.50	19.91	0.7
02 May 06	38.1	381.00	1,313.79	13.14	19.58	0.7
03 May 06	35.65	356.50	1,229.31	12.29	20.00	0.7
04 May 06	33.45	334.50	1,153.45	11.53	17.49	0.7

Source: own elaboration on Fortis Bank data

Table 10 – Calculation of the CO2 Theoretical Coal-to-gas Switch Price

	Coal €/Mwh	Gas €/Mwh	Coal 38% €/Mwh	Gas 53% €/Mwh	Coal Emission Factor	Gas Emissions Factor	CO_2 Coal-to-gas Switch Price	CO_2 Spot Prices	CO_2 Future Price Dec 08
24 Apr 06	6.11	20.39	16.09	38.47	0.95	0.45	**28.56**	29.43	30.95
25 Apr 06	6.08	19.46	16.00	36.71	0.95	0.45	**26.75**	27.95	29.55
26 Apr 06	6.07	19.21	15.99	36.24	0.95	0.45	**26.27**	24.3	22.15
27 Apr 06	6.06	18.72	15.95	35.31	0.95	0.45	**25.31**	15.7	21.45
28 Apr 06	6.05	19.29	15.94	36.38	0.95	0.45	**26.46**	13.19	18.8
01 May 06	5.59	19.29	14.71	36.38	0.95	0.45	**27.39**	13.35	18.5
02 May 06	5.59	18.77	14.71	35.41	0.95	0.45	**26.35**	10.9	18.25
03 May 06	5.42	17.56	14.26	33.13	0.95	0.45	**24.28**	12	20
04 May 06	5.39	16.48	14.20	31.09	0.95	0.45	**22.16**	14.6	22.15

Sources: own elaboration on Fortis bank data

Appendix II: Relevant Data to Assess the ETS Permits Over-Allocation (Mt Co2)

MS	Base Period ETS Emissions	Observed Annual GDP Growth Rate 2002-2005	Carbon Intensity Assumed Annual Rate of Change 2000-2004	CO_2 Increase Annual Rate	Counterfactual 2005 BAU Emissions	Verified Emissions 2005	Permit Allocation 2005	Difference 2005 – BAU Emissions	Difference Permit Allocation – BAU Emissions
Austria	30.2	00.19	0.022	0.04	34	33.4	32.4	-0.6	-1.6
Belgium	63	0.016	-0.009	0007	64.4	55.4	58.3	-9	-6.1
Cz Repub.	89	0.048	-0.034	0.014	92.9	82.5	96.9	-10.4	4
Denmark	30.9	0.02	-0.005	0.014	32.2	26.5	37.3	-5.7	5.1
Estonia	12.4	0.088	-0.044	0.043	14.1	12.6	16.7	-1.5	2.6
Finland	36.2	0.028	0.018	0.046	41.5	33.1	44.7	-8.4	3.2
France	141.1	0.015	-0.008	0.006	143.8	131.3	150.4	-12.5	6.6
Germany	501	0.006	-0.006	0.001	501.8	474	495	-27.8	-6.8
Greece	70.1	0.046	-0.033	0.012	72.7	71.3	71.1	-1.4	-1.6
Hungary	32	0.044	-0.037	0.007	32.7	26	30.2	-6.7	-2.5
Ireland	20.9	0.049	-0.047	0.003	21.1	22.4	19.2	1.3	-1.9
Italy	224	0.004	0.005	0.009	229.9	225.3	215.8	-4.6	-14.1
Latvia	3.7	0.095	-0.06	0.034	4.1	2.9	4.1	-1.2	0
Lithuania	9	0.09	-0.092	-0.002	8.9	6.6	13.5	-2.3	4.6
Luxemb.	2.9	0.036	0.03	0.065	3.5	2.6	3.2	-0.9	-0.3
Netherlands	89.5	0.013	0.006	0.018	94.5	80.4	86.5	-14.1	-8
Poland	219.8	0.043	-0.029	0.015	229.6	205.4	235.6	-24.2	6
Portugal	36.6	0.001	0	0.002	36.8	36.4	36.9	-0.4	0.1
Slovakia	26.5	0.055	-0.024	0.03	29	25.2	30.5	-3.8	1.5
Slovenia	9	0.037	-0.024	0.013	9.4	8.7	9.1	-0.7	-0.3
Spain	164.1	0.033	0.001	0.033	181.2	182.9	172.1	1.7	-9.1
Sweden	20.2	0.028	-0.013	0.014	21.1	19.3	22.3	-1.8	1.2
UK	245.9	0.027	-0.02	0.007	250.8	242.5	206	-8.3	-44.8
EU23	2,078	-	-	0.011	2,150.1	2,006.6	2,087.8	-143.5	-62.3

Source: Ellerman Buchner 2006

Appendix III: ETS Proportional Kyoto Targets and Range

	Kyoto Target (Mt CO2)	**Pre-2005 ETS Share**	**2005 ETS Share**	**ETS Proport-ional Kyoto Target (1)**	**ETS Propor-tional Kyoto Target (2)**	**ETS 2005-2007 Cap**	**2008 – 2012 Propos-ed Cap**	**ETS 2008-2012 Appr-oved Cap**	**NORMALIZED VALUES**				
									Pre-2005 ETS Propor-tional Target	2005 ETS Propor-tional Target	2005-2007 Cap	2008 - 2012 Appr-oved Cap	2008-2012 Proposed Cap
Austria	68.68	0.35	0.36	24.038	24.7248	33	32.8	30.7	100	103	137	127	136.5
Belgium	135.8	0.475	0.39	64.53	52.98	62.1	63.3	58.5	100	82.1	96.2	90.6	98.1
Cz. Rep.	180.6	0.603	0.57	108.9	102.93	97.6	101.9	86.8	100	94.5	89.6	79.7	93.6
Denmark	54.77	0.448	0.41	24.53	22.45	33.5	24.5	24.5	100	91.5	136.5	99.8	99.8
Estonia	39.23	0.615	0.61	24.12645	23.93	19	24.38	12.72	100	99.2	78.8	52.7	101.1
Finland	71.1	0.53	0.48	37.683	34.128	45.5	39.6	37.6	100	90.6	120.7	99.8	105.1
France	567.0	0.235	0.24	133.26	136.10	156.5	132.8	132.8	100	102	117.4	99.7	99.7
Germany	971.6	0.493	0.47	479.03	456.6	499	482	453.1	100	95.3	104.2	94.6	100.6
Greece	138.8	0.528	0.51	73.29	70.79	74.4	75.5	69.1	100	96.6	101.5	94.3	103.0
Hungary	114.8	0.364	0.32	41.81	36.76	31.3	30.7	26.9	100	87.9	74.8	64.3	73.4
Ireland	63.03	0.297	0.32	18.71991	20.16	22.3	22.6	22.3	100	108	119.1	119	120.7
Italy	485.8	0.414	0.39	201.13	189.473	223.1	209	195.8	100	94.2	110.9	97.3	103.9
Latvia	23.82	0.376	0.27	8.95632	6.4314	4.6	7.7	3.43	100	71.8	51.4	38.3	86.0
Lithuania	46.86	0.357	0.29	16.72	13.5894	12.3	16.6	8.8	100	81.2	73.5	52.6	99.2
Lux.	9.14	0.242	0.2	2.21188	1.828	3.4	3.95	2.5	100	82.6	153.7	113	178.6
NL	201.4	0.382	0.38	76.9539	76.551	95.3	90.4	85.8	100	99.5	123.8	111	117.5
Poland	531.3	0.571	0.51	303.3951	270.983	239.1	284.6	208.5	100	89.3	78.8	68.7	93.8
Portugal	76.15	0.425	0.43	32.36375	32.7445	38.9	35.9	34.8	100	101	120.2	107	110.9
Slovakia	67.36	0.524	0.52	35.29	35.0272	30.5	41.3	30.9	100	99.2	86.4	87.5	117.0
Slovenia	18.6	0.489	0.43	9.0954	7.998	8.8	8.3	8.3	100	87.9	96.8	91.3	91.3
Spain	332.8	0.438	0.42	145.7	139.771	174.4	152.7	152.3	100	95.9	119.6	104	104.8
Sweden	75.35	0.291	0.29	21.9	21.8515	22.9	25.2	22.8	100	99.7	104.4	104	114.9
UK	671.9	0.425	0.37	285.5	248.603	245.3	246.2	246.2	100	87.1	85.9	86.2	86.2

Chapter 6. Analysis of the Allocation Rules: Do Polluters Pay under Grandfathering?[26]

1. Introduction

To create political acceptability, grandfathering has been used as the primary method to allocate the allowances. This means that polluters have received most emission rights free of charge primarily based on their historical emissions. As a result, they have not had to buy rights in an auction. As stated in Art. 10 of Directive 2003/87/EC, every EU MS was required to allocate at least 95 per cent of the allowances free of charge for the three-year period 2005-2007 and at least 90 per cent of the allowances free of charge for the five-year period 2008-2012.

However, after the ETS was launched, different studies have shown empirically that in different regions the power sector has incorporated part of the value of free allocated emissions allowances into the price of electricity. For instance, Sjim et al. estimate a rate of CO_2 price pass through into wholesale electricity price, which has varied between 60 and 100 percent in Germany and in the Netherlands.[27] Honkatukia et al, found empirically with econometric analysis that in 2005, on average, 75 to 95 percent of the variation of the price of emissions allowances had been transferred to the Finnish Nord Pool day-ahead prices.

The possibility that producers generate the so-called windfall profits by passing through the market value of the allowances that they have received for free into the final product price raises the general argument that "grandfathering of allowances creates a government subsidy of polluters." Under this perspective, the fact that consumers pay for what producers receive for free is perceived to be neither fair nor efficient.

A popular perception in the economic and legal literature is that assigning allowances for free (i.e., grandfathering) is inconsistent with the polluter-pays principle. "Free allocation violates the polluter-pays principle […]," according to Sorrell and Sijm (2003: 427). Also Nash (2000: 13), based on a thorough analysis of the issue,

[26] Part of this chapter has been originally published as a research article written jointly with Edwin Woerdman and Alessandra Arcuri and appearing in the *Review of Law and Economics*. For major details see: E. Woerdman, A. Arcuri and S. Clò (2008), "Emissions Trading and the Polluter-Pays Principle: Do Polluters Pay under Grandfathering?", *Review of Law and Economics,* 4(2).

[27] "Using numerical models we find that, at a CO_2 price of 20 €/t, ET-induced increases in power prices range between 3 and 18 €/MWh, depending on the carbon intensity of the price-setting installation" (Sjim et al. 2006: 67).

concludes that "grandfathering […] runs contrary to the polluter pays principle's core […]." This suggests that the EU ETS is inconsistent with an important principle of environmental law.

However, at the same time we see that grandfathering is allowed in legal practice, without the polluter-pays principle impeding the operation of these trading programs. After discussing the ETS' effectiveness by assessing the ETS cap stringency at a macro-level, this chapter focuses on the allocation rule adopted during the first and the second ETS trading periods. The main purpose of this chapter, which is partly based on the work of Woerdman et al. (2008), is to assess whether grandfathering can be considered—in theory and in practice—an efficient and fair allocation rule by clarifying the conditions under which this allocation rule is consistent with the polluter-pays principle. The basic question is: do polluters pay under grandfathering, or not?

This question is an interesting object of study for researchers of environmental law and economics because the polluter-pays principle, by mandating cost internalization in most of its versions, is an eminently economic principle (e.g. Faure and Grimeaud, 2003). This observation makes the economic analysis directly relevant for legal scholars. Aware of the complexities inherent in the interpretation of principles, we also discuss other ways to define the polluter-pays principle. In particular, by distinguishing an economic interpretation from an equity interpretation, we aim to shed light on a sometimes confusing debate, which often treats issues of efficiency and distributive justice together. Part of the Law and Economics scholarship has analyzed the efficiency of different legal rules without disregarding other goals of law, such as equity (e.g., Calabresi, 1970). By combining a micro-economic analysis of law with an analysis of the nature of legal principles, we have followed this interdisciplinary tradition.

In the light of the different interpretations of the polluter-pays principle, this chapter develops a comparative analysis of grandfathering and auctioning in order to assess to what extent the different allocation criteria can be considered efficient and fair. Finally, this chapter analyses whether the theoretical findings concerning the efficiency and fairness of grandfathering can still be considered valid within the ETS. By highlighting the inefficiencies that emerged at the time of applying this allocation rule in the ETS, the chapter concludes determining various conditions that have to be satisfied to ensure the consistency of grandfathering with the efficiency interpretation of the polluter-pays principle.

The chapter is structured as follows. In the second section, the economic origin and legal nature of the polluter-pays principle are described. Moreover, a taxonomy of possible interpretations of this principle, ranging from efficiency to equity, is presented. The third section analyses whether grandfathering is compatible with an efficiency interpretation of the polluter-pays principle by focusing on the concepts of opportunity costs and lump-sum subsidies. The fourth section offers a comparison of grandfathering and auctioning. Both allocation rules are analysed to assess their consistency with the extended equity interpretation of the polluter-pays principle.

The fifth section analyses the inefficiencies emerged at the time of applying grandfathering within the ETS. The problem of baseline year updating, the case of closures, the degree of harmonization and the case of over-allocation are analysed in order to define under which conditions grandfathering can be considered an efficient allocation rule. In the final section, conclusions are drawn.

2. The Origin and Nature of the Polluter-Pays Principle

Principles are characterized by relatively vague formulations and do not work as legal rules: different outcomes might result from the application of a principle since it does not dictate any specific decision. Principles state “a reason that argues in one direction, but does not necessitate a particular decision” (Dworkin, 1977: 26). A similar characterization of principles (as opposed to rules) has been elaborated by Hart (1994: 260) who describes principles as being “broad, general or unspecific” and stresses that the term “principles” refers to the attainment of general goals or values for the good of society. In spite of their vagueness, principles are important legal guidelines helping to circumscribe the discretion of decision-makers and/or judges when they have to shape, apply or interpret the law. “Discretion, like the hole in a doughnut, does not exist except as an area left open by a surrounding belt of restriction” (Dworkin, 1977: 31). As such, principles can be seen as a belt of restriction. Therefore, it is first necessary to understand what the general goals of the polluter-pays principle are and how the principle constrains the discretion of the decision-maker or judge. To answer these questions, it can be useful to recall some of the most significant formulations of the polluter-pays principle.

The polluter-pays principle first appeared in 1972 in the *Recommendation of the OECD Council on Guiding Principles concerning International Economic Aspects of Environmental Policies* (reprinted in OECD, 1975: 11-14). This principle basically explains that polluters should bear the cost of pollution; thus, they should pay for pollution prevention and control measures as well as for the environmental damage they cause. Moreover, this has been interpreted with the additional principle that the government should not subsidize pollution. Although the OECD document itself is not a binding international law since it was never ratified by a government, the polluter-pays principle can now be found in an increasing number of international treaties and instruments. Most importantly, Principle 16 of the 1992 *Rio Declaration on Environment and Development*, which "constitutes at present the most significant universally endorsed statement of general rights and obligations of states affecting the environment" (Birnie and Boyle, 2002: 82), reads as follows: "National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the costs of pollution, with due regard to the public interest and without distorting international trade and investment."

Many international law treaties, including the 1992 *Convention on the Protection and the Use of Transboundary Watercourses and International Lakes*, the 1992 *Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area* and the 1996 Protocol to the *London Dumping Convention*, endorse this principle in various ways. The polluter-pays principle has been included in many national legal systems. Although US domestic law has never codified the polluter-pays principle, it has influenced US environmental law, such as the *Comprehensive Environmental Response, Compensation and Liability Act* of 1980 (CERCLA), which seeks to fulfil the polluter-pays principle by imposing liability for cleanup costs on those parties that are responsible for the pollution.

In the European legal context, the polluter-pays principle has been formally adopted in Art. 174 of the *EC Treaty*. In this legal document, the principle is mentioned but not defined.[28] A precise and generally accepted legal definition of the polluter-pays principle is lacking. As put by Verhoef: "the question of whether the polluter should

[28] "Community policy on the environment […] shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay" [EC Treaty, Title XIX Environment, Article 174 (2)].

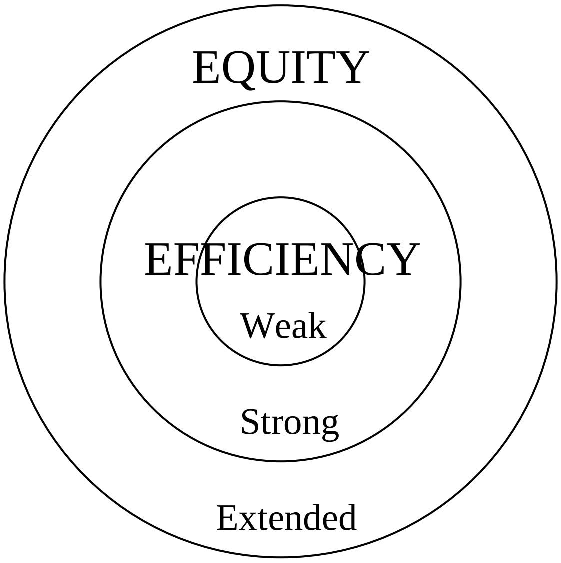
pay […] may often lead to different outcomes in terms of both allocation efficiency and equity. […] This ambiguity in the interpretation of the polluter pays principle is, unfortunately, often overlooked" (Verhoef, 1999: 206-207). To bring clarity to this issue, the alternative allocation rules are going to be analysed in the light of two fundamental versions of the polluter-pays principle: (1) an efficiency interpretation, and (2) an equity interpretation. This distinction warrants further explanation. The efficiency interpretation reflects the idea that pollution costs should be internalized with the aim of achieving an efficient allocation of resources, irrespective of distributive issues. Equity has a wide variety of meanings, but in this context it is limited to the notion of the fair distribution of costs. The efficiency interpretation should be considered the core of the polluter-pays principle, while the equity interpretation can be framed as an as an extension of the basic form of this principle, which does not depart from, but rather includes the efficiency dimension.

As emphasized by Faure and Grimeaud, "one can say that the polluter-pays principle is probably the most 'economic' of all environmental principles" (Faure and Grimeaud, 2003: 33). Conceptualizing the polluter-pays principle as an eminent "economic" principle is in line both with its origin (OECD, 1975) and with some of its most representative definitions, which explicitly endorse the criterion of cost internalization, such as the above-mentioned Principle 16 of the Rio Declaration. In addition, legal scholars concede that "it remains an economic principle that was turned into a legal principle and helps justifying policy decisions—whatever the decisions are" (Krämer, 2005).

Yet, it is clear that in addition to efficiency also equity has been used as a criterion to impart meaning to the polluter-pays principle. In this context, Bugge (1996) distinguishes between the polluter-pays principle, on the one hand as an "economic principle (a principle of efficiency)," and on the other hand as a "legal principle of (just) distribution of costs." In Bugge's view, the efficiency principle is independent from the distributive principle. Alternatively, it is possible to conceive of the polluter-pays principle as a principle endowed with dimensions of both efficiency and equity. This view is supported by several authors who have observed that the polluter-pays principle is a principle that allocates the costs to the polluter not only for reasons of efficiency but also equity (Pearson, 1994: 563; Parikh, 1993). The OECD's 1975 analysis of the principle confirms this viewpoint: "It should be noted that the problem of cost sharing calls for equity as well as efficiency […]. The question is now whether there is a principle permitting the dual requirements of efficiency and equity to be satisfied together […]" (OECD, 1975: 25). Our equity interpretation of the principle, which subsumes the efficiency dimension, would satisfy this double requirement.

In relation to the efficiency dimension of the polluter-pays principle, it is possible to further distinguish 1) a weak form (i.e., no subsidization) from 2) a strong form (i.e., cost internalization) of this normative doctrine. This distinction has been devised by Jonathan Remy Nash, building upon the work of Wirth (1995), in the context of an extensive and thorough study of the potential conflict between tradable allowances and the polluter-pays principle (Nash, 2000). The weak form of the doctrine prohibits governmental subsidies for pollution control equipment to ensure that product prices reflect the costs of pollution abatement. The strong form calls for governments to ensure the internalization of environmental costs (and not just to refrain from subsidizing pollution control equipment). This means that the strong form subsumes the weak form: both versions require that companies internalize pollution costs [Nash, 2000: 31]. Therefore, both the weak and the strong form are manifestations of an efficiency interpretation of the polluter-pays principle. In summary, the efficiency interpretation of the polluter-pays principle includes both a weak and a strong form. In addition, the equity interpretation is an additional criterion in addition to—and not instead of—efficiency, and it could be interpreted as an extended form of the polluter-pays principle. It is possible to visualize the interpretation of the polluter-pays principle presented above as a system of concentric circles, as shown in figure 14.

Figure 14 - Graphic Interpretation of the Polluter-pays Principle



According to the taxonomy outlined above, the initial research question can be shaped as follows: is grandfathering consistent 1) with a weak and strong efficiency interpretation of the polluter-pays principle and 2) with an extended equity interpretation of the polluter-pays principle? The next section addresses the first part of this question, and the section thereafter its second part.

3. Grandfathering and the Efficiency Interpretation of the Polluter-Pays Principle

Under auctioning, firms have to buy the allowances, which means that they pay for their emissions and for their emission reductions. Under grandfathering, polluters receive their emission rights for free proportionally to their historical level of emissions, which means that they do not have to pay for their emissions, but only for the reduction of their emissions.

This raises the question of whether grandfathering (and auctioning) is an efficient allocation rule consistent with both the weak form and the strong form of the efficiency interpretation of the polluter-pays principle.

Based on the conceptual differentiation described above, Nash (2000: 13) finds that "grandfathering […] runs contrary to the polluter-pays principle's core, violating even the principle's weak form." He states: "The core of the polluter-pays principle argues that neither the government nor society-at-large should subsidize pollution and polluters and that polluters should internalize the costs of pollution abatement" (Nash, 2000: 3). Nash presents two main arguments to support his claim. First, he says: "Grandfathering of allowances creates a government subsidy of polluters […]. The recipients are at liberty to sell the allowances, which they received at no cost, on the market for cash payments" (Nash, 2000: 13). Second, he argues that grandfathering "creates an artificial, and undesirable, incentive for existing market participants not to exit the industry by shielding them from new competition" (Nash, 2000: 13). The problem as he sees it is that grandfathering thus "increases the incentive to keep in service older, less efficient plants […]" (Nash, 2000: 24). He then concludes that grandfathering is inconsistent with the polluter-pays principle.

The purpose of this section is to show that, once the opportunity cost of free assigned allowances is properly taken into account, grandfathering proves consistent with the efficiency interpretation of the polluter-pays principle. The concept of opportunity cost has to be taken into account any time a good has alternative uses. This concept corresponds to the foregone revenue that would have been earned by choosing the rejected option. Resources are allocated efficiently only if the first-best option is chosen, thus implying that the opportunity cost linked to the resources' alternative and rejected option has to be a second-best. If the opportunity cost were a first-best and not a second-best, then the way resources are allocated would not be efficient.

In the ETS context, grandfathered permits have two alternative uses: in the case that the ETS installation does not reduce its emissions, they can be used to cover the amount of released emissions; alternatively, in the case that the ETS installation reduces its emissions, the exceeding amount of grandfathered allowances can be sold in the ETS at the market price. Thus, if permits are used to cover the produced emissions, then the opportunity cost of these permits is determined by the foregone profit that could be earned by producing less and selling the surplus of permits at the market price. When these alternative options are taken into account, it follows that an ETS installation will continue to produce and to cover their emissions with the grandfathered permits only if it is the first-best option and if the opportunity cost of the alternative option is a second-best: they have to be sure that their productive activity can grant a profit that is at least as big as the one they could earn by shutting down their plant (or decreasing production) and selling the exceeding amount of allowances received at no cost. This (second-best) alternative use of tradable permits explains why firms have to internalize the market price of free assigned allowances into their marginal production costs and then to pass them into final prices in secondary markets, in order to be sure it will earn at least the opportunity cost's second best alternative. It is possible to conclude that the windfall profits the electricity generators earn from passing the permits' opportunity cost to the final price are economically founded.

So far this study has explained the reasons why the windfall profits that producers earn from passing the permits' opportunity cost of free assigned allowances to the final price do not distort the market outcome efficiency. However, it is necessary to further explain why producers should effectively pay in the case that permits are assigned for free and then transferred to the final price that consumers pay. We argue that when the grandfathered permits' opportunity costs are passed through to the final price, not only do consumers pay in terms of higher product prices, but so do polluting producers in terms of loss of competitiveness in the secondary market.

In fact, grandfathering permits according to historical emissions implies that firms that pollute more receive a higher amount of permits than less polluting firms; thus, the more a firm pollutes, the more allowances are assigned and the higher the opportunity cost to be internalized and to be passed through to the market price. Thus, after the ETS has been implemented and allowances have been grandfathered, firms producing with polluting plants face a higher marginal cost increase than those firms adopting clean technologies.

When secondary markets are competitive, firms that pollute more have to compete at higher prices; thus, their competitiveness suffers, and in the long run polluting plants tend to be driven out from the market to be substituted by less carbon-intensive efficient plants.

For instance, in the energy sector the internalization of the CO_2 price into the production cost may induce a plant switch in the merit order supply function,[29] thus giving polluting firms an incentive to invest in clean generation and to substitute obsolete plants with environmentally friendly technologies (Reinaud, 2007). This concept is illustrated by the following table.

[29] The merit order function is the typical step supply function in the electricity market. Plants are classified according to their constant marginal cost of production, and the more efficient plants are called for production before the others. It implies that when demand is low only efficient plants enter the market, and as demand increases reaching its peak level, also the more inefficient plants are called for production.

Table 11 – Marginal Costs of Coal- and Gas-Fired Plants Pre- and Post-ETS

	Coal Plant	**Gas-Fired Plant (CCGT)**
Thermal Efficiency	*35%*	*50%*
Fuel Price (£/MMBTu)	*1.2*	*2.3*
Fuel Cost (£/MWh)	***11.7***	***15.7***
CO_2 Emission rate (tCO2/Mwh)	*930*	*366*
Allowance Price (£/tCO2)	*10*	*10*
Allowance Cost (£/Mwh)	*9.3*	*3.6*
Post-ETS Marginal Fuel Cost (£/MWh)	***21***	***19.3***

Source: Martinez Neuhoff 2004

This table shows how the plants' merit order in the electricity market can change after the ETS has been implemented. Coal is a more carbon-intensive fuel than gas. However, before a price was attached to the emissions of CO_2, coal on average was also a cheaper fuel than gas; thus, before the ETS' establishment, it was more convenient to produce electricity by burning coal and emitting more CO_2 rather than switching to gas and reducing CO_2 emissions. However, after the ETS' establishment, the cost-efficiency to burn gas or coal depends, *ceteris paribus*, also on the price attached to each ton of CO_2 released into the atmosphere.

Under the ETS regulation, it must be evaluated whether it is more economical to call first the coal plants, which have to buy a higher amount of permits in the ETS to cover their *emissions gap*, or, alternatively, they should first call the less carbon-intensive gas plants, which have to buy a lower amount of permits. When the real CO_2 price is higher than the *theoretical CO2 switching price*, the electricity supply function registers a switch in the merit order from coal to gas plants. At the off-peak level of electricity demand, gas plants are called for production instead of more polluting coal plants.

This competitive mechanism explains why in the long run polluters passing through their permits' opportunity costs to the final price pay—in terms of loss of competitiveness and market share—even when permits are free allocated. Thus, under grandfathering consumers pay higher prices and polluting producers pay as well because they face higher (opportunity) costs, which undermine their competitiveness, in turn lowering their market share.

In practice, this mechanism might not work properly in the case that (secondary electricity) markets are not fully competitive. In this case, it is possible that firms internalize the grandfathered permits' opportunity cost increasing their final market price, but without worsening their competitive position or exiting the market.

In the electricity markets, it has been observed that, although polluters should fully pass on the opportunity costs of grandfathered allowances in their product prices, electricity companies in the EU have done this only to a limited extent (Sjim et. Al 2006). It can be argued that the main reason for a limited pass-through is the oligopolistic nature of the electricity market. According to economic theory, any price variation caused by a marginal cost change is greater in perfectly competitive markets than in oligopolistic ones. In a perfectly competitive market, price equals marginal costs; therefore, any widespread variation of the marginal costs is reflected in an equal variation of the market price. On the contrary, in a standard monopoly case, with constant marginal cost and linear market demand, precisely half of the variation of the marginal cost is passed into prices, independently of the parameters of demand and the initial cost level.[30]

This result can be explained on the basis of different market equilibrium conditions: marginal costs equal marginal revenues in both perfectly competitive and oligopolistic markets, but the equivalence between price and marginal cost is guaranteed only under perfect competition. Intuitively, in oligopolistic markets where prices are already above marginal costs, there is little opportunity for a further marginal price increase, but when markets become more competitive, prices tend to be aligned more closely with costs (e.g., Ten Kate and Niels, 2005). The implication is that the less competitive the electricity market is, the lower the pass-through rate will be. Consequently, the opportunity costs of free allowances are only partly incorporated in a higher power price when the electricity market is oligopolistic.

In an oligopolistic scenario, polluters face lower risk of exiting the market and, thus, a lower incentive to adopt environmentally friendly technologies. In this case, the ETS installations receiving free allowances bear the cost of pollution only to a limited extent, and the consistency with the efficiency interpretation of the polluter-pays

[30] In the alternative case with a convex demand (i.e., positive second derivative) the slope of the monopolist Marginal revenue is less than twice that of inverse demand; thus, the monopolist passes into the final market price at least half of its marginal cost variation. Vice versa, if the demand is concave (i.e., a second derivative is negative) the slope of the marginal revenue function is more than twice the slope of the inverse demand, implying that the monopolist passes into the final market price at most half of its marginal cost change.

principle can be criticized. However, it should be noted that the main problem does not seem to be the pass through of the grandfathered permits' opportunity cost into electricity prices, as generally claimed. Rather, the main problem consists of the artificial maintenance of electricity prices above production marginal costs in markets that are not competitive. According to economic theory, internalizing the cost of the environmental externality into electricity prices is correct; on the contrary, it is the presence of prices above marginal costs in oligopolistic markets that should be avoided.

This analysis has clarified that firms receiving grandfathered allowances do have costs: opportunity costs, which have to be passed into the product price. The consequence is that the costs of pollution are internalized. This internalization makes grandfathering consistent with the strong form of the polluter-pays principle (i.e., "cost internalization"). Because the strong form subsumes the weak form (i.e., "no subsidization"), full compatibility with the polluter-pays principle is ensured.

Under grandfathering, market efficiency is not distorted. This conclusion is consistent with the principles of the Coase theorem: as long as transaction costs tend toward zero, free bargaining of allowances will induce an efficient internalization of the externality. Tradable permits will be allocated to those who value them most, while emissions will be reduced where marginal abatement costs (MAC) are the lowest. The final CO_2 price will equal the lowest MAC, and in the long run MAC among polluters will be equalized. This efficient equilibrium will be reached through Coasian bargaining independently of how permits are initially allocated. Thus, the market outcome will be the same when firms have to buy permits in an auction or when the government assigns them for free according to their historical emissions (i.e., grandfathering).

Auctioning or grandfathering permits does not have any impact in terms of efficiency: the externality is internalized in the market price system, and the final market equilibrium is the same independently of the initial allocation rule.

As stated by Reguant and Ellerman, "[g]iven that the allowances can be sold in the market, operators should recognize the full opportunity cost involved in emitting a unit of emissions in the same manner as they would if they had not been allocated allowances for free and had to purchase them in the market or at an auction" (Reguant and Ellerman 2008: 2).

3.1 Lump-sum Subsidies

The internalization of opportunity costs of allowances makes grandfathering consistent with the strong form of the polluter-pays principle ("cost internalization").

Moreover, it can be argued that grandfathered allowances constitute lump-sum subsidies that do not distort competition. This implies that Nash's analysis is incomplete on this point.

Under grandfathering, firms receive their emission allowances for free, and thus have a lower cash outflow than under auctioning. Since grandfathering implies a capital gift to the firm, a firm with grandfathered allowances has more financial resources, or its own capital, than an identical firm, which has to acquire allowances in an auction. Grandfathering thus entails a transfer of wealth to firms since they receive an asset with a market value. This means, as also correctly noticed by Nash, that grandfathering allowances could be viewed as granting a subsidy to the firm (e.g., Hepburn et al., 2006b; Nash, 2000; Böhringer et al., 1998).

However, this subsidy is a capital gift to the firm, and has the character of a lump-sum subsidy (e.g. Hepburn et al., 2006b; Hargrave et al., 1999). In other words, this subsidy is conceptually different from a subsidy that is directly linked to the costs of pollution control and prevention measures. If a firm receives its allowances free of charge, it obtains a non-distortionary windfall profit (e.g. Bohm, 1999). In efficiency terms, a lump-sum subsidy does not distort the market since it affects neither the marginal emission reduction costs, nor the output and price decisions of firms. Consequently, the incentive to abate is not distorted.

As stated by Ellerman and Reguant, "it is clear that free allowances improve the profitability of the units so endowed, but as long as the endowment does not change according to the facility's output or emissions, the lump-sum endowment should have no effect on operations" (Reguant and Ellerman, 2008: 2).

Moreover, not only auctioning, but also grandfathering entails costs for firms, namely the opportunity costs that are part of the cost price and must be incorporated in the product price.

Governments do not subsidize pollution when allocating emission rights free of charge. As a result, grandfathering is also consistent with the weak form of the polluter-pays principle (i.e., "no subsidization"). Product prices under an environmental regime of grandfathered allowances will reflect the costs of pollution abatement as the weak form of this principle requires.

This analysis has demonstrated that grandfathering does in fact induce internalization of pollution costs, which makes the free distribution of allowance consistent with the strong form of the polluter-pays principle. If consistency with even the strong form is demonstrated, grandfathering must logically be consistent with the weak form as well. Moreover, if we double-check consistency with the weak form, it turns out that grandfathering does not subsidize pollution but rather implies a lump-sum subsidy that does not affect marginal emission reduction costs and does not distort the ETS' effectiveness. These considerations make it clear that emissions can be reduced consistently with the P.P.P even when permits are grandfathered for free. These considerations do not change the fact that a firm receiving allowances free of charge has more financial resources than a comparable firm with auctioned allowances. Because grandfathering implies a capital gift, Nash (2000: 24) fears that this allocation method tends to keep less efficient installations in service. We agree with him that such an undesirable incentive might exist. This problem, however, only arises under particular circumstances (e.g., the problem of updating the baseline year) which will be discussed in the following sections.

4. Grandfathering, Auctioning and Consistency with the Equity Interpretation of the Polluter-Pays Principle

Although consistent with an efficiency interpretation of the polluter-pays principle, grandfathering might have some undesired distributive effects, which raise the question of whether this allocation rule could be considered consistent also with an extended interpretation of the polluter-pays principle, which entails both efficiency and equity. This section tries to clarify this issue. According to the Coase theorem, when the ETS cap is set at a stringent level, the negative environmental externality will be internalized efficiently and independently of how permits have been initially assigned. This is because, once opportunity costs are taken into account, economic agents face the same marginal costs of emitting an extra ton of CO_2 when permits are allocated for free or auctioned. Profit-maximizing firms will add the allowances' opportunity cost to the final price even when allowances are freely allocated; therefore, the final price will be the same whether the permits are auctioned or grandfathered.

Like grandfathering, auctioning is consistent with the efficiency interpretation of the polluter-pays principle; the reason is even more intuitive: no permits are assigned for free and polluters need to buy an amount of permits equivalent to the emissions they produce.

Despite that both allocation criteria are consistent with the polluter-pays principle from an efficiency perspective, opting for one particular allocative criterion (instead of another) has different distributional effects. In fact, the distribution of permits among participants affects the way permit trade takes place: who pays whom?

To highlight this point, it can be useful to make a comparison between the allocation of tax and allowances under grandfathering and auctioning. In the case that polluters had to pay a carbon tax proportional to the emissions they produced, the increased marginal cost would be transferred to the final market price. However, the pass through of the carbon tax to the final price that consumers have to pay does not mean that producers are not paying at all. The higher final market price lowers the quantity sold at equilibrium, and the cost of the tax is borne both by consumers and producers depending on the elasticity of supply and demand.

Auctioning could be thought of as a carbon tax imposed on the polluters, whose tax revenue is transferred from the private polluters to the State, while under grandfathering the tax revenue would be kept by the polluters themselves.

Producers have to internalize the cost linked to the allowances they own and pass it to the final market price in both cases. Thus, different allocation rules have the same impact on the final market outcome, but they have different distributional effects. Under certain conditions, grandfathering is an efficient allocation rule consistent with the weak and strong form of the polluter-pays principle; thus, the claim that polluters do not pay under grandfathering can only be defended from an equity perspective since polluters do not actually purchase their allowances and the State does not raise any revenue. Grandfathering implies a wealth transfer from the public to the polluter. This transfer in turn improves the financial position of the shareholders. That is, the value of a share increases because the polluter has received an asset with a market value for free. The producer then includes the emission price in consumer prices (because it has to cover the opportunity costs of using the allowances). Moreover, the fact that polluters earn the so-called windfall profits—since consumers pay the value of allowances that producers have obtained for free—may be perceived as unfair from a polluter-pays perspective.

Even if the polluter pays under grandfathering because of the opportunity costs he or she has to internalize, this allocation rule implies a sort of capital gift equal to the revenue that the government would have obtained in an auction. Such a capital gift, while not distortive in efficiency terms, does have a redistributive impact, which is beneficial for the polluter. Grandfathering means that polluting firms do not have to purchase their emission rights and that their shareholders become richer. This situation may be perceived as unfair from a polluter-pays perspective.

Only auctioning is consistent with the extended form of the polluter-pays principle—which operates according to both efficiency and equity—since it induces the internalization of the pollution costs, and additionally it forces polluters to purchase their emission rights, thereby avoiding a rise in the so-called windfall profits, which are generally perceived to be unfair.

The idea that auctioning provides a “better reflection” of the polluter-pays principle (noted in Egenhofer and Fujiwara, 2006: 25) can be defended based on an equity view of this normative doctrine.

It is possible to conclude that, in theory, auctioning is superior to grandfathering: they are both consistent with the efficiency interpretation of the polluter-pays principle and, in addition, auctioning is also consistent with its extended equity interpretation. Despite these arguments in favour of auctioning, Art. 10 of the first ETS Directive has established that during the first and second trading periods respectively, at least 95% and 90% of permits should have been assigned free of charge. In fact, given that auctioning entails higher private costs than grandfathering, the latter has increased the ETS’ political acceptability in the eyes of the ETS regulated sectors.

5. Conditions for Consistency with the Polluter-Pays Principle

Although it has been shown that grandfathering is consistent with the efficiency interpretation of the polluter-pays principle, the implementation of this allocation rule in the ETS has raised some problems concerning market efficiency. Because of the lack of clear and harmonized allocation criteria (Annex III), the way grandfathering has been interpreted and implemented in different NAPs has had negative repercussions on the ETS’ functioning and effectiveness. Specific repercussions include reduced incentives to abate emissions and distortions of competition among installations belonging to the same European sector and operating in the same Cap and Trade mechanism but *de facto* regulated by different MS (e.g., Johnston 2006). The following subsections analyse in more detail the inefficiencies related to grandfathering that have emerged in the ETS and the conditions that have to be satisfied in order to ensure the consistency of grandfathering with the Efficiency interpretation of the polluter-pays principle.

5.1 Grandfathering and the Baseline Updating Problem

The European Directive 2003/87/EC divides the EU ETS in different trading periods.[31] Art. 9 specifies that "for each period [...] each MS shall develop a national plan stating the total quantity of allowances that it intends to allocate for that period and how it proposes to allocate them." Moreover, Art. 13 establishes that "allowances shall be valid for emissions during the period [...] for which they are issued." These articles imply that allowances can be traded only within a phase, while they cannot be banked and transferred to the following trading period.

MS have to specify with a new NAP the amount of permits they intend to allocate to each plant every year within the specific ETS phase (e.g. Neuhoff, Martinez and Stato 2006).

This temporal subdivision of the ETS in different phases creates the risk of inconsistency among different NAPs. In particular, the way permits are grandfathered might change from one phase to the other (e.g. Demailly and Quirion 2006).

In both the EU ETS and US SO_2 trading programs, allowances have been grandfathered among economic agents according to their historic emissions; however, the way permits have been allocated has differed substantially. In the SO_2 emissions trading program, permits have been *one-off grandfathered*: the amount of allowances to be allocated according to historical emissions has been determined *ex-ante* at the beginning of the program without any *ex-post* adjustment. The amount of allowances to be assigned has decreased from one phase to the other proportionally to the progressive reduction of the total cap, but—differently from the European experience—independently of firms' current behaviour. That is, the historic emissions' year baseline adopted to assess how many allowances to assign free of charge has not been updated (Shmalensee et al. 1998).

On the contrary, across the consecutive trading periods of the ETS, permits have been grandfathered proportionally to a baseline year that has been updated to recent emissions (e.g., Demailly and Quirion, 2006). In the first trading period, MS grandfathered permits to incumbents proportionally to the average of emissions

[31] A five-year phase (2008 – 2012) follows the first three-year testing period started in 2005.

produced in a 3-5 year period between 1990 and 2002. Yet, after the publication of the emissions produced by the ETS installations in 2005, several MS (including Estonia, France, Germany, Latvia, the Netherlands, Poland and Slovakia) extended their base period to 2005, which has been chosen as new baseline year to calculate the proportional amount of permits to allocate during the second phase 2008 – 2012 (Neuhoff et al., 2006). The baseline updating process has a negative impact on the ETS' functioning by reducing the ETS installations' financial incentive to abate emissions. This process is not efficient, and it affects the consistency of grandfathering with the polluter-pays principle. As long as permits are one-off grandfathered and the future amount of allowances allocated free of charge does not depend on the regulated agents' behaviour, the free allocated allowances' opportunity cost does not vary, giving effective incentives to reduce emissions.

On the contrary, if the historic baseline year is updated to the current emissions level, then the opportunity cost of abating emissions diminishes, distorting the polluters' incentives to reduce emissions. In fact, if ETS' installations anticipate that the policy-maker intends to allocate future allowances according to the current level of emissions by updating the baseline year, they will be deterred from undertaking emissions abatement projects: the more emissions are reduced today, the less permits will be assigned tomorrow.

When the baseline is updated, the amount of permits economic agents will receive in future ETS phases is no longer an exogenous parameter; rather, it becomes an endogenous variable that economic agents internalize into their profit-maximizing function: the marginal benefit from abating pollution decreases and the abatement opportunity cost decreases as well.

The main consequence of an allocation criterion rewarding higher emissions today with more permits in the future is that it creates a perverse incentive to postpone investments in emissions reduction by making actual abatement less convenient. As a result, it distorts the incentives to abate pollution efficiently. The baseline updating process generates an early action problem: "*if future allowances are allocated as a function of present emission levels, firms have incentive to emit more now in order to extract a larger allocation in the future [...]; incentives are created for plant lifetime extension rather than plant modernization or replacement*" (Hepburn et al. 2006: 142-143).

Grandfathering is not consistent with the P.P.P. if firms have the possibility to influence the amount of permits they will receive in the future. This is because updating the grandfathering baseline to current polluters' behaviour distorts abatement opportunity costs and thus economic agents' incentive to abate pollution. Grandfathering is effective only if the amount of permits allocated free of charge does not depend on ETS installations' current behaviour. Therefore, the historic emissions' baseline adopted to calculate the amount of grandfathered permits should not be updated to current emissions.

A necessary condition for grandfathering to be consistent with an efficiency interpretation of the polluter-pays principle is that allowances should be on-off grandfathered without any update of regulated agents' current emissions. As long as current behaviour does not affect the amount of free allowances to be allocated in future phases, the allowances' opportunity cost will remain unchanged over time and the consistency between P.P.P. and grandfathering will be confirmed.

On one hand, updating the historic baseline is inefficient, but on the other hand, continuing to allocate the same level of permits to firms that have reduced their emissions permanently might be perceived as unfair. Such a trade-off between efficiency and fairness is exacerbated in the case of closures, and, together with the case of windfall profits, it highlights the risk that grandfathering—despite being consistent with the efficiency interpretation of the polluter-pays principle—might entail problems regarding fairness.

5.2 Grandfathering and the Closure Rules

The ETS has been established to induce polluters to internalize the emissions externality into their production cost. Once polluters have to pay for the emissions they produce, carbon-intensive technologies become relatively less economical and polluters have an incentive to reduce their emissions. In fact, the ETS installations have to internalize into their profit maximizing function both the marginal cost of increasing pollution (i.e., the need to buy more permits) and the marginal benefit of reducing it (i.e., selling permits received for free). Therefore, when permits are grandfathered, the permits' opportunity cost (i.e., the possibility to reduce emissions and sell the exceeding permits) is the fundamental factor inducing emissions reduction. In the long run, an effective cap and trade scheme should promote emissions abatement by favouring the progressive substitution of obsolete plants with cleaner technologies.

Because grandfathering implies a capital gift, Nash (2000: 24) fears that this allocation method provides incentives to keep older, less efficient plants in service. This section is aimed at showing that this undesirable incentive could exist, but only under specific circumstances.

It is important to analyse how the incentives to close inefficient and obsolete plants change under one-off grandfathering or baseline updating grandfathering. When permits are one-off grandfathered (i.e., independently of current plants' emissions), economic agents are entitled to receive the amount of permits initially established independently of their current behaviour—even if they decide to shut down a plant. In this case, closing an obsolete plant is economical if the profits earned from selling the free assigned permits exceed the potential profits deriving from production. On the contrary, when the historic baseline for grandfathering permits is updated to current polluters' emissions, the ETS installations do not receive any additional permits in the case that a plant is shut down. Compared to the previous case, the amount of permits that can be sold in the ETS decreases, and closing an inefficient polluting plant now becomes less cost-efficient.

Also in this case, when the allocation of permits is ex-post adjusted, pollution abatement incentives are distorted. As a consequence, inefficient carbon-intensive plants will continue to operate even if closing them would be socially more efficient. Paradoxically, interrupting the allocation of allowances after a plant shuts down becomes a form of indirect subsidy to production because "the firm earns the allocation if and only if it continues to operate the installation" (Ahman et al. 2006: 8).

Such an ex-post adjustment stimulates plant lifetime extension rather than plant modernization or replacement and leads to the postponement of emission reductions (e.g. Hepburn et al., 2006a; Matthes et al., 2005). These considerations support a strong argument against withdrawing permits in the case that closures take place. However, fairness considerations would suggest exactly the opposite: awarding indefinite emissions permits to closed plants that do not need them (i.e., those not producing emissions anymore) should be avoided. This argument seems particularly convincing in the case that obsolete, inefficient plants are closed and substituted with more efficient ones for economic reasons, and thus even in the absence of an emissions reduction environmental policy. In this case, awarding indefinite tradable permits after the closure takes place is perceived to be an unfair subsidy that MS give to private installations to induce them to shut down inefficient plants (e.g. Ahman et al. 2006; Hepburn et al. 2006).

When opportunity costs are taken into account, it is clear that this free allocation does not distort efficiency in the market. However, free allocation could have undesired redistributive effects. Fairness concerns support the proposal to impose some limits on the indefinite allocation of permits. In fact, most MS have included a closure rules in their NAPs stating that closed plants are not allowed to receive any allowances in the following years (e.g. Åhman et al., 2005). For instance, Germany has established that plants emitting less than 10% of their average annual emissions are not entitled to receive permits in the following years.

5.3 Re-questioning Consistency with the Polluter-Pays Principle in the Case of Over-Allocation

Arguing that both grandfathering and auctioning are consistent with the efficiency interpretation of the polluter-pays principle does not necessarily imply that the whole cap and trade mechanism is consistent with this principle.

So far it has been shown that both allocation rules are efficient under the implicit assumption that the whole cap and trade system works effectively, requiring that the cap is sufficiently stringent.

If this condition is satisfied, the market allowances' free bargaining will make sure tradable permits are allocated to those who value them most. On the other hand, emissions will be reduced by those who can do it at the lowest marginal abatement cost, independently of how emissions have been initially allocated. However, unlike other markets, the ETS is an artificially designed system in which scarcity has to be ensured by the regulatory authority; without scarcity, permits would not have any positive market value and the system would fail to give polluters any incentive to reduce their emissions.

The analysis conducted so far has confirmed that the effectiveness of the ETS depends on the amount of permits created and allocated by the regulatory authority, rather than on the allocation rules, both of which prove consistent with the efficiency interpretation of the polluter-pays principle. It is thus interesting to extend the analysis conducted so far by asking whether the results concerning the consistency of both auctioning and grandfathering with the weak, strong and extended interpretations of the polluter-pays principle can still be considered valid when the implicit assumption of the stringency of the ETS cap is relaxed.

In chapter 5, we have previously proved that over-allocation of allowances has occurred to a certain extent during both the trading periods of the ETS. This implies (by construction) that the ETS sectors have to bear a part of the emissions reduction burden in order to comply with the Kyoto target, which is lower than their emissions share. It has been shown that the ETS cap has not been set at a stringent level, causing the price of allowances to fall toward zero. One might be tempted to conclude that there is no violation of the weak interpretation of the polluter-pays principle: *de facto,* no subsidy is given to the ETS sectors by allocating them free allowances since the allowances are literally worthless. On the contrary, it has been shown that over-allocation of permits to ETS sectors has imposed on the ETS sectors an emissions reduction burden that is less proportional than their emissions share. Although free bargaining of allowances within the ETS can ensure that the emissions reduction burden deriving from the level of the ETS cap is abated effectively, part of the emissions reduction burden deriving from the Kyoto Protocol ratification (confirming that the ETS sectors should bear the reduction burden consistently with the polluter-pays principle) is transferred to the non-ETS sectors. Indeed, compliance with the Kyoto Protocol requires that, given the emissions reduction target, the lower the emissions reduction burden imposed on the ETS sectors is (i.e., the higher the ETS cap is), the higher the non-ETS emissions reduction burden has to be, and vice-versa.

The transfer of the emissions reduction burden constitutes a form of cross-subsidization from non-ETS to ETS sectors that is inconsistent with the weak interpretation of the polluter-pays principle (i.e., no subsidization). In this case, the subsidy should be thought of in terms of avoided environmental costs from which the ETS sectors are exempted and which are transferred to the non-ETS sectors. In the case of over-allocation, consistency with the weak form of the polluter-pays principle is violated independently of the allocation rule. Indeed, the cross-subsidization in favour of the ETS sectors takes place independently whether the over-allocated permits have been grandfathered or auctioned. Moreover, it is interesting to analyse whether the strong interpretation of the polluter-pays principle is also violated in the case of over-allocation.

It has been previously asserted that the strong form of the polluter-pays principle calls for governments to ensure the internalization of environmental costs (and not just to refrain from subsidizing pollution control).

It is straightforward to show that when allowances are over-allocated, the strong interpretation of the polluter-pays principle is also violated. If the ETS cap is stringent and no over-allocation occurs, then the environmental cost to be internalized by the ETS sectors is proportional to the percentage of emissions they generate. On the contrary, when over-allocation takes place, then the ETS sectors have to internalize only part of the externality they generate and the remaining costs are shifted (or "externalized") to the non-trading sectors outside the scheme.

Moreover, it has been shown that within the ETS the allocation of an excessive amount of allowances has caused a fall in the CO_2 prices toward zero. The price of one allowance is a proxy of the monetization of the externality that the ETS sectors have to internalize within their production cost and to pass through into the final market price. A zero CO_2 price implies that the environmental externality has not been priced and, thus, that there is no cost internalization. This in turn leads to a violation of the strong form of the polluter-pays principle as well.

It is worth noticing that inconsistency with the strong form of the polluter-pays principle holds independently of the allocation criterion adopted to distribute the over-allocated permits. Indeed, according to the Coase theorem, at equilibrium the market price does not depend on how permits have been initially allocated; therefore, if permits have been over-allocated, the price of allowances would fall toward zero independently of the initial allocation rule. Thus, neither grandfathering nor auctioning is consistent with the strong form of the polluter-pays principle.

From the previous analysis, it follows immediately that in the case of over-allocation also the consistency with the extended form of the polluter-pays principle is violated. Indeed, according to this interpretation, the equity criterion is used in addition to—and not instead of—efficiency. Therefore, since both the weak and strong efficiency interpretations are violated, then also the equity interpretation of the PPP is violated as well. Indeed, according to the polluter-pays principle, when permits are over-allocated, part of the environmental costs that the ETS sectors should bear in order to contribute in a proportional way to the Kyoto target achievement are transferred to another subject (i.e., the non-ETS sectors). While the ETS sectors bear an emissions reduction burden that is less proportional than their ETS share, the non-ETS will conversely have to abate an amount of emissions that is excessive if compared to the percentage of emissions they generate. Clearly, in addition to being inefficient, this environmental cost transfer is also unfair.

5.4 Harmonization of the Allocation Criteria

It has been shown that as long as allowances are not over-allocated the free trading of allowances within the ETS should ensure a cost-effective abatement, independently of how allowances have been initially allocated. Both grandfathering and auctioning are consistent with the efficiency interpretation of the polluter-pays principle. The criterion according to which allowances are initially allocated has only a distributive effect, which does not affect the correct functioning of the ETS. However, this last section wants to stress that when allowances are not allocated according to a common and harmonized rule among sectors and across different MS, the resulting distributional effects might undermine the efficiency in the secondary market where the ETS sectors compete.

It has been previously stressed that the costs imposed by the ETS on the regulated installations and sectors are inversely proportional to the amount of allocated allowances. These costs are then internalized and transferred to the final price in the market where the ETS installations compete, thereby indirectly affecting their competitiveness. Given the ETS cap (and assuming it is stringent), when MS decide how to distribute the total amount of permits among the firms and sectors involved in the ETS, they indirectly define the emissions gap that each sector and installation has to cover to comply with the European regulation and therefore the amount of costs for which the regulated sectors are responsible. Defining the criterion to distribute the permits becomes therefore a potential economic instrument MS wield to intervene and influence their competitiveness in the national sector.

Harmonized allocation rules within the ETS are required to avoid the risk that MS will arbitrarily allocate allowances among ETS sectors in order protect particular sectors and to favour their competitiveness in the secondary markets, thus distorting competition. As previously mentioned, the allocative criteria mentioned in Annex III are quite vague and do not define clear guidelines for deciding how to grandfather allowances. The lack of harmonized allocation rules and non-homogeneous NAPs risks distorting free market competition. Indeed, the possibility of a decision to over-allocate permits to some sectors in order to preserve their competitiveness and to under-allocate to the other sectors that are less exposed to international competition can be thought of as a sort of cross-subsidization among ETS sectors. Such a cross-subsidization may ultimately distort the competition in the European internal market.

The delegation of the allocative criteria's decision making policy to MS and the lack of any EC guidelines about how the allocative criteria should be applied homogeneously among sectors and countries, risks creating a problem of inconsistency among the different allocation criteria. Such inconsistency in turn risks generating obstacles to the integration and harmonization of the European internal market. Moreover, the discretion MS have in shaping the way to distribute permits among sectors may be used by MS to preserve some key sectors' competiveness in the international market by creating a mechanism of cross-subsidization among sectors (i.e., the over and under-allocation of permits)

This is the tendency we are observing currently in Europe where some countries, arguing they want to contain electric firms' windfall extra-profits, intend to under-allocate permits to the electric sector in order to over-allocate them to those industrial sectors that are more exposed to international competition.

6. Conclusions

Tradable emission rights, also called allowances, can either be auctioned off or handed out for free by means of grandfathering. To increase political acceptability, allowances have been mainly grandfathered during the first ETS trading periods. Polluters do not have to buy their emission rights in an auction, but rather they obtain them for free based on their historical emissions. Because polluters do not pay for their emission rights, it is a popular perception in the economic and legal literature that grandfathering is *inconsistent* with the polluter-pays principle (e.g., Sorrell and Sijm, 2003; Nash, 2000). This chapter has investigated whether this perception is correct.

First, a taxonomy of efficiency and equity interpretations of the polluter-pays principle has been presented. Within the efficiency interpretation, a "weak" form of the polluter-pays principle (i.e., no subsidization) must be distinguished from its "strong" form (i.e., cost internalization). The weak form requires that the government refrains from subsidizing pollution control, the strong form requires that polluters internalize the costs of pollution. This means that the strong form subsumes the weak form: both versions require that companies internalize pollution costs.

Nash (2000) argues that grandfathering runs contrary to the core of the polluter-pays principle, violating even the principle's weak form, since it corresponds to a government subsidy for polluters. Because grandfathering violates even the weak form of the polluter-pays principle, it must also be incompatible with the strong form, he argues, which makes him conclude that grandfathering is inconsistent with the polluter-pays principle.

This chapter reaches different conclusions. First, the compatibility of grandfathering with the efficiency interpretation of the polluter-pays principle is analysed. It is stressed that grandfathered allowances used for covering the emissions of the allowance owner have an opportunity cost that has to be taken into account. Instead of using allowances to cover the emissions, the firm could have sold those emission rights. This opportunity cost, equal to the allowance price, must be included in the product price. The consequence is that the costs of pollution are internalized and passed through to the final market price, which makes grandfathering consistent with the strong form of the polluter-pays principle (i.e., "cost internalization"). Moreover, it is argued that grandfathering allowances constitutes lump-sum subsidies that do not distort competition, making grandfathering consistent with the weak form as well.

The claim that polluters do not pay under grandfathering can only be defended from an equity perspective. The comparative analysis of auctioning and grandfathering shows that, while both allocation rules are consistent with the efficiency interpretation of the polluter-pays principle, only auctioning complies also with the "extended" form of the polluter-pays principle, where equity is used as a criterion in addition to—and not instead of—efficiency. Grandfathering improves the financial position of the shareholders because polluters receive an asset with a market value for free. Even if the polluter pays under grandfathering because of the opportunity costs faced, companies receive a capital gift equal to the revenue that the government would have obtained in an auction. Such a capital gift, while not distortive in efficiency terms, does have a redistributive impact that is beneficial to the polluter. Because polluting firms do not have to purchase the emission rights, while their shareholders become richer, grandfathering may be perceived as unfair from an extended polluter-pays perspective.

Auctioning ensures the internalization of the pollution costs and, on the top of that, forces polluters to purchase their emission rights. However, grandfathering can make a (more stringent) cap-and-trade scheme more acceptable to producers.

The last section has described the conditions to be satisfied in order for grandfathering to be an efficient allocation criterion inducing the internalization of external environmental costs.

Each allocation rule is effective under the condition that allowances are not over-allocated. This condition implies that the ETS cap has to be set at a stringent level. Grandfathering is efficient if allowances are one-off grandfathered: as long as the current behaviour does not affect the amount of free allowances to be allocated in future phases, the allowances' opportunity cost will remain unchanged over time and the effectiveness of grandfathering will be confirmed. Finally, distortions of competition in the secondary markets are minimized only if the allocation rules are applied according to homogeneous and harmonized criteria.

Chapter 7. ETS Reform and Carbon Leakage: Assessing the Inconsistencies of the New ETS Directive

1. Introduction

During the meeting held in Brussels on 8-9 March 2007, the European Council declared its intention to strengthen the European Climate Policy beyond the Kyoto Protocol commitment. On 23 January 2008, the European Commission (EC) published a package of proposals (the so-called Climate and Energy Package) aimed at mitigating climate change and promoting renewable energy sources through 2020 and beyond.

In the field of Climate Change, the Commission officially expressed its firm intention to cut unilaterally European emissions by 20% below 1990 by 2020 in the case that no international post-Kyoto treaty is signed.[32] Moreover, the EC published a proposal [COM(2008) 16 final] designed to amend the current European GHG emissions trading system (EU ETS) Directive (Directive 2003/87/EC). A revised version of the Commission's proposal was officially approved by both the European Council and the European Parliament on 17 December 2008, and was finally adopted in April 2009.

The new ETS Directive 2009/29/EC amending the first ETS Directive 2003/87/EC first extends the EU ETS to a third post-Kyoto trading period (2013-2020). Moreover, it reforms the ETS institutional framework in order to improve its functioning and effectiveness in promoting the reduction of CO_2 emissions. Indeed, according to the EC itself, "the overall functioning of the Emissions Trading Scheme could be improved in a number of aspects" [COM(2008) 16 final, 2].

In the light of the new ETS Directive, it becomes relevant to study if and how the ETS' functioning will be effectively improved during its third post-Kyoto trading period (2013-2020).

This chapter focuses on the major provisions that reform the two variables upon which the ETS' effectiveness depends: the ETS cap level, which indicates the quantity of emissions the ETS sectors can produce, and the allocation rule, which establishes how the initial amount of allowances should be distributed among the ETS sectors.

---

[32] The EC also declared its willingness to reduce the Community greenhouse gas emissions by 30% below 2005 levels by 2020 in the case of the achievement of an international "post-Kyoto" treaty that would commit the non-EU developed countries to reduce their emissions and the other economically more advanced developing countries to contribute to global warming mitigation according to their responsibilities and respective capabilities.

After recalling the inefficiencies that emerged in the past trading periods, this chapter analyses how these variables have been reformed in order to assess if and to what extent the new ETS Directive will improve the ETS' functioning, by increasing its effectiveness, avoiding undesirable distributive effects and granting a higher harmonization of rules aimed at minimizing distortions of competition.

For this purpose, the chapter focuses on the phenomenon of Carbon Leakage, by analyzing the methodology defined to assess it and discussing the results of the EC quantitative assessment.

The chapter is structured in five sections. Section 2 focuses on the ETS cap setting procedure. After recalling which inefficiencies have emerged in the ETS' past trading periods, the section describes the new ETS cap setting procedure, assessing if and how it will improve the ETS' functioning by reducing the past inefficiencies.

Section 3 focuses on the allocation criteria. It briefly recalls the previous allocation rule and describes both the new allocation rule that will be applied in the third trading period and the arguments in favour of switching from grandfathering to auctioning.

Section 4 constitutes the core of the research. The methodology to assess the ETS sectors' exposure to Carbon Leakage is analysed, and the results of the EC quantitative assessment are presented and discussed. Particular attention is devoted to the discussion of both the criteria and the level of data aggregation adopted to assess the risk of Carbon Leakage. This discussion aims to highlight both when the defined procedures have a solid economic basis and when they can be considered mainly political or extra-economical. Section 5 concludes.

2.The New ETS Cap Setting Procedure

The new ETS Directive deeply reforms the legal procedure required to set the ETS cap. This section first analyses the previous procedure to assess the ETS cap, focusing on the related economic inefficiencies that have emerged in the past ETS trading periods. Then it describes the new methodology and criteria established to assess the ETS cap in the next trading phase, discussing whether an effective improvement of the ETS' functioning can be reasonably expected.

2.1 The Past Regulation and Related Inefficiencies

Chapter 4 has explained that the ETS' first and second trading periods have been characterized by a decentralized legal procedure for setting the ETS cap. Indeed, the first ETS Directive 87/2003/EC delegated to MS the duty to design a NAP for each trading period, specifying both how many permits would be assigned at a national level and how they would be distributed among national ETS sectors and installations. NAPs had then to be submitted to the EC, which could accept, modify or reject them consistently with the allocation criteria set out in the EC Directive's Annex III.[33]

In chapter 5, we have shown that the vagueness of the Annex III criteria characterizing the NAP decentralized procedure has allowed MS to set national caps that were not equally proportional—neither to their national target nor to the national percentage of emissions produced by the ETS sectors. As a consequence, despite being subjected to a common regulation, the same European ETS sectors have borne different emissions reduction burdens depending on the MS in which they have been located. The lack of harmonized national caps has been also the consequence of the non-homogeneous evaluation of the submitted NAPs on behalf of the EC. The distribution of different reduction burdens across national ETS sectors has undermined the level playing field in the secondary European common market where ETS sectors compete causing a distortion of competition.

The lack of permit scarcity in the ETS has caused the fall of CO_2 prices toward zero, thereby failing to give any significant incentive to reduce emissions (chapter 5).

The EC has recognized that delegating the duty to set national ETS caps has created a sort of prisoner's dilemma where "each individual MS recognises the collective interest to set restrictive caps for optimal reduction of emissions in the EU, but also has an interest to maximise the national cap" [SEC (2008) 52, 90].

Moreover, the NAP decentralized procedure has increased uncertainty in the market among the ETS installations. In fact, the European ETS cap could be determined only *ex-post* by summing up the different national caps once all the NAPs had been definitively approved by the EC. NAPs should have been examined and approved by the EC fifteen months before the beginning of the subsequent trading period, but during both the first and second ETS phases some NAPs were finally approved only some months after the beginning of the concerning trading period. As a result, at the time that the ETS trading periods were officially launched, many installations did not

[33] These criteria mainly indicate that the ETS cap should be set consistently with MS emissions reduction targets (criterion 1) and with the other existing emissions reduction policies (criterion 2), ensuring that emissions can be reduced at lower marginal abatement costs (MACs) (criterion 3).

know the amount of permits they would initially receive, and the level of the ETS cap was unknown.

This long procedure involved substantial transaction costs—of a monetary and administrative nature—causing, in turn, price volatility in the ETS and increasing uncertainty among the regulated actors, and thereby deterring them from developing long-term investment strategies for a low-carbon economy.

Finally, during the first ETS pilot phase, the ETS sectors' emissions were not sufficiently capped. The ETS cap indicates both the amount of emissions the ETS sectors are allowed to produce and how the burden of the European emissions reduction target will be shared among emitting sources: how many emissions trading and non-trading sectors are required to abate in order to ensure the European compliance with the target established in both the Kyoto Protocol and in the Climate Package.

A stringent ETS cap and a distribution of the emissions reduction burden among ETS and non-ETS sectors according to their marginal abatement costs are two necessary conditions for creating effectiveness in the ETS. On the contrary, in the first pilot trading period the lack of permit scarcity caused the CO_2 price to fall to zero, thereby failing to give any significant incentive to reduce emissions. Consequently, the emission reduction burden imposed on the ETS sectors was too weak, while the reduction burden indirectly imposed on ETS sectors was excessive compared to their abatement potentialities and marginal abatement costs.

In summary, the experience gathered from the first trading period has induced the EC to affirm that "a system based on national cap-setting does not provide sufficient guarantees that the emission reduction objectives […] will be achieved. Moreover, such a system is not likely to lead to minimise overall cost of emissions reductions" [COM (16) 2008 final, 7].

2.2 The ETS Cap Setting Reform

The new ETS Directive has further centralized the ETS regulatory framework in the hands of the EC. Indeed, the NAP procedure has been abandoned and substituted by a unilateral EU-wide ETS cap setting procedure on behalf of the EC [COM (16) 2008 final]. This procedure is aimed at increasing the ETS' effectiveness by reducing the transaction costs linked to the NAP design, submission and approval procedure—costs due to time, administrative and monetary factors. Increased effectiveness is also sought by enhancing harmonization in the European market through a unique regulation. Differently from the previous trading periods, the amount of permits to be assigned will be defined according to a common criterion across the MS where the ETS sector might be located.

The EC has evaluated different options for setting the ETS cap and sharing the emissions reduction burden between ETS and non-ETS sectors [SEC (2008) 52]:

1. *Status quo approach*: MS have to determine the national caps with NAPs. This approach corresponds to the same procedure applied in the past trading periods.
2. *Equal effort approach*: the cap would be determined at a level that would impose the same total costs on the ETS and non-ETS sectors.
3. *Benchmark-based approach*: this criterion implies that the cap is set according to each sector's abatement potential.
4. *Proportional reduction approach*: the emissions reduction burden imposed on trading and non-trading sectors would be proportional to the European target (-20%). Both ETS and non-ETS should reduce their emissions by 20%.
5. *Efficiency approach*: the ETS cap should be set at a level that would equalize the marginal abatement costs among trading and non-trading sectors.

Subsequently, the EC has chosen the most appropriate option according to three criteria:

1. *Effectiveness*: the ETS cap should be set in order to ensure the achievement of the objective of the proposal.
2. *Efficiency*: the ETS cap should be set at a level that would allow the emissions reduction target to be achieved at the least cost.
3. *Consistency*: the ETS cap should be determined according to an approach that is likely to limit trade offs across the economic, social and environmental domains.

While the undesirable effects of the *status quo* approach have been already commented upon, the *equal effort approach* has not been considered economically efficient, while the EC has considered the *benchmark approach* quite vague and as increasing uncertainty and the risk of additional market distortions.[34] Moreover, the EC has identified this approach to be neither effective in setting a cap nor efficient

[34] The EC maintains that the outcome of the benchmark approach "*is not known either, as the cap would rather be determined by assumptions as regards the period within which the required reductions could be achieved*" [SEC(2008) 52, 99].

since it would require a complicated and very expensive modeling analysis. Therefore, these three options have been discarded by the EC.

The *proportional reduction approach* is consistent with the European objective and coherent with the equity principle, according to which polluters have to pay proportionally to the pollution they produce. The ETS cap determined according to this approach is clear and easy to calculate; however, it would not be efficient since it would impose a -20% emissions cut to all agents independently of their marginal abatement costs.

According to the Commission, only the *efficiency approach* “would comply fully with the objective of least abatement cost to reduce emissions” [SEC(2008) 52, 99]. The EC has established that it is the most appropriate criterion to share the emissions reduction burden among trading and non-trading sectors, given that it is consistent with the reduction target and that it is both efficient and effective.

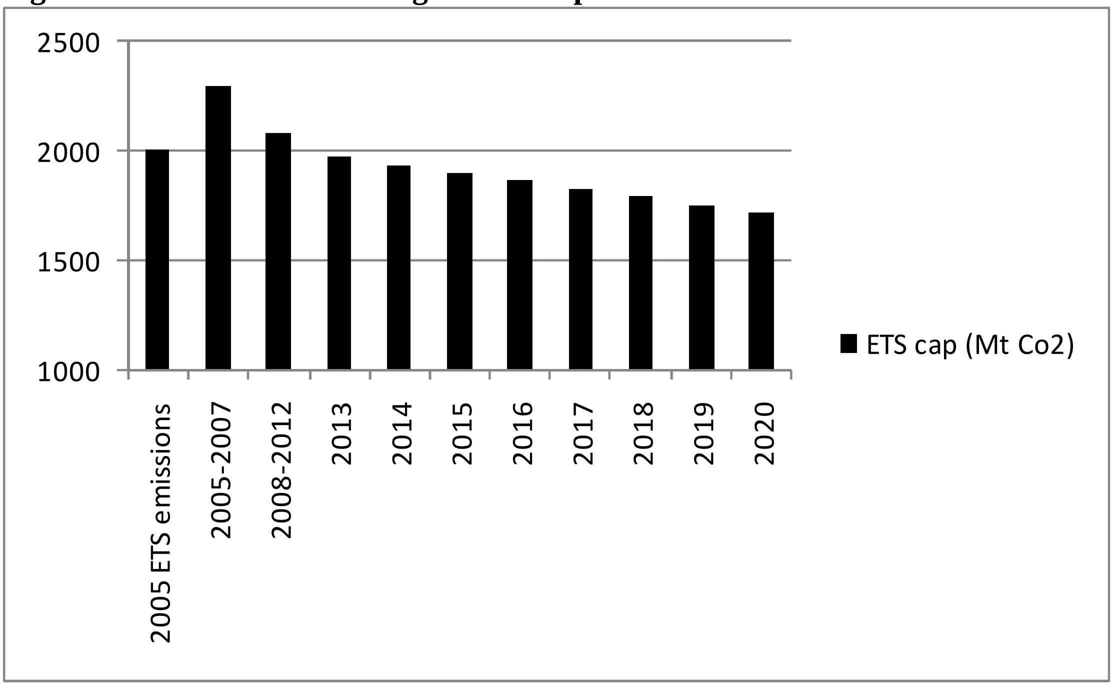
In fact, permit scarcity and an efficient distribution of the emissions reduction burden among ETS and non-ETS sectors are two necessary conditions for creating effectiveness in the ETS.

Perfect competitive trade would be sufficient to ensure an efficient emissions abatement that would minimize and equalize marginal abatement costs, no matter how quotas and emissions reduction burdens have been initially allocated among ETS and non-ETS sectors. However, there is no linking market between ETS and non-ETS sectors ensuring their MACs equalization through *ex-post* trade; therefore, the ETS cap should be set *ex-ante* at a level that would equalize trading and non-trading MACs from the very beginning.

Based on a general equilibrium simulation model, the EC has established that the -20% below 1990 emission reduction target would be achieved at the minimum cost, thereby imposing on the ETS sectors a -21% emissions abatement compared to 2005, while non-trading sectors would be required to reduce their emissions by 10% [COM (2008) 17 final]. The different reduction burdens among trading and non-trading sectors have been justified by the trading and non-trading sectors’ different marginal abatement costs: the ETS sectors have on average lower marginal abatement costs and higher abatement opportunities than non-ETS sectors. Therefore, they have to bear a higher emissions reduction burden than non-ETS sectors.

However, no data or results that could prove that ETS sectors have on average lower marginal abatement costs and higher abatement opportunities than non-ETS sectors— and to what extent— have been published by the EC.
According to the modeling assessment analysis, the cost-effective ETS cap consistent with the EU's commitment (-20% by 2020) corresponds to a level of 1,720 Mt CO_2 in 2020. From 2013 through 2020, the ETS cap will be annually reduced by 1.74% as shown in Table 1 below [COM (2008) 16 final, art. 9]. The ETS cap indicates the quantity of emissions the ETS sectors has to reduce in order to comply with the European regulation. The increasing and progressive strictness of the ETS cap gives a first indication of the increasing cost and emissions reduction burden imposed by the European Climate Policy on the regulated sectors.
Figure 15 shows that the annual caps set by the EC for the third trading period are stricter than both the historical level of ETS emissions and the past ETS caps, thus ensuring higher permit scarcity, which is required to promote emissions reductions. More than being the result of the new centralized ETS framework, the increased ETS cap stringency and predictability are the results of the increasing European political commitment to building a credible and effective climate policy.

Figure 15 - ETS Third Trading Period Cap



In conclusion, the new ETS Directive has improved the ETS' effectiveness on different fronts. The new centralized procedure for setting the ETS cap reduces the transaction costs linked to the previous decentralized procedure. It improves the harmonization of the European regulation among ETS sectors, which will be subjected to a homogeneous cap across MS defined according to a common criterion aimed at imposing on both trading and non-trading sectors an emissions reduction burden coherent with their marginal abatement costs. Moreover, the ex-ante definition of the ETS cap from 2013 to 2020 improves the regulation transparency and its effectiveness by reducing the CO_2 price volatility and increasing the certainty that the ETS installations need to build up their long-term investment strategies.

3. The ETS Allocation Criteria

Once the ETS cap has been set at an effective level, the corresponding amount of allowances can be distributed among the regulated sector either free of charge or as auctioned. Art. 10 of the first ETS Directive has established that during the first and second trading periods respectively at least 95% and 90% of permits should have been assigned free of charge according to historical emissions (i.e., grandfathering). Since auctioning entails higher private costs than grandfathering, the adoption of the latter allocation rule has increased the ETS' political acceptability in the eyes of the ETS regulated sectors.

However, since the first ETS pilot trading period was launched, grandfathering has been criticized on different grounds (e.g. Cramton and Kerr 2002, Hepburn et al. 2006, Demailly and Quiron 2006). According to the EC, the allowances allocation rule has to ensure environmental effectiveness and economic efficiency and avoid any distortion of competition and undesirable distributive effects. Only auctioning satisfies these conditions of efficiency and distributional fairness [SEC (2008) 52]. Thus, a gradual shift occurs from grandfathering toward auctioning as an ETS default allocation rule. The next sections focus on the new allocation rule (i.e., auctioning), analysing both the way it will be applied and the potential inefficiencies that could arise in the post-Kyoto trading period.

3.1 The New ETS Allocation Rule

According to the EC, the allowances allocation rule has to ensure environmental effectiveness and economic efficiency, and avoid any distortion of competition and undesirable distributive effects [SEC (2008) 52]. While the first conditions ensure efficiency, the last one is related to a principle of fairness. In order to satisfy these conditions, the EC has decided that allowances have to be initially sold in an auction rather than being assigned free of charge. According to the EC, “full auctioning of allowances scores best in increasing the efficiency of the system and taking away undesirable distributional effects” [SEC (2008) 52, 163] and “full auctioning is […] the only option that entirely solves efficiency problems” [SEC (2008) 52, 106], while on the other hand “the availability of free allowances reduces the financial necessity for undertakings to reduce emissions” [SEC (2008) 52, 92].

While the theoretical superiority of auctioning over grandfathering has been already proved (they are both efficient and, what is more, auctioning is fair), the EC’s latest argument against grandfathering does not seem to take properly into account economic theory, and in particular the concept of opportunity costs. Under grandfathering, ETS installations are called to decide between using the grandfathered permits to cover their CO_2 emissions or reducing their emissions in order to sell at the market price the allowances they have received for free. Under auctioning, installations have to decide between buying allowances in an auction in order to cover their CO_2 emissions or reducing emissions in order to lower the initial amount of allowances to be acquired in an auction. While in the latter case the incentive to reduce emissions is determined by a cost that the operator does not want to bear, in the former case the same incentive is determined by the gain that the operator could earn by reducing its emissions and selling the permits received at no cost. Thus, in spite of free allocation, the ETS installations face the same financial incentive to reduce emissions that they would face under auctioning.

Moreover, in chapter 6 we have already argued that, when the opportunity cost of free assigned permits is properly taken into account, both grandfathering and auctioning are efficient allocation criteria. This analysis is consistent with an efficiency interpretation of the polluter pays principle.

However, despite that both auctioning criteria are in theory efficient, the implementation of grandfathering in the ETS has created problem concerning market efficiency. Because of the lack of clear and harmonized allocation criteria, the way grandfathering has been interpreted and implemented in different NAPs had negative repercussions on the ETS functioning and effectiveness, by reducing the incentives to abate emissions and by generating distortions of competition among installations belonging to the same European sector and operating in the same Cap and Trade mechanism but *de facto* regulated by different MS.

In the light of both the inefficiencies and the undesired distributional effects caused by the free allocation of allowances, the EC expressed its intention to progressively abandon grandfathering in favour of auctioning as the new ETS default allocation rule. That is, according to the EC, only *full auctioning* can ensure the efficiency of the ETS. However, with both the Climate Package and the new ETS Directive's final approval it has become clear that the new allocation rule to be applied during the third ETS trading period is far from being *full auctioning*. Instead, three different allocation rules, which vary from full auctioning to full grandfathering, will be applied to three different types of sectors.

The new ETS Directive states that from 2013 onwards no free allocation will be given to energy installations, with the exception of co-generation plants, which can receive an amount of free permits proportional to the heat delivered to district heating or industrial installations and to certain electricity plants located in the Eastern EU MS, that respect particular conditions reported in points 9 and 10 of Art. 10a of the new ETS Directive.[35] This first measure is effectively a *full auctioning* allocation rule.

On the other hand, energy-intensive manufacturing installations not included in the power sector will face a progressive transition from grandfathering to auctioning. In 2013, they will receive free of charge 80% of the amount allowances to be assigned.[36] The initial proposal for a new ETS Directive published on January 2008 stated that 80% percent of free allocation should progressively decreased toward zero in 2020, while the final proposal approved in December 2008 states that the same initial percentage of free assigned allowances (80%) will decrease by an equal amount each year, arriving at 30% free allocation in 2020 and reaching full auctioning only in 2027. This second measure is here defined as *mixed auctioning*, since it combines both grandfathering and auctioning. Rather than supported by economic

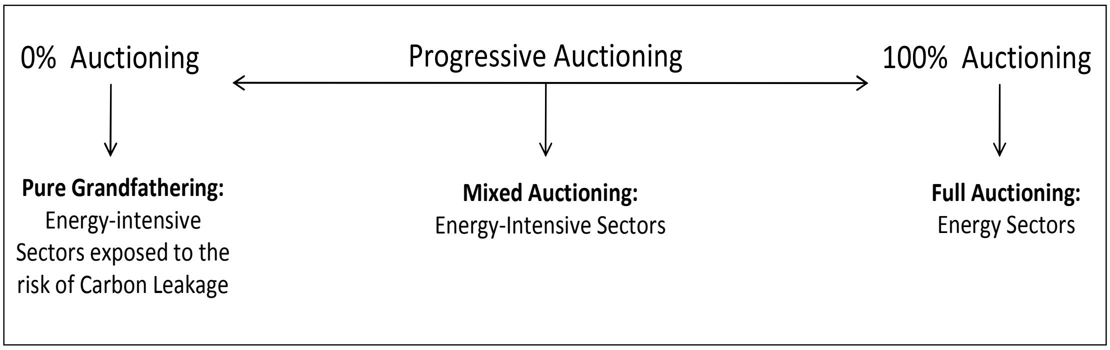
[35] The amendment to Art. 10a of the first ETS Directive states that full auctioning should be the allocation rule for the electricity generators, as well as the capture and the pipelines for the transport or storage of carbon dioxide, while "electricity generators may receive free allowances for district heating and cooling and for heat and cooling produced through high efficiency cogeneration as defined by Directive 2004/8/EC in the event that such heat produced by installations in other sectors were to be given free allocations, in order to avoid distortions of competition" [2008/0013 (COD), 12]. Moreover, the new ETS Directive grants derogation from full auctioning to some electricity generators located in certain East European MS [Art. 10a, point 9. 10. 2008/0013 (COD)].

[36] The new ETS Directive specifies that grandfathering would correspond to 80% of the "amount that corresponded to the percentage of the overall Community-wide emissions throughout the period 2005 to 2007 that those installations emitted as a proportion of the annual Community-wide total quantity of allowances" [2008/0013 (COD), 12].

considerations, the progressive adoption of auctioning seems to be the result of a political compromise aimed at increasing the political acceptability of the ETS in the eyes of the regulated sectors.

Finally, those sectors that are found to be at risk of exposure to Carbon Leakage are entitled to complete exemption from acquiring permits in an auction. This third and last measure is a *pure grandfathering* allocation rule.

Figure 16 – Third ETS trading period allocation rule



The next section focuses on the problem of Carbon Leakage. After defining what is meant by the term "Carbon Leakage," the methodology to assess the ETS sectors' exposure to Carbon Leakage is analysed and the results of the EC quantitative assessment are presented and discussed.

4. The Risk of Carbon Leakage: Causes and Preventative Measures

After the CO_2 emissions have been priced, high energy intensive installations face a cost increase, which weighs more heavily on those sectors highly exposed to international competition. In fact, differently from the energy sector, which faces limited international competition,[37] manufacturing sectors facing international competition might have a limited possibility to pass through their increased costs into the final product price without incurring a significant loss of market share against non-EU installations that are not subjected to the same costly environmental regulation.

A European climate policy imposing an unilateral cost on European firms gives an indirect comparative advantage in favour of extra-EU competitors whose products are thereby guaranteed to become relatively less expensive and, thus, more economically

[37] Electricity can be traded only if a grid infrastructure is in place and, even in this case, electricity can be transmitted only to a limited extent, as long as the grid is not congested and bottlenecks are avoided

worthwhile. Foreign goods' substitutability for domestic production increases and as a result might cause imports to grow and internal production to decrease.

The European industrial lobbies have claimed that a European Climate Policy imposing a stricter cap and switch from grandfathering to auctioning would further worsen their competitiveness against international competitors, forcing them either to delocalize their production activity or to re-address their investment strategies toward non-EU countries where stringent and costly climate regulations are not in place. In the worst-case scenario, European installations might also be forced to shut down their plants with their production being replaced by the importation of cheaper extra-EU products.

Such a risk derives mainly from the fact that the European climate policy is unilateral (i.e., there are no symmetric climate policies outside Europe) and production-based, rather than consumption-based. That is, the ETS regulates the emissions linked to the production of a good (i.e., production emissions), rather than the emissions linked to the final consumption of that good (i.e., product emissions). Being production based, the ETS installations can comply with the European regulation just by switching the European production activity to outside Europe.

This is to say that the main effect of a unilateral and costly European climate policy could be to outsource production and emissions outside Europe, with detrimental effects on European economic growth. If this case were true, a unilateral European climate policy imposing substantial asymmetric costs on the European economic agents would not only be inefficient, but also ineffective for the environment: emissions would decrease in Europe, while increasing proportionally in the rest of the world. Goods would be produced outside Europe and then imported, causing additional emissions from their importation.

The risk of Carbon Leakage would make the European climate policy both economically and environmentally ineffective: "[given] the extent that energy-intensive industrial production is shifting globally from developed to developing countries (which it is), the 20 per cent target can be achieved without reducing carbon concentrations globally by the implied amount. Indeed, if the production techniques in developing countries are less carbon-efficient than in developing countries, and if we add the emissions from shipping, aviation, and other transport, it could even increase emissions" (Helm 2009: 6).

In the light of the political will of moving beyond Kyoto before Copenhagen 2009, the European Commission has had to solve a conundrum: how to approve a credible climate policy in a short time, while at the same time ensuring political acceptability and reducing the risk of Carbon Leakage. Since the renegotiation of the emissions reduction target was not a political option, the EC proposed a political compromise: mitigate the cost impact of the ETS by granting 100% free allocation instead of auctioning to all the ETS sectors found to be subjected to the risk of Carbon Leakage.

In the eyes of the industrial lobbies, grandfathering means lower financial expenditures, while in the eyes of the EC it means political acceptability of the new European Climate Package and reduction of the Carbon Leakage risk: "in the absence of international agreement on climate change policy, some allocation of allowances for free could be an efficient instrument to avoid net carbon leakage" [SEC (2008) 52, 163].

However, this statement is not necessarily true. Given the asymmetric and unilateral nature of the European climate policy, the risk of Carbon Leakage will persist. This is also because the ETS binding cap approved with the Climate Package is anyhow imposing an asymmetric costly emissions reduction burden on the European industrial sectors. Moreover, considering the opportunity costs associated with free allocation, one could also question whether the total exemption from auctioning would provide any real protection against leakage. The role of opportunity cost is critical to any Carbon Leakage risk assessment under grandfathering. Free assigned allowances have an opportunity cost that installations have to take into account when deciding whether it is more cost-efficient to produce in Europe and use the grandfathered permits to cover the related emissions or to delocalize production and sell the exceeding amount of allowances at the market price. In spite of free allocation, the ETS installations could still find it cost-efficient to delocalize their plants outside Europe and sell within the ETS the total amount of allowances they have received for free.

Therefore, it is not a given that the adoption of grandfathering instead of auctioning will mitigate the risk of Carbon Leakage. This decision looks more politically driven than economically grounded.

Another issue concerns how to determine which ETS sectors should be considered effectively at risk of exposure to Carbon Leakage and which not. The following sections analyse whether the final methodology adopted to assess which sectors should be considered at risk of exposure to Carbon Leakage has a solid economic background, or rather if it is mainly politically driven.

4.1 Guidelines to Assess Carbon Leakage

Despite recognizing the necessity of assessing the risk of Carbon Leakage, the Commission initially stated that the sectors or sub-sectors exposed to the risk of Carbon Leakage would be determined, if necessary, only after the final outcome of the international negotiations for a Post-Kyoto treaty to be held in Copenhagen at the end 2009 [COM(2008) 16, Art. 10b].

Indeed, the first proposal for the new ETS Directive limited itself to the introduction of some general guidelines to analyse the ETS sectors' exposure to Carbon Leakage, without specifying under which conditions a sector could be effectively considered exposed to Carbon Leakage and thus exempted from auctioning [SEC (2008) 52].

According to the EC definition, the *net cost increase* is the variable that best represents the risk of Carbon Leakage. It is defined as the part of cost increase caused by the ETS that the regulated installations cannot pass through to the final product price without losing a significant share of the market (against non-EU installations). The *net cost increase* is the result of a two-step analysis defined by the EC and which will be described in the following sub-sections.

4.1.1 Carbon Intensity and Cost Increase Assessment

The first step consists of the ETS sectors' *industrial production process analysis*, and it is aimed at assessing to what extent the ETS might increase the regulated sectors' costs.

After the CO_2 emissions have been priced, energy intensive installations bear two types of costs.

First, they are required either to reduce their emissions or to cover their emissions gap by acquiring a corresponding amount of permits in the ETS. Direct costs are proportional to the installations' direct emissions, a function of the plant **emissions intensity** (tons of CO_2 emissions per ton of production), which mainly depends on the fuel mix, the technology efficiency, the amount of self-produced electricity and the industrial process emissions.

Moreover, energy-intensive installations have to pay a higher price for the electricity, which is increased by the market value of the allowances passed through by the energy generators (e.g., Sjim et al. 2006). These indirect costs are proportional to the production process' indirect emissions represented by the installations' **electricity intensity** (MWh per ton of production), which mainly depends on the amount of electricity purchased and on the fuel mix used to generate the purchased electricity (i.e., fuel emissions factor). When assessing the ETS' impact on the regulated sectors' production costs, both direct and indirect emissions need to be taken into account. It is worth noticing that products' indirect emissions are related not only to electricity consumption, but to all the phases composing the product life-cycle: from the extraction and transportation of raw material to the distribution of the final product and its final disposal.

In principle, it would be more appropriate to account for the product life-cycle direct and indirect emissions; however, the EU ETS Directives regulates only the production process rather than the whole product life-cycle, thus limiting itself to the consideration of only the direct and indirect emissions related to the plants that can be easily measured.

Table 12 – Determinants of Sectors' Carbon Intensity

	Low Electricity Intensity	**High Electricity Intensity**
Low Emissions Intensity	Agriculture (non-ETS)	Aluminium, Electric Arc Furnace
High Emissions Intensity	Lime, Clinker	Pulp and Paper

4.1.2 Assessment of Trade Intensity and Exposure to Competition

Assessing the cost increase caused by the ETS is not sufficient to determine the risk of Carbon Leakage. Sectors that are not exposed to international competition are able to pass through the cost increase to the final market price without losing market share, and are thus neutralized against the risk of Carbon Leakage.

Therefore, it is necessary to assess to what extent the effective exposure to international non-EU competition allows the ETS regulated installations to pass through the cost increase to the final product price without any substantial loss of market share. Thus, an assessment of the elasticity of the relevant market demand price is required. Alternatively, the Carbon Leakage could be estimated by means of a numerical general equilibrium model (e.g., CGE models like the GEM-E3 already financed by the EC). Nevertheless, given the time constraints imposed by the political agenda, the EC has considered that a simplified estimation of the European markets' exposure to non-EU competition based on the amount of import/export trade would be sufficient to get first quantitative results, to be eventually improved and completed by a deeper qualitative analysis of the characteristics of the sectors' markets and technology.

The EC affirmed that exposure to competition could be assessed according to two different indicators: 1) the *import penetration ratio* determined by the ratio of the amount of imported products to consumed products and 2) the *export ratio,* determined by the ratio of the exported products to produced products. From the first EC guidelines, it is possible to conclude that both the cost increase and the exposure to international competition should be taken simultaneously into account to assess the risk of Carbon Leakage.

Table 13 – Determinants of Carbon Leakage

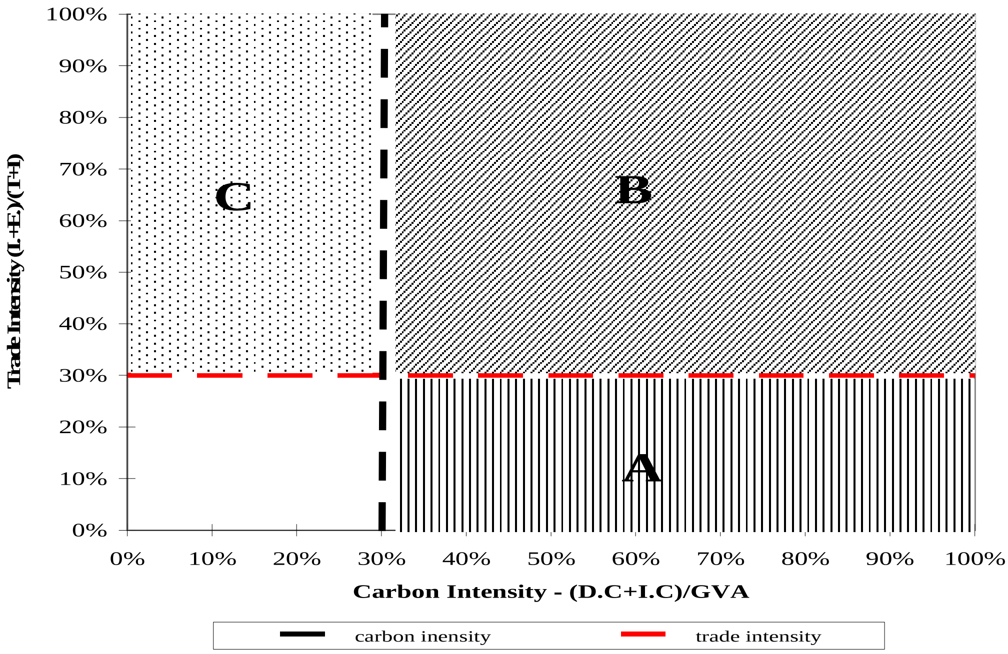
	Low Carbon Intensity	**High Carbon Intensity**
Low Trade Intensity	I – no risk of CL	II – low risk of CL
High Trade Intensity	III – low risk of CL	IV – high risk of CL

4.2 The Approved Methodology to Assess Carbon Leakage

After having published some general guidelines to assess the risk of Carbon Leakage, the new ETS Directive specifies a two-step methodology to assess which sectors are at risk of exposure to Carbon Leakage. First, the EC has been charged with determining the sectors at risk of exposure to Carbon Leakage via a quantitative assessment based on two alternative approaches.

First, a sector or sub-sector is considered to be exposed to Carbon Leakage if the sum of direct and indirect costs induced by the ETS would lead to an increase in production costs exceeding 30% of its Gross Value Added **or if** the value of its exports and imports divided by the total value of its turnover and imports exceeds 30%. Since it is sufficient to satisfy one of the two carbon and trade intensity conditions in order to be considered exposed to Carbon Leakage, this first criterion is here defined "*separated approach*," and it corresponds to one of the three areas (A, B or C) of figure 17.

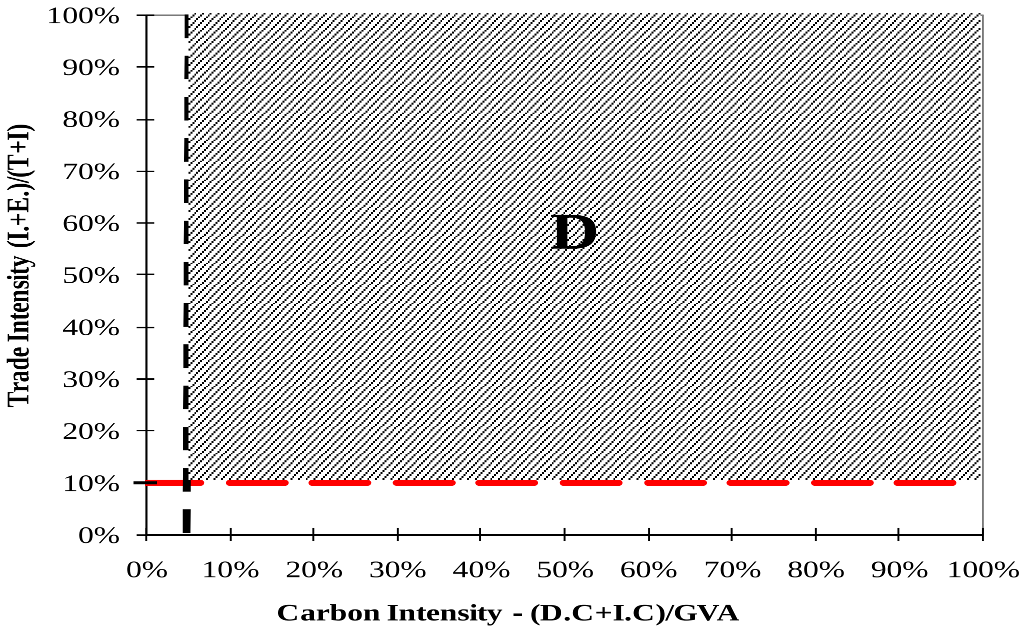
Figure 17 – Exposure to Carbon Leakage according to the "Separated Approach"



Second, even if neither carbon nor trade intensities exceed the 30% threshold, a sector or sub-sector can be fully exempted from auctioning if its carbon intensity (sum of direct and indirect cost divided by the gross value added) exceeds 5% **and if** its trade exposure (value of its exports and imports divided by the total value of its turnover and imports) exceeds 10%. This second criterion is here defined "integrated approach" because exposure to Carbon Leakage occurs only if both the carbon-trade intensity conditions are satisfied (area D of figure 18).

The new ETS Directive specifies that the list of sectors found to be exposed to Carbon Leakage according to the quantitative assessment can be eventually supplemented after completion of a qualitative analysis, which should focus on both the sectors' technological potential to reduce emissions or electricity consumption and the sectors' current and projected market characteristics.

Figure 18 - Exposure to Carbon Leakage according to the “Integrated Approach”



4.3 Analysis of the European Commission’s Quantitative Assessment Results

On April 29th 2009, the European Commission officially published the list of industrial sectors found to be at risk of exposure to Carbon Leakage by using the quantitative assessment procedure specified in the previous section. These preliminary results refer to 257 industrial sub-sectors analysed by the European Commission at a NACE 4 digit level of disaggregation.[38]

The NACE 4 sub-sectors’ carbon intensity has been estimated on the basis of historical emissions registered in the Community International Transaction Log (CITL) and, when required, with information provided by MS and by the industrial associations themselves.[39]

Coherent with the former EC guidelines, the direct cost increase has been estimated assuming that all the emissions had to be covered acquiring permits at a price of 30 €/ton. This assumption does not reflect the content of the new ETS Directive,

[38] NACE is the Statistical Classification of Economic Activities in the European Community. The number of digits of the code specifies the level of the classification system and the level of sector integration.

[39] The emissions produced by those sectors and plants which are going to participate in the ETS starting only from the third trading period (2013-2020) are not reported in the CITL; thus, they have been prevalently estimated by applying to the fuel mix combustion level the related emissions factors and summing up the industrial process emissions weighted by the historical level of production.

according to which permits will have to be 100% acquired in an auction only in 2027, while in 2013 80% of permits will be assigned free of charge and in 2020 only 70% of permits will be sold with an auction. The EC quantitative assessment over-estimate the direct costs imposed by the new ETS Directive to the regulated sectors, thus over-estimating the sectors' risk of exposure to Carbon Leakage.

Given the historical data of electricity consumption, indirect costs are estimated by multiplying the amount of electricity consumed by the marginal increase of electricity price under the assumption that the 30€/ton price is fully passed through into electricity prices (e.g., Reinaud 2007; Reinaud 2008; EC DG Environment et al. 2006).[40]

Out of the 257 NACE 4 examined sectors, 98 sectors did not result as exposed to Carbon Leakage, 19 sectors have not been examined because of the lack of official and reliable data, while 140 sectors (56%) have been found exposed to the risk of Carbon Leakage. Out of these 140 NACE 4 sectors exempt from auctioning, 3 sectors comply only with the requirements imposed by the integrated approach (5%< C.I.<30% and 10%<T.I.<30%); 3 sectors have been considered exposed to Carbon Leakage according to the separated approach because of their high Carbon Intensity (C.I.>30% and T.I.<10%), while 134 sectors (98% of the exempted sectors) have been found exposed to Carbon Leakage according to the separated approach because of their high trade exposure (T.I.>30%). The majority of these sectors included in the latter group are not carbon intensive at all: 83 out of the 134 sectors have been exempted from auctioning only because of their high trade exposure since they would face a (direct + indirect) cost increase lower than 1% of their Added Value, while 92 sectors would face a cost increase lower than 1.5% of their Added Value. Out of these 134 exempted sectors, 39 sectors would face a cost increase between 1.5% and 5% of their Added Value, while the last three sectors would face a cost increase higher than 5%, thus resulting to be exposed to Carbon Leakage according to both the integrated and separated approach.

[40] "Reinaud assumes that electricity pricing would lead to a full pass-through of the carbon opportunity cost in power prices. A EUR20 per tonne of CO_2 would result in a 21% price increase in Continental Europe (or an increase of EUR10/MWh). McKinsey and Ecofys (2006) follow the same methodology and also estimate that a EUR20/tCO_2 price will increase in electricity prices by EUR10/MWh" (Reinaud 2008).

Table 14 – Results of the Carbon Leakage Quantitative Assessment

	Number of sectors
Sectors not evaluated	**19**
Sectors not exposed to Carbon Leakage	**98**
Sectors exposed to Carbon Leakage	**140**
– C.I.> 5% and 10%<T.I.<30% (integrated approach)	3
– C.I.>30% and T.I.<10% (separated approach)	3
– T.I.> 30% (separated approach)	134
T.I.>30% and C.I.< 1%	*83*
T.I.>30% and 1%<C.I.<1.5%	*9*
T.I.>30% and 1.5%<C.I.<5%	*39*
T.I.>30% and C.I. >5% (both separated and integrated approaches)	*3*

Source: data elaboration based on European Commission 2009

The Carbon Leakage assessment allows us to understand which role both auctioning and free allocation will cover during the ETS third trading period. Indeed, we can estimate the amount of permits that will be auctioned by assuming that it will be proportional to the percentages of emissions produced by the ETS manufacturing sectors not exposed to Carbon Leakage.

Unfortunately, assessing the amount of emissions that has been historically produced by the ETS sectors exposed and not exposed to Carbon Leakage is puzzling. In fact, while the Carbon Leakage has been assessed quantitatively at a NACE 4 level, the emissions data are collected at an installation level and then aggregated in the CITL registry in 9 different categories, which do not correspond to the NACE code classification (table 15).

Table 15 - ETS Verified Emissions per Sector t CO_2 eq - EU 25

	2005	**2006**	**2007**	**2008**
1. Combustion installations	1,458,440,788	1,469,722,527	1,482,556,567	1,434,380,809
2. Mineral oil refineries	150,018,675	148,543,346	148,440,503	147,831,560
3. Coke ovens	19,193,122	21,301,035	22,073,888	20,984,289
4. Metal ore roasting or sintering	12,638,622	14,048,755	14,610,022	9,646,738
5. Pig iron or steel	129,292,592	132,899,646	132,240,627	132,897,010
6. Cement clinker or lime	177,537,990	182,078,934	190,653,632	177,543,699
7. Glass, including glass fibre	20,113,068	20,027,365	19,953,995	21,164,105
8. Ceramic products by firing	14,732,205	14,884,435	14,275,761	12,655,292
9. Pulp, paper and board	29,905,467	30,001,704	28,964,649	30,718,015
99. Other activity opted-in	2,143,082	2,142,936	2,180,743	1,478,693
Total	2,014,015,611	2,035,650,683	2,055,950,387	1,989,300,210

Source: CITL

The different data aggregation criteria create some problems. First, the emissions data of combustion installations reported in the CITL (table 15, category 1) aggregate emissions produced by sectors both exposed and not exposed to Carbon Leakage. Thus, it is not possible to estimate the percentage of emissions produced by sectors exposed to Carbon Leakage. We can subtract from the combustion installations' emissions aggregated data the amount of emissions produced by the Public Electricity and Heat Production fuel combustion activities and registered in the European Environment Agency's GHG inventory reports. In this way, we can separate the emissions produced by the energy sector, which is required to acquire permits in an auction, from the emissions produced by all the other manufacturing installations with a total rated thermal input exceeding 20 MW, which however belong to different NACE 4 sectors.

Table 16 – EU 25 GHG Emissions from Combustion Installations (t CO_2 eq)

	2005	**2006**	**2007**
Combustion installations	1,458,440,788	1,469,722,527	1,482,556,567
– Energy sector (Public Electricity and Heat Prod.)	1,171,588,399,50	1,177,863,590,91	1,191,771,838,14
– Manufacturing Sectors	286,852,389	291,858,936	290,784,729

Source: CITL and EEA 2009

Unfortunately, it is not possible to further disaggregate the *Manufacturing Sectors combustion installations' emissions data* in order to assess the amount of emissions produced by the combustion installations belonging to NACE 4 sectors exposed and not exposed to Carbon Leakage. Second, different sectors corresponding to the CITL categories (table 15: 7. glass, 8. ceramic, and 9. pulp and paper) include some NACE 4 sub-sectors, which have been exempted from auctioning, and other NACE 4 sub-sectors, which have not. However, since the emissions data are collected at an installation level and aggregated at a sector level without giving any NACE 4 specification, within a macro sector it is not possible to separate the emissions produced by the NACE 4 sectors exempted from auctioning from the emissions produced by the NACE 4 sectors that are not. By selecting only the CITL categories that entirely participated in the ETS during the past trading periods and whose NACE 4 subsectors have been entirely exempted from auctioning (2. Oil refineries, 3. coke ovens, 5. iron and steel, and 6. cement, clinker or lime), it is possible to conclude that at least 57% of the permits to be allocated to the industrial manufacturing sectors will be assigned free of charge. This is a precautionary under-estimation of the percentage of permits that will be freely assigned to the ETS manufacturing sectors since it does not take into account either the sectors that present only some NACE 4 sub-sectors exposed to Carbon Leakage (and thus entitled to receive free permits) or the fact that even the sectors not exposed to Carbon Leakage will receive in any case a progressively decreasing percentage of free permits (80% in 2013, and 30% in 2020). However, these considerations are sufficient to conclude that auctioning will be the default allocation rule only for the energy sector; on the contrary, the free assignment of permits will remain the dominant allocation criterion for the ETS manufacturing sectors, even in the third ETS trading period.

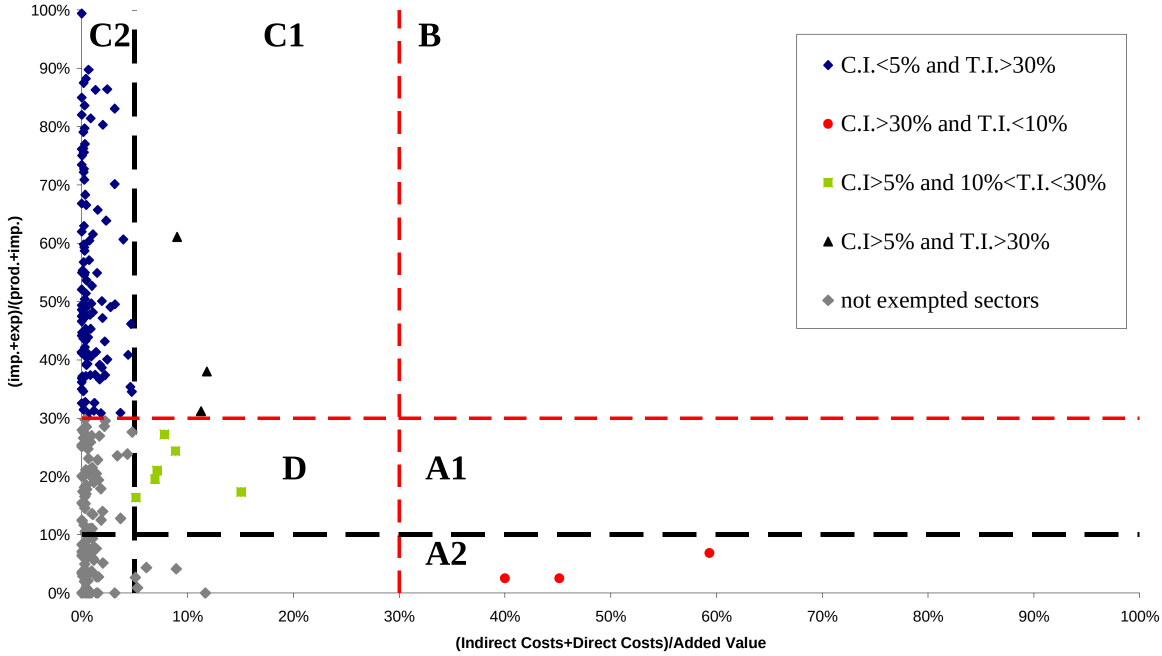
Table 17 – Emissions from Sectors Exempted and Not Exempted from Auctioning

	(ton Co_2 eq.)	(%)
ETS Manufacturing Sectors		
Exempted from auctioning	476,042,379	57%
Partially exempted	366,384,833	43%
Total	842,427,212	100%

4.3.1 Analysis of the Carbon Leakage Assessment Methodology

The methodology defined to assess Carbon Leakage is based on two alternative approaches, which differ substantially. The *integrated approach* takes simultaneously into account both the carbon and trade intensities, as well as both the cost increase and the possibility to pass through this increased cost to the product price, which depends on the sector’s exposure to international competition. Each of these conditions is necessary but not sufficient for a sector to be considered exposed to Carbon Leakage; their combination defines the areas of exemption from auctioning A1, B, C1 and D of figure 19.

Figure 19 - Areas of Exposure to Carbon Leakage



On the contrary, according to the *separated approach*, Carbon Leakage is assessed either on a “cost increase” basis or on a “trade exposure” basis. Above the 30% carbon intensity threshold a sector is automatically exempted from auctioning, independently of both its effective exposure to international competition and of its pass-through possibility (areas A1, A2 and B of figure 19). Similarly, above the 30% trade intensity threshold a sector is automatically exempted from auctioning independently of the ETS cost impact (areas B, C1 and C2 of figure 19).

However, three of the five exemption areas defined by the *separated approach* have been already delimited by the *aggregated approach* (A1, B, C1). Thus, the unique additional contribution of the separated approach to the Carbon Leakage assessment methodology is the delimitation of the two areas A2 and C2. These two areas grant exemption from auctioning both to sectors exposed to international trade, which do not face any substantial cost increase from the ETS (131 sectors located in the area C2), and to the most carbon-intensive sectors, which have some cost pass-through possibility ensured by their limited exposure to international competition (3 sectors located in the area A2).

It is possible to conclude that the *separated approach* is distortive and hence not an appropriate criterion to assess Carbon Leakage. The criterion’s unique effect is to protect many sectors that, being either carbon free or neutralized against international competition, do not face a real risk of Carbon Leakage, as it has been defined by the

EC guidelines on the *net cost increase* basis; thus there is no real economic rationale supporting their exemption.

Based on an integrated analysis of both carbon and trade intensities, the *integrated approach* is the unique criterion suitable for assessing the risk of Carbon Leakage. After discussing the consistency and effectiveness of both the criteria defined in order to determine which sectors should be exempted from auctioning, the defined thresholds need to be considered in order to evaluate the effectiveness of the Carbon Leakage assessment methodology. First, the EC does not explain if and why the chosen thresholds should be tailored to evaluate the risk of Carbon Leakage. It is not clear whether the 5%, 10% and 30% thresholds have been set arbitrarily or whether they have been specified according to economic principles. Moreover, deciding on a threshold basis whether permits should be assigned for free or auctioned, thereby implying that sectors can be either fully exempted from auctioning or not exempted at all, will impose a regulatory measure that is not proportional to the sectors' effective exposure to the risk of Carbon Leakage and might give them a distortive incentive to adopt opportunistic behaviour.

For instance, fully exempting a sector whose carbon and trade intensities are respectively 5.1% and 10.1%, while at the same time not exempting at all a sector whose carbon and trade intensities are 4.9% and 9.9%, might induce ineffective behaviour on the part of the unexempt sector, which could increase its emissions in order to pass the given threshold.[41] Alternatively, rather than evaluating the risk of Carbon Leakage according to a discrete threshold, free allocation could be granted proportionally to a continuous variable which reflects the degree of carbon and trade intensity. According to this hypothetical allocation rule, each sector would initially receive 80% of allowances for free, as defined by the ETS Directive, plus a percentage of free allowances proportional to the degree of risk of exposure to Carbon Leakage.

Finally, the relevance and appropriateness of the variables chosen to assess the risk of Carbon Leakage need to be discussed. The cost increase and the consequent risk of exposure to Carbon Leakage has been assessed weighting the sectors' aggregated level of historical emissions and electricity consumptions with the sector added value data. Thus, the higher the level of emissions and the more electricity that is consumed,

[41] The ETS directive specifies that the Carbon Leakage Assessment can be updated every year on the basis of new data.

the higher the probability to be exempted from auctioning, independently of sectors' carbon and energy efficiency. The ETS additional cost from auctioning allowances is more likely to be borne by the more carbon and energy efficient sectors, which have taken early action to reduce their emissions and energy consumption and which are more likely to have higher than average marginal abatement costs and lower potential for further emissions reduction.

The public willingness to shift from grandfathering to auctioning under the constraint of minimizing the risk of Carbon Leakage has led to the establishment of an allocation mechanism that ends up favouring and protecting the most polluting sectors, which are more likely to be exempted from auctioning. At the same time, this allocation mechanism ironically imposes additional costs on the most carbon and energy efficient sectors, which face less probability of being exposed to Carbon Leakage, and thus have to acquire permits in an auction. In conclusion, the new ETS Directive has defined a procedure to allocate allowances among ETS sectors according to arbitrary criteria, which do not seem to have a solid economic foundation, thus failing to improve the harmonization within the ETS required to minimize possible market distortion.

4.3.2. Relevant Market and Optimal Level of Data Aggregation

While the previous section has analysed the effectiveness of the criteria defined by the EC to assess the risk of Carbon Leakage, this section focuses on the level of data aggregation adopted to assess the sectors' exposure to Carbon Leakage.

Data can be aggregated either at a national or at a European level (i.e., horizontal aggregation) and at a sector NACE 3 or sub-sector NACE 4 level (i.e., vertical aggregation). The degree of risk of exposure to Carbon Leakage can vary depending on how data are aggregated. Therefore, it becomes necessary to define the more appropriate level of horizontal and vertical data aggregation.

Table 18 – Levels of Data Aggregation

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Horizontal Aggregation</th></tr>
<tr><th>European level</th><th>National level</th></tr>
<tr><th rowspan="2">Vertical Aggregation</th><th>NACE-3 Code Aggregation</th><td>I</td><td>II</td></tr>
<tr><th>NACE-4 Code Aggregation</th><td>III</td><td>IV</td></tr>
</table>

When evaluating the optimal level of data aggregation, two opposite considerations should be borne in mind: first, the higher the degree of data disaggregation, the higher the risk of applying different allocation criteria that undermine the harmonization of the regulation among sectors and countries. On the other hand, the more data that are aggregated, the higher the risk that the Carbon Leakage assessment will not reflect the technologies, industrial processes and market characteristics of the regulated sectors.

The new ETS Directive states that "the Carbon Leakage risk […] should be assessed, as a starting point, at a 3-digit level (NACE-3 Code), or where appropriate and where the relevant data are available, at a 4-digit level (NACE-4 Code)" [2008/0013 (COD), 14].

The EC has assessed the sectors' Carbon Leakage exposure on the basis of European data aggregated at a NACE 4 level (Table 18, cell III), without specifying the reason why it should be more appropriate to assess the risk of Carbon Leakage on the basis of industrial data disaggregated at a 4-digit level, and geographical data aggregated at a European level. It is not clear if the decision regarding the level of data horizontal aggregation and vertical disaggregation has been made according to a common economic criterion.

In order to fill this legal gap, this analysis proposes a uniform criterion to determine the optimal level of data aggregation: the risk of Carbon Leakage should be assessed on the basis of data aggregated *consistently with the relevant product and geographical market where the regulated sectors compete.*[42] This criterion is coherent with the qualitative assessment guidelines, which state that the Carbon Leakage assessment should take into account the sectors' *current and projected market characteristics.* Potential distortions of competition deriving from the European regulation would be minimized if the installations competing in the same relevant market were subjected to a uniform allocation rule. First, the relevant product and geographic market where the ETS installations compete should be assessed,[43] and

---

[42] According to the European Commission, "[t]he relevant market combines the product market and the geographic market, defined as follows: a relevant product market comprises all those products and/or services which are regarded as interchangeable or substitutable by the consumer by reason of the products' characteristics, their prices and their intended use; a relevant geographic market comprises the area in which the firms concerned are involved in the supply of products or services and in which the conditions of competition are sufficiently homogeneous" *Official Journal C 372 , 09/12/1997 P. 0005 – 0013*, available at http://europa.eu/scadplus/leg/en/lvb/l26073.htm

[43] The Commission attempts to define the product market by investigating whether product A and product B belong to the same market. It also tries to determine the geographic market by producing an overview of the breakdown of the market shares held by the parties in question and by their

then risk of exposure to Carbon Leakage should be estimated using data aggregated consistently with the relevant market assessment.

When deciding the most appropriate level of *horizontal-geographical data aggregation*, it is necessary to evaluate to what extent data aggregated at a European level can represent the relevant market where European installations compete and thus reflect the exposure to international competition faced by installations or sectors located in specific geographic areas.[44] When deciding the optimal level of *vertical-industrial data aggregation*, it is necessary to evaluate which classification (i.e., NACE-3 or NACE-4) better represents the relevant product market where the ETS installations compete. On one hand, a 3-digit level analysis risks aggregating sectors characterized by different industrial processes with specific energy or emission intensities required to produce goods, which—albeit belonging to the same NACE classification—are characterized by different degrees of quality (such as primary and secondary aluminium, BOF and EAF steel). Despite having similar physical characteristics, products belong to different relevant markets if they have different levels of quality. On the other hand, a Carbon Leakage assessment based on data disaggregated at a 4-digit level might have the undesired effect of applying two different allocation rules to different sub-sectors that *de facto* compete in the same relevant market.[45]

Moreover, an analysis at a 4-digit level risks producing insignificant and misleading results also in the case that installations produce simultaneously different products that are classified in different NACE 4 categories and that might have been regulated by different allocation criteria despite being produced by the same installation. In cases like this, the related plants' emissions and energy consumption data cannot be disaggregated easily among the different NACE 4 levels. The higher the data disaggregation level, the higher the risk of using unrepresentative data and obtaining

---

competitors, as well as of the prices charged and any price differentials. *Official Journal C 372, 09/12/1997 P. 0005 – 0013*, available at http://europa.eu/scadplus/leg/en/lvb/l26073.htm

[44] For instance, when analysing sectors that produce goods whose transportation costs significantly impact the final price (e.g., cement), it can be observed that sectors located in continental countries are less exposed to international competition than sectors located in sea countries.

[45] For example, in the case that the two NACE 4 sub-sectors—one *manufacturing ceramic tiles and flags* and the other *brick tiles and construction products in baked clay*—were producing substitute goods competing in the same market, then these sectors should be homogeneously regulated and subjected to the same allocation criterion. In this case, the qualitative analysis would suggest a unique Carbon Leakage assessment based on NACE 3 aggregated sectors.

biased results. This suggests that an analysis at a 3-digit level would be more appropriate. Alternatively, the EC should clarify how aggregated data from plants producing simultaneously different goods have been disaggregated at a NACE 4 level in order to improve the transparency of European regulation. In conclusion, the Carbon Leakage quantitative assessment should be improved by a qualitative valuation concerning the appropriate NACE level of data aggregation. This chapter interprets the EC guidelines, asserting that it is appropriate to use 4-digit level data when this degree of aggregation better reflects the characteristics of the relevant market where installations compete. Indeed, distortions of competition in the European markets would be minimized if the risk of Carbon Leakage were assessed using data aggregated according to the relevant market where sectors compete.

5. Conclusions

In 2008, the European Commission declared its firm intention to strengthen the European Climate Policy beyond the Kyoto Protocol commitment. The new ETS Directive has re-designed the ETS legal framework in order to improve its functioning during the third post-Kyoto trading period (2013-2020). In fact, the experience gathered from the past ETS trading periods suggests that the ETS effectiveness could be improved on different fronts.

This chapter has analyzed the ETS reform focusing on both the ETS cap setting procedure and on the allocation mechanism to distribute permits among ETS installations. Different conclusions have been reached concerning the two different topics of investigation.

Regarding the ETS cap setting procedure, it is possible to conclude that the new ETS Directive has improved the ETS effectiveness in different areas. The new centralized procedure for setting an EU-wide cap reduces the transaction costs linked to the previous decentralized procedure. It improves the harmonization of the European regulation among ETS sectors, which will be subjected to a homogeneous cap determined according to a common criterion aimed at imposing on both trading and non-trading sectors an emissions reduction burden coherent with their marginal abatement costs. Moreover, the ex-ante definition of the ETS cap from 2013 to 2020 will improve the regulation transparency and its effectiveness, by reducing the CO_2 price volatility and increasing the certainty ETS installations need to build up their long-term investment strategies.

Different conclusions have been reached when analysing the allocation rule reform.
First, the EC has expressed a clear intention to shift from grandfathering to auctioning. However, a theoretical full auctioning rule has been substituted with three co-existing allocation measures that will be applied to different sectors depending on their risk of exposure to Carbon Leakage, thus decreasing, rather than improving, the rules' harmonization within the ETS.
Moreover, the analysis of the Carbon Leakage assessment methodology has shown that instead of improving the allocation transparency and creating a higher harmonization of rules, the EC has defined highly arbitrary and inefficient criteria to assess which sectors are entitled to be exempted from auctioning. The results of the EC Carbon Leakage quantitative assessment show that the free assignment of permits will remain the dominant allocation criterion for the ETS manufacturing sectors, even during the third ETS trading period. Moreover, the analysis conducted by the EC is based on data aggregated in a discretionary way, which do not reflect the relevant market where ETS sectors compete, thus failing to improve the harmonization within the ETS by minimizing any possible market distortion.

Chapter 8 - Summary and Conclusions

1. The Challenge of the European Climate Policy

The last decades have experienced an increasing awareness about global warming, its causes and potential consequences for the ecosystem in general, and humankind in particular. Global warming is currently recognized as one of the most impressive negative externalities ever experienced within the western market economy. In the light of the problematic trade-off between environmental protection and economic growth, mitigating climate change without preventing economic development has become one of the most significant issues on the European political agenda. With the ratification of the Kyoto Protocol, the former EU 15 MS first committed to reduce 8% of emissions below the level of 1990 by 2012. In 2007, the European Commission published the communication "Limiting Global Climate Change to 2° Celsius: The Way Ahead for 2020 and Beyond," where it expressed its firm intention to enforce emissions-reduction climate policies even beyond the terms of the Kyoto Protocol. At the end of 2008, the European Climate Package, which imposes a unilateral 20% emissions cut below the 1990 emissions level by 2020, was finally approved. The real challenge of the European climate policy is not so much to reduce the European emissions. Such a goal could be easily achieved by lowering the European levels of production and consumption. However, this scenario would constitute a failure of the European climate policy, rather than a success, since it would be characterized by an increase in unemployment rates and by a worsening of the European welfare.

The real challenge is to promote a gradual switch to a low-carbon economy in which emissions can be reduced without compromising European economic growth and well-being. This sustainable scenario needs to be supported by the innovation and introduction of technologies that are simultaneously efficient and environmentally friendly.

2. The Political and Economic Origins of the Emissions Trading Scheme

Achieving the EU's ambitious environmental targets without slowing down European economic growth requires adequate economic instruments tailored to induce a cost-effective reduction of GHG emissions. The European Directive 87/2003/EC has established a cap and trade system—the European Emissions Trading Scheme (ETS)—as the main legal and economic instrument aimed at promoting a reduction of emissions in a cost-effective way. According to the relevant economic literature, both taxes and tradable permits constitute an efficient and flexible means to internalize the costs of pollution; therefore, it has been questioned why a cap and trade system has been preferred to a tax system to facilitate compliance with the Kyoto target. Different explanations have been given.

First, it has been argued that in an international context a cap and trade instrument—compared to carbon taxes—garners higher political acceptability in the eyes of MS, which are not willing to give up their sovereignty in this strategic field. Second, while taxes are subjected to the risk of normative and fiscal arbitrage which might cause a race to the bottom and thereby limit international cooperation, a cap and trade system is more likely to favour and induce international cooperation according to both a top-down approach (i.e., linking of different cap and trade schemes) and to a bottom-up approach (i.e., voluntary agreements in the form of certified emissions reduction contracts—such as the case of clean development mechanisms).

The general preference for a cap and trade scheme over a tax system, which has been already experienced in Europe, has been also explained as the result of the failure of European regulation, which has been *captured* and influenced by private interests. While equally efficient, taxes and tradable permits have different redistributive effects: a tax system entails a transfer of money from the private to the public sector. Imposing a carbon tax (or auctioning allowances) results in firms having to pay not only for the emissions they abate but also for the pollution they generate. On the contrary, a cap and trade scheme—where allowances are allocated for free (as in the ETS)—entails opposite consequences for the public finance, as the potential revenue from taxing carbon emissions (or from auctioning allowances) is kept by the private parties, which have to pay only for the emissions they reduce. Compared to a tax system (and to auctioning), the advantage of grandfathering allowances within a cap and trade scheme increases the political acceptability of regulation in the eyes of the regulated agents (e.g. Baumol and Oates, 1998; Tietenberg et al., 1999). For this reason, a cap and trade scheme has been preferred over a tax system, and grandfathering has been adopted as the prevalent method of allocating emission allowances (e.g. Revesz and Stavins, 2004). After mentioning the different redistributive effects that exist between a tax system and a cap and trade system (of grandfathered allowances)—and after highlighting the higher political acceptability of the second instrument over the first— it is important to focus on the efficiency properties of the cap and trade scheme. The Law & Economics literature considers a *cap and trade* system, where a limited number of freely tradable polluting property rights is generated and assigned to economic agents, an optimal instrument to induce efficient emissions reduction. According to the European ETS Directive, the ETS was expected to promote emissions reduction in an efficient and cost-effective way by reducing the GHG emissions where the marginal abatement costs are lowest (art. 1). The European Commission estimated that "the scheme should allow the EU to achieve its Kyoto target at a cost of between € 2.9 and € 3.7 billion annually. This is less than 0.1% of the EU's GDP. Without the scheme, compliance costs could reach up to € 6.8 billion a year" (EC 2004: 6).

3. The Purpose, Scope and Methodology of the Thesis

In the light of the theoretical properties of a cap and trade system, this research has analyzed both the legislation that established the ETS and its economic performance in order to assess whether the ETS can be considered a cost-effective instrument to reduce emissions, as theorized by the relevant literature. A Law and Economics approach has been applied. First, the research has questioned whether the ETS has been affected by some inefficiencies, and where identified, it has investigated to what extent they could be considered a consequence of the underlying legislation (positive analysis). When the ETS institutional and legal design has been found to be ineffective or distortive, we have analyzed whether the ETS inefficiencies could be corrected by improving the European legislation (normative analysis). In this analysis, the Kyoto emissions reduction target has been taken as a given; thus, by questioning the effectiveness of the EU ETS to reach a given target, no attempt has been made to infer conclusions about the efficiency of the Kyoto Protocol in general. The positive-normative approach of this thesis has been developed at two parallel levels of analysis upon which both the ETS' effectiveness and the ETS sectors' production costs mainly depend. First, a macro-level analysis of the ETS has been developed focusing on the ETS cap level. The stringency of the cap determines the amount of emissions the ETS sectors have to reduce and how much MS rely on this economic flexible mechanism to comply with the Kyoto target. A second analysis of the ETS has focused on the allocation rule adopted to assign the initial amount of allowances among the ETS sectors. The choice between grandfathering and auctioning impacts both the ETS sectors' costs and competitiveness in the secondary markets. These allocation rules have been compared according to both an efficiency and equity perspective.

4. Analysis of the ETS Cap Stringency to Assess the Effectiveness of the ETS

In **chapter 5** of this thesis we have analysed to what extent MS are effectively relying on the ETS to comply with their Kyoto commitments, and we have determined whether the emissions reduction burden deriving from the ratification of the Kyoto Protocol has been divided between ETS and non-ETS sectors in a cost-effective way.

This research has focused mainly on the ETS cap and on its stringency, where the ETS cap indicates the proportion of emissions that the ETS sectors are legally required to abate and, consequently, the amount of emissions the non-trading sectors have to reduce to comply with Kyoto commitments. A theoretical benchmark has been determined to assess the ETS cap stringency and to evaluate if emissions permits were over-allocated during the first and second ETS trading periods. According to this benchmark, over-allocation occurs when the ETS cap exceeds a theoretical ETS cap that would impose an emissions reduction burden on the ETS sectors proportional to the share of European emissions they produce.

This methodology has clarified how the emissions reduction effort has been divided between ETS and non-ETS sectors, highlighting to what extent MS have been effectively relying on the ETS to comply with their Kyoto commitments.

The analysis has first demonstrated that over-allocation of allowances occurred in most of the European MS during both the first and second ETS trading periods. Then, the causes and consequences of over-allocation have been discussed. First, we have seen that the over-allocation of allowances has been favoured by the ETS' decentralized legal procedure where, according to the principle of subsidiarity, MS were delegated the duty to design for each trading period a NAP to specify both how many permits would be assigned at a national level and how they would be distributed among national ETS sectors and installations. Given the lack of clear allocation criteria (Annex III of the Directive) and the lack of historical data on ETS emissions, MS ended up over-allocating allowances by setting national caps which were not equally proportional either to their national target or to the national percentage of emissions produced by the ETS sector.

Five years after the first ETS Directive, also the EC has recognized that delegating to MS the duty of setting national ETS caps has created a sort of prisoner's dilemma where “each individual MS recognises the collective interest to set restrictive caps for optimal reduction of emissions in the EU, but also has an interest to maximise the national cap” [SEC (2008) 52, 90].

According to the political economic approach to the theory of regulation, it is possible to infer that national regulators have been captured by the private interests of the regulated agents, who have succeeded in receiving a generous amount of permits, thereby reducing the impact of the ETS on their costs, but in the mean time compromising the effectiveness of the ETS. This is the main consequence of over-allocation: the CO_2 price has fallen toward zero, thus failing to provide any significant incentive to reduce emissions.

Moreover, the methodology and the benchmark chosen to asses the ETS cap stringency has highlighted that the ETS, despite being the most important mechanism of the EU climate policy, is not sufficient to ensure compliance with the Kyoto target. This is because the ETS regulates only part of the EU emissions, and it has to be coordinated with the national climate policies aimed at inducing emissions reduction in the non-ETS sectors. Indeed, compliance with the Emissions reduction target established in the Kyoto Protocol requires that the lower the emissions reduction burden imposed on the ETS sectors is (and the higher the ETS cap is), the stricter non-ETS environmental policies must be, and vice-versa.

Thus, the other shortcoming of permit over-allocation is that stricter national non-ETS policies should have been promoted in order to comply with the Kyoto target, entailing a transfer of the emissions reduction effort from trading to non-trading sectors—a transfer that is not cost effective. In fact, since the ETS sectors have on average lower MACs than non-ETS sectors, they should bear a higher emissions reduction burden. Thus, the reduction burden indirectly imposed on non-ETS sectors is excessive compared to their abatement potentialities and marginal abatement costs.

This analysis has shown that the size of over-allocation has differed among MS. As a consequence, despite being subjected to the same European regulation, national firms and sectors competing in the same European market have borne different emissions reduction burdens depending on the MS in which they were located. The distribution of different reduction burdens across national ETS sectors has undermined the level playing field in the secondary European common market where they compete, causing a distortion of competition and creating undesirable economic consequences at the expense of an effective EU common market integration.

Moreover, the NAP decentralized procedure has increased uncertainty in the market among the ETS installations. In fact, the European ETS cap could be determined only *ex-post* by summing up the different national caps once all the NAPs were definitively approved by the EC. NAPs should have been examined and approved by the EC fifteen months before the beginning of the subsequent trading period, but during both the first and second ETS phases some NAPs were finally approved only some months after the beginning of the trading period in questions. As a result, at the time the ETS trading periods were officially launched many installations did not know the amount of permits they would initially receive, and the level of ETS cap was unknown.
This long procedure involved substantial information and administrative costs, causing price volatility in the ETS and increasing uncertainty among the regulated actors, and ultimately deterring them from developing long-term investment strategies for a low-carbon economy.

5. Analysis of ETS Allocation Rules: Efficiency and Equity

As stated in Art. 10 of the first ETS Directive, during the first and second trading periods respectively at least 95% and 90% of permits were assigned free of charge (i.e., through grandfathering). Since auctioning entails higher private costs than grandfathering, the adoption of grandfathering has increased the ETS' political acceptability in the eyes of the ETS regulated sectors. However, since the first ETS pilot trading period was launched, grandfathering has been criticized on different levels. First, it has been blamed for causing undesired redistributive effects: many electricity generators could earn windfall profits by passing through to the final electricity price the market value of the allowances they initially received for free. The general criticism has regarded the unfairness of inducing consumers to pay for what producers received for free. Grandfathering has been criticized also regarding the issue of efficiency as some claim that it is equivalent to a government subsidy, which creates an artificial and undesirable incentive for existing market participants not to exit the industry and to keep operating older and less efficient plants (Nash 2000). Also the European Commission has expressed its doubts concerning the properties of grandfathering by arguing that "full auctioning of allowances scores best in increasing the efficiency of the system and taking away undesirable distributional effects" [SEC (2008) 52, 163] and "full auctioning is […] the only option that entirely solves efficiency problems" [SEC (2008) 52, 106].

This thesis has analysed whether it was correct to classify grandfathering as an inefficient allocation rule *per se.* The main purpose of **chapter 6** has been to assess whether grandfathering could be considered—in theory and in practice—an efficient and fair allocation rule. In order to do this, this chapter has analysed the conditions under which this allocation rule is consistent with the polluter-pays principle. The basic question is: do polluters pay under grandfathering, or not? First, a taxonomy of efficiency and equity interpretations of the polluter-pays principle has been presented. Within the efficiency interpretation, a "weak" form of the polluter-pays principle (i.e., no subsidization) has been distinguished from its "strong" form (i.e., cost internalization). The weak form requires that the government refrains from subsidizing pollution control, while the strong form requires that polluters internalize the costs of pollution. This means that the strong form subsumes the weak form: both versions require that companies internalize pollution costs.

Contrary to this view, which finds grandfathering inefficient *per se*, it has been argued that, once the opportunity costs of freely assigned allowances are properly taken into account, both grandfathering and auctioning are equally efficient in inducing emissions reduction, while continuing to have different redistributive effects. Once a market for tradable permits where parties can freely bargain their allowances at zero transaction costs is in place, an efficient outcome is reached independently of how allowances are initially assigned. Moreover, passing the opportunity costs of the grandfathered permits to the final market price is economically correct. In fact, grandfathered permits can be used to cover the amount of emissions resulting from the production activity or, in the case of emissions reduction, they can be sold in the ETS at the market price. When the first option is chosen, the opportunity cost of the grandfathered allowances is determined by the foregone profit the firm could have earned by reducing emissions and selling the surplus of permits at the market price. Given these two alternative uses of grandfathered permits, the ETS installations will continue to produce and to cover their emissions with the freely assigned allowances only if this option is a first best. In other words, ETS installations have to be sure that when producing and using their allowances to cover their emissions they can gain a profit which is at least as big as the one they could earn by reducing emissions (or decreasing production) and selling the exceeding amount of allowances received at no cost. This alternative use of tradable permits explains why it is correct that firms internalize the market price of free assigned allowances into their marginal production costs, passing it into final prices.

Internalizing the cost of the emission externality into the price is not only correct but effective: as the price increases, polluting products become costlier and less attractive, whereas market competition should ensure a progressive switch toward cleaner and less expensive products and technologies. In fact, grandfathering permits according to historical emissions results in more polluting firms receiving a higher amount of permits than less polluting firms; thus the more a firm polluted, the more allowances are assigned and the higher the opportunity cost to be internalized and passed through to the market price. Thus, after the ETS has been established and allowances have been grandfathered, firms producing with polluting plants face a higher marginal cost increase than those firms adopting clean technologies.

When secondary markets are competitive, more polluting firms have to compete at higher prices; thus, their competitiveness is worsened and in the long run polluting plants tend to be driven out from the market to be substituted by less efficient carbon-intensive plants. The claim that polluters do not pay under grandfathering can only be defended from a fairness perspective. The comparative analysis of auctioning and grandfathering has shown that, while both allocation rules are consistent with the efficiency interpretation of the polluter-pays principle, only auctioning complies also with the "extended" form of the polluter-pays principle, where equity is used as a criterion on top of—and not instead of—efficiency.

While having the same effects in terms of market outcome, the real difference between auctioning and grandfathering is redistributive: who pays whom. The former solution entails a money transfer from the regulated sectors to the governments. In the latter solution, the ETS installations keep the money. Clearly, while private companies have a preference for grandfathering, governments intended to switch toward auctioning as a default allocation rule for the third ETS trading period. Because polluting firms do not have to purchase the emission rights while their shareholders become richer, grandfathering may be perceived as unfair from an extended polluter-pays perspective. Auctioning ensures the internalization of the pollution costs and, in addition, forces polluters to purchase their emission rights.

Finally, this chapter has analysed whether the theoretical findings concerning the efficiency and fairness of grandfathering within the ETS can still be considered valid in the light of the lack of ETS cap stringency. By highlighting the inefficiencies that emerged at the time of applying this allocation rule in the ETS, the chapter concludes by determining some conditions that have to be satisfied to ensure the consistency of grandfathering with the efficiency interpretation of the polluter-pays principle.

First, it has been argued that the way grandfathering has been implemented in the ETS has created some inefficiencies. In particular, the decision to update (to recent emissions levels) the baseline adopted to grandfather allowances to the existing ETS installations has created an early action problem with the risk of both postponing emissions abatement and giving a distortive incentive to continue operating polluting and less efficient plants. It has been argued that grandfathering has been applied non homogeneously among MS, limiting the internal harmonization within the ETS and causing additional undesired redistributive effects. The lack of a level playing field for ETS operators has distorted competition in the European market under Articles 81 and 82 of the EC Treaty (e.g. Johnston 2006; Weishaar 2007). Moreover, it has been found that if allowances are over-allocated, consistency with the weak form of the polluter-pays principle is violated independently of the allocation rule. Indeed, the cross-subsidization from the non-ETS sectors to the ETS sectors takes place whether or not the over-allocated permits have been grandfathered or auctioned.

To summarize, each allocation rule is effective under the condition that allowances are not over-allocated. This implies that the ETS cap has to be set at a stringent level. Grandfathering is efficient only if allowances are one-off grandfathered and in the absence of any baseline updating process: as long as current behaviour does not affect the amount of free allowances to be allocated in future phases, the allowances' opportunity cost will remain unchanged over time and the effectiveness of grandfathering is confirmed. Finally, distortions of competition in the secondary markets are minimized only if the allocation rules are applied according to homogeneous and harmonized criteria.

6. Analysis of the ETS Reform and the Risk of Carbon Leakage

In 2007, the European Commission declared its firm intention to strengthen the European Climate Policy beyond the Kyoto Protocol commitment, and in 2008, the EU Climate Package was finally approved. A pillar of the EU Climate Package is the new ETS Directive 2009/29, which amends the first ETS Directive 2003/87 and re-designs the ETS legal framework in order to improve its functioning during the third post-Kyoto trading period (2013-2020). In fact, the experience gathered from the past ETS trading periods suggests that the ETS' effectiveness could be improved on different fronts.

Chapter 7 of this thesis has analyzed the ETS reform, focusing on both the ETS cap setting procedure and on the allocation rule. Different conclusions have been reached concerning the two different topics of investigation. Regarding the ETS cap setting procedure, it is possible to conclude that the new ETS Directive has improved the ETS' effectiveness on different levels. The new centralized procedure for setting a EU-wide cap reduces the transaction costs linked to the previous decentralized procedure. It improves the harmonization of European regulation among ETS sectors that will be subjected to a homogeneous cap determined according to a common criterion aimed at imposing on both trading and non-trading sectors an emissions reduction burden coherent with their MACs. Moreover, the ex-ante definition of the ETS cap from 2013 to 2020 improves the regulation's transparency and effectiveness, thereby increasing the certainty that ETS installations need in order to build up their long-term investment strategies.

Different conclusions have been reached when analysing the reform of the allocation rule. Many inconsistencies emerged at the time of defining the new allocation rule, which is likely to worsen, rather than improve, harmonization within the ETS. In fact, despite the initial intention to shift from grandfathering toward auctioning, the new ETS Directive will apply three different allocation rules, granting exemption from auctioning to those sectors found to be at risk of exposure to Carbon Leakage. First, the problem of Carbon Leakage has been introduced and discussed: since CO_2 emissions have been priced, energy intensive installations face a cost increase which depends on their direct and indirect emissions (from fuel and electricity consumption). ETS sectors claim to have high MACs, limited internal abatement opportunities and limited possibilities to pass their increased marginal costs into the final price without incurring a significant loss of market share against non-EU competitors not subjected to any environmental regulation. In the light of the more stringent and costly Climate Package, ETS sectors might be induced to delocalize their production activity and re-address their investments toward non-EU countries where costly regulations are not in place. In the worst-case scenario, ETS installations might be forced to shut down and their production replaced by extra-EU competitors as a result. The main effect of the European climate policy would be to slow down European economic growth without bringing any environmental benefits since emissions would decrease in Europe, while increasing proportionally in the rest of the world.

We have identified three main causes of the risk of Carbon Leakage. First, the risk of Carbon Leakage arises because the EU climate policy imposes three types of costs on the regulated sectors: a direct cost deriving from the duty to reduce emissions, which increases as the ETS cap is lowered; a second cost deriving from the duty to acquire the initial amount of permits in an auction; and, finally, an indirect cost caused by the electricity price, which is increased by the cost of the CO_2 emissions. The second cause of Carbon Leakage is the asymmetric nature of the European Climate Policy. Being unilateral, it creates an incentive for normative arbitrage, inducing the regulated sectors to move where no stringent regulation is in place.

Finally, and most importantly, the risk of Carbon Leakage arises mainly from the fact that the European Climate policy, and the ETS in particular, is *production-based*, rather than *product-based*. That is, regulated agents can comply with the EU regulation by either buying allowances in the ETS or by reducing internally their direct emissions within their production process. However, the ETS fails to give any monetary incentive to reduce indirect emissions, that is whenever emissions would be reduced in a different economic sector from the one undertaking the abatement investment.[46] The ETS internalizes the negative externality deriving from direct emissions *within* the production process, while failing to internalize positive externality deriving from any emissions abatement *outside* the production process. This shortcoming creates inefficiency whenever reducing direct emissions within the production process is more expensive than reducing the same amount of emissions in other economic sectors outside the production process. Moreover, because of the production-based nature of the EU regulation, compliance with the ETS can be ensured just by switching production to outside Europe (i.e., outsourcing emissions).Given these different causes of Carbon Leakage, it is possible to conclude that the EC decision to grandfather allowances—instead of auctioning them—to those sectors that are found to be exposed to Carbon leakage can only partially reduce the risk of Carbon Leakage, which is, however, likely to persist. In fact, the more stringent ETS cap of the third trading period is anyhow imposing an asymmetric and

[46] For instance, if an ETS installation improves its plant's electricity intensity, total emissions are likely to decrease, but the ETS installation emissions gap is not. Equally, if a firm decides to switch from wheel to rail transportation, overall emissions are likely to decrease, while the firm's emissions gap is not.

costly emissions reduction burden on the European industrial installations. Moreover, free assigned allowances have an opportunity cost that installations take into account when deciding whether it is more cost-efficient to produce in Europe (using the grandfathered permits to cover the related emissions) or to delocalize production and sell the exceeding amount of allowances at the market price. Thus, in spite of free allocation, the ETS installations might still find it cost-efficient to delocalize their plants outside Europe, since they could sell the total amount of allowances they have received for free and Carbon Leakage would persist to a certain extent even if permits are grandfathered. Deriving from the *unilateral* and *production-based* nature of the EU climate policy, the risk of Carbon Leakage is likely to persist even if the sectors found to be at risk of exposure to Carbon Leakage are exempted from auctioning

Another shortcoming of the EU climate policy concerns the definition of an appropriate methodology to determine which ETS sectors should be considered effectively at risk of exposure to Carbon Leakage, and which not. This thesis has verified whether the Carbon Leakage risk assessment methodology adopted in the new ETS Directive can be considered economically grounded, or rather politically driven. The ex-post analysis of the results of the Carbon Leakage risk assessment performed by the EC has shown that, instead of improving the allocation transparency and creating higher rules harmonization, the EC has defined highly arbitrary and inefficient criteria to assess which sectors are entitled to being exempted from auctioning.

We have shown that the methodology adopted to decide which allocation rule is to be applied to the different ETS sectors is quite arbitrary and not sufficiently economically grounded. This is because it ends up favouring and protecting the vast majority of sectors, which have been exempted from auctioning according to a criterion (i.e., separated approach) that fails to consider simultaneously both the sectors' carbon and trade intensities and, therefore, independently of their effective risk of exposure to Carbon Leakage. In spite of the EC's declarations and intentions, this research has shown that the free assignment of permits will remain the dominant allocation criterion for the ETS manufacturing sectors even during the third ETS trading period.

Moreover, the analysis conducted by the EC is based on data aggregated in a discretionary way, which does not reflect the relevant market where ETS sectors compete and the basic economic principles of competition policy. As a result, regulation fails to improve harmonization within the ETS by minimizing any possible market distortion.

7. Conclusions and Further Research

Thanks to the ETS, for the first time, CO_2 emissions have been priced. This is the first practical and international attempt to internalize the negative externality that is at the core of global warming— a crucial step required to mitigate climate change. Such an attempt constitutes a milestone within the European climate policy.

Without denying the importance of such a result, this thesis has analysed the legal framework of the ETS and its economic performance in order to verify how effective this mechanism is in promoting emissions abatement and to determine how much the European MS effectively rely on this instrument to comply with their emissions reduction targets. Being the first experiment of a cap and trade system in Europe, it was plausible to expect that some shortcomings would have emerged within the ETS and that its performance could have been improved by correcting the underlying legislation. This thesis has first focused on the ETS cap setting procedure and on the rule adopted to assign allowances among the regulated sectors designed by the first ETS Directive 2003/87. Finally, it has analyzed how these variables have been reformed by the second ETS Directive 2009/29 amending the first one.

We have found that during the ETS first and second trading periods the ETS cap was not sufficiently stringent, as MS over-allocated allowances to ETS national sectors: national caps set by MS were proportional neither to the national targets nor to the ETS share of national emissions. Over-allocation of allowances to the ETS sectors implies that part of the emissions reduction burden has been transferred from trading to non-trading sectors. This analysis has demonstrated the importance of coordinating European and national climate policies: without such an integrated approach, the Kyoto and post-Kyoto emissions reduction targets are not likely to be achieved. In addition, setting *ex-ante* an ETS cap, which allocates the emissions reduction burden among ETS and non-ETS sectors according to their MACs, is a necessary condition to achieve the targets effectively, at the minimal cost. The following comparative analysis of grandfathering and auctioning has stressed how these allocation rules, while having different distributive impact, have the same impact on the final markets, thereby offering comparable incentives to reduce emissions. However, the non-harmonised way these rules have been applied within the ETS contributed to the distortion of competition in the European internal market. This conclusion has been confirmed when analysing the second ETS Directive 2009/29; the Directive has defined a new procedure to allocate allowances among ETS sectors according to arbitrary and distortionary criteria, which have been more politically than economically driven and thus have failed to improve the harmonization of the rules within the ETS. Finally, the analysis of the causes of the risk of Carbon Leakage, of the methodology to assess it and the measures defined to prevent it, has highlighted the major shortcomings of the European climate policy.

The risk of Carbon Leakage arises mainly from the fact that the European climate policy is unilateral (i.e., there are no symmetric climate policies outside Europe) and it is production based, rather than consumption based. That is, the ETS regulates the emissions linked to the production of a good (i.e., production emissions), rather than the emissions linked to the final consumption of that good (i.e., product emissions). Being production based, the ETS installations can comply with the European regulation just by switching the European production activity where no costly regulation is in place. This is to say that the main effect of a unilateral and costly European climate policy could be to outsource both European production and emissions, with detrimental effects on European economic growth. A unilateral European climate policy that imposes substantial asymmetric costs on the European agents risks not only being economically inefficient, but also environmentally ineffective: emissions risk decreasing in Europe, while increasing proportionally in the rest of the world.

In light of the causes of the risk of Carbon Leakage, the decision to grandfather allowances to those sectors found to be at risk of exposure to Carbon Leakage is not likely to prevent such a risk, which arises from the asymmetric and production-based nature of the EU climate policy. Rather, its main effect is to lower the harmonization of the allocation criteria within the ETS, and as a result to distort market competition. The real solution to this risk is not to grant allowances free of charge, but rather to reduce the possibility of normative arbitrage by promoting international negotiations and to make the whole ETS regulation consumption based. That is, while currently the European climate policy and the ETS are limited to regulating the installations, focusing on the emissions deriving from the production process, it is necessary to develop an integrated climate policy that shifts its focus from the production process to the whole product life cycle. This is to say that the ETS has to become more flexible, offering the ETS installations the possibility to comply with the ETS regulation not only by acquiring allowances or abating emissions internally in the production process, but also by reducing emissions in the other chains of the product life cycle (i.e., importation, transportation, distribution, consumption, waste recycling), and basically in the non-ETS sectors.

The first step for increasing the flexibility of the ETS is to determine a linking mechanism between ETS and non-ETS sectors. This would give the ETS installations the possibility to reduce emissions also in the non-ETS sectors. In this way, new abatement opportunities would be generated—with a higher possibility of reducing emissions at lower marginal abatement costs—while giving the ETS sectors the possibility to participate more actively in the economic mechanisms generated by the market-based instruments such as the ETS, which would benefit from its opportunities and sustain the related costs. By making such mechanisms more flexible, the coordination between the ETS and non-ETS climate policies could be improved, and many unregulated sectors of our economic system would be called to consider more directly the externalities that they generate. Switching to a consumption-based regulation and granting higher flexibility and coordination are the preliminary recommendations aimed at improving the economic and environmental effectiveness of national and European climate policies. These topics needs to be further analysed and developed and might constitute the core of further research.

References

Åhman M., Burtraw D., Kruger J., and Zetterberg L. (2005), "The Ten-Year Rule: Allocation of Emission Allowances in the EU Emission Trading System," *Resources for the Future*, Discussion Paper 05–30, Washington D.C..

Aldy J.E., Barrett S. and Stavins R.N. (2003), "Thirteen Plus One: A Comparison of Global Climate Policy Architectures," *Nota di Lavoro Fondazione Eni Enrico Mattei*, 64, Milan.

Anthoff D., Hepburn C. and Tol R., (2009), "Equity weighting and the marginal damage costs of climate change," *Ecological Economics*, Elsevier, 68(3): 836-849.

Anttonen K., Mehling M., Upston-Hooper K. (2007) "Breathing Life into the Carbon Market: Legal Frameworks of Emissions Trading in Europe," *European Environmental Review*,April : 96-115.

Arce D. and Sandler T. (2001), Transnational public goods: Strategies and Institutions *European Journal of Political Economy* Volume 17, Issue 3, Pages 493-516

Armstrong, M., Cowan, S. and Vickers, J. (1994) "Regulatory Reform - Economic Analysis and British Experience," Oxford University Press: Oxford.

Arrow, K. J., Fisher, A. C. (1974), 'Environmental Preservation, Uncertainty, and Irreversibility', *Quarterly Journal of Economics*, 88, 312–19.

Axelrod R. and Hamilton W. (1981), "The Evolution of Cooperation" *Science* 211: 1390–96

Barrett S. (1994) "Self-enforcing International Environmental Agreements," *Oxford Economic Papers*, 46: 804–78

Barrett S. (2002) "Supplying International Public Goods: How Nations Can Cooperate", in *International Public Goods: Incentives, Measurements, and Financing*, edited by Ferreri M. and Mody A., The World Bank, Kluwer Academic Publisher

Barrett S. (2003) "Supplying International Public Goods – How Nations Can Cooperate," in *International Public Goods Incentives, Measurement, and Financing*, Edited by Marco Ferroni and Ashoka Mody, World Bank Ed.

Baumol W.J. and Oates W.E. (1988). "The Theory of Environmental Policy," Second Edition. Cambridge: Cambridge University Press.

Betz R. and Stato M. (2006), "Emissions trading: lessons learnt from the 1st phase of the EU ETS and prospects for the 2nd phase", *Climate Policy* 6: 351-359.

Betz R., Cozijnsen J., Rogge K. and Schleich J. (2006b), "Increasing the Ambition of EU Emissions Trading," Report commissioned by Greenpeace International, Amsterdam.

Betz R., Rogge K. and Schelich J. (2006), "EU emissions trading: an early analysis of national allocation plans for 2008–2012", *Climate Policy*, 6, 361–394

Birnie, P.W. and Boyle A.E (2002), "International Law and the Environment," Second edition. Oxford: Oxford University Press.

Bodansky D. (1993), "The Framework Convention on Climate Change: a Commentary", 18 Yale Journal of International Law 451

Bodansky, D. (2004), 'International climate efforts beyond 2012: a survey of approaches', Arlington, VA, Pew Center on Global Climate Change.

Bohm, P. (1999), "International Greenhouse Gas Emission Trading – With Special Reference to the Kyoto Protocol," in *Efficiency and Equity in Climate Change Policy*

Böhringer C. (2003) "The Kyoto Protocol: A Review and Perspectives," *Oxford Review of Economic Policy*, 19 (3), 451-466

Böhringer C., Helm C. (2001), 'On the Fair Division of Greenhouse Gas Abatement Cost', ZEW Discussion Paper No. 01-67, Mannheim

Böhringer C., Hoffmann T., de Lara-Penante M. (2006), "The efficiency costs of separating carbon markets under the EU emissions trading scheme: A quantitative assessment for Germany," *Energy Economics* 28 (1): 44-61.

Böhringer C., Hoffmann T., Lange A., Löschel A. and Moslener U. (2005), "Assessing Emission Regulation in Europe: An Interactive Simulation Approach," *Energy Journal* 26: 1-22.

Böhringer, C., Rutherford T.F. and Voβ. A. (1998), "Global CO_2 Emissions and Unilateral Action: Policy Implications of Induced Trade Effects," *International Journal of Global Energy Issues* 11(1-4): 18-22.

Borenstein, S., Bushnell, J., Knitell, C.R. (1999), "Market power in electricity markets: beyond concentrations measures," *Energy Journal* 20 (4): 65–88

Botteon M., and Carraro C. (1997), "Burden Sharing and Coalition Stability in Environmental Negotiations with Asymmetric Countries," in C. Carraro (ed.), *International Environmental Negotiations: Strategic Policy Issues*, Cheltenham: Edward Elgar, 26–55.

Brown C. (2005), "*The Kyoto Protocol Enters into Force*", The American Society of International Law, available at: http://www.asil.org/insights050301.cfm

Buchanan J. And Tullock G. (1975) "Polluters' Profits and Political Response: Direct Control Versus Taxes," *American Economic Review* 65(1): 139 - 47.

Buchner B., Carraro C., and Cersosimo I. (2002), "Economic Consequences of the US Withdrawal from the Kyoto/Bonn Protocol," *Climate Policy* 2(4): 273–92.

Bugge H. C. (1996), "The Principles of 'Polluter-Pays' in Economics and Law," in E. Eide and R. Van den Bergh, eds., *Law and Economics of the Environment*, 53.

Calabresi G. (1970), "*The Costs of Accidents: A Legal and Economic Analysis*," New Haven: Yale University Press.

Calabresi G. and Melamed A.D. (1972), "Property Rules, Liability Rules, and Inalienability: One View of the Cathedral," *Harvard Law Review* 85 (6): 1089-1128.

Capoor K. and Ambrosi P. (2007), "State and Trends of the Carbon Market 2007," World Bank, Washington.

Carraro C., and Siniscalco D. (1993), "Strategies for the International Protection of the Environment," *Journal of Public Economics* 52: 309–28.

Carraro, C., and Siniscalco, D. (1998), 'International Environmental Agreements: Incentives and Political conomy', *European Economic Review*, **42**, 561–72.

Christiansen, A.C. and Wettestad J. (2003), "The EU as a Frontrunner on Greenhouse Gas Emissions Trading: How Did it Happen and Will the EU Succeed?," *Climate Policy* 3: 3-18.

Clarich M. (2007) "La Tutela dell'Ambiente attraverso il Mercato," *Diritto Pubblico* 1: 219-240.

Clò S. (2009), "An analysis of the EU Emissions Trading Effectiveness," *Climate Policy* 9: 227–241.

Coase, R.H., (1960), "The Problem of Social Cost," *Journal of Law and Economics* 3: 1-44.

Cole, D.H. (1999), “Clearing the Air: Four Propositions about Property Rights and Environmental Protection,” *Duke Environmental Law & Policy Forum* 10 (103): 103-130.

COM (1997), “Commission Notice on the Definition of Relevant Market for the Purposes of Community Competition Law,” *Official Journal C 372 ,* 09/12/1997 P. 0005 - 0013.

COM (1999), “Preparing for Implementation of the Kyoto Protocol”, *Commission Communication to the Council and the Parliament* 230, Brussels

COM (2005), “EU Action Against Climate Change: EU Emissions trading – An Open Scheme Promoting Global Innovation,” Brussels.

COM (2006a), “A European Strategy for Sustainable, Competitive and Secure Energy,” Green Paper 105 final, Brussels.

COM (2006b), “Building a Global Carbon Market – Report Pursuant to Article 30 of Directive 2003/87/EC,” 676 final, Brussels.

COM (2008) 17 Final, 2008/0014 (COD) “Proposal for a Decision Of The European Parliament and of the Council on the Effort of MS to Reduce Their Greenhouse Gas Emissions to Meet the Community’s Greenhouse Gas Emission Reduction Commitments up to 2020,” Brussels.

COM (2008a) 18 Final 2008/0015 (COD) “Proposal for a Directive of the European Parliament and of the Council on the Geological Storage of Carbon Dioxide and Amending Council Directives 85/337/EEC, 96/61/EC, Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC and Regulation (EC) no 1013/2006,” Brussels.

COM (2008b) 19 final, 2008/0016 (COD) “Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources,” Brussels.

COM (2009) 16 final, 2008/0013 (COD), “Directive 2009/29/EC of the European Parliament and of the Council Amending Directive 2003/87/EC So As to Improve and Extend the Greenhouse Gas Emission Allowance Trading System of the Community,” Brussels.

Compte O. Jenny F. and Rey P. (2002) “Capacity Constraints, Mergers and Collusion”, *European Economic Review*, 46, pp 1-49

Cooper R. (1998), “Towards a Real Treaty on Global Warming,” *Foreign Affairs*

77(2): 66–79.

Cooter R. and Ulen T. (2004), "*Law and Economics*" Boston: Pearson Addison Wesley, fourth edition.

Cramton P. and Kerr S. (2002), "Tradable Carbon Permit Auctions: How and Why to Auction Not Grandfather," *Energy Policy* 30: 333-345,

Criqui P. and Kitous A. (2003), "Kyoto Protocol Implementation (KPI): Technical Report: Impacts of Linking JI and CDM Credits to the European Emissions Allowance Trading Scheme. A Report for DG Environment," CNRS-IEPE and ENERDATA S.A. (ed.)

Dales J.H. (1968), "Pollution, Property and Prices: An Essay in Policy-Making and Economics," Toronto: Toronto University Press.

Damro C. and P.L. Méndez (2003), "Emissions Trading at Kyoto: From EU Resistance to Union Innovation," *Environmental Politics* 12 (2): 71-94.

Dasgupta P. (2006), "Comments on the Stern Review's Economics of Climate Change"

Demailly D. and Quirion P. (2006), "CO_2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: grandfathering versus output-based allocation," *Climate Policy* 6 (2006): 93–113.

Demsetz H. (1967), "Toward a Theory of Property Rights," *American Economic Review* 57: 347-359.

Denicolò V. (1999), "Pollution-reducing innovations under taxes or permits," *Oxford Economic Papers* 41: 184-199.

Derek B. W. and Fezzi C. (2007) "Interaction of European Carbon Trading and Energy Prices," FEEM NOTA DI LAVORO 63.2007.

Dimas, S. (2007), "Dimas on Business Attitudes to Climate Change," *EurActiv.com: EU News, Policy Positions & EU Actors online*, Brussels.

Dixit, A., and Pindyck, R. (1994), *Investment Under Uncertainty*, New York, Princeton University Press.

Downs G. and Jones M. (2002),"Reputation, Compliance and International Law" *Journal of Legal Studies*, vol. XXXI

Dworkin R. (1977), "*Taking Rights Seriously*," Cambridge: Harvard University Press.

ECCP (2007), "Final Report of the 1st meeting of the ECCP working group on emissions trading on the review of the EU ETS on the Scope of the Directive"

Ecofys (2005), “Analysis of the National Allocation Plans for the EU Emissions Trading Scheme,” Ecofys UK Winchester House.

Ecofys (2006), “Initial Assessment of National Allocation Plans For Phase II of the EU Emission Trading Scheme,” Ecofys UK Winchester House.

Egenhofer C. and Fujiwara N. (2005), “Reviewing the EU Emissions Trading Scheme: Priorities for Short-Term Implementation of the Second Round of Allocation (Part I),” Brussels: Centre for European Policy Studies (CEPS).

Egenhofer, C. Fujiwara and N. (2006), “Reviewing the EU Emissions Trading Scheme: Priorities for Short-Term Implementation (Part II),” Brussels: Centre for European Policy Studies (CEPS).

Egenhofer,C.,N. Fujiwara,D.Kernohan, T. Brewer and L.Van Schaik (2004), ‘The future of the international climate change regime: the contribution of “regional approaches” towards an international agreement’, study by the Centre for European Policy Studies prepared for the Economic and Social Research Institute, Cabinet Office, Government of Japan.

Ellerman A. D., Joskow P., Schmalensee R., Montero J. and Bailey E. M (2000), “*Markets for Clean Air: The U.S. Acid Rain Program*,” New York: Cambridge University Press.

Ellerman D. and Buchner B. (2006), “Over-Allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005 Emissions Data,” *FEEM Nota Di Lavoro* 139.2006, Milan.

European Commission (2003), “Directive 2003/87/EC of the European Parliament and the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC,” Brussels.

European Commission (2004), “EU Emissions Trading. An Open Scheme Promoting Global Innovation to Combat Climate Change,” Brussels.

European Commission (2005), “EU action against climate change, EU emissions trading — an open scheme promoting global innovation,” Brussels.

European Commission (2006a), “Communication from the Commission to the Council and to the European Parliament on the assessment of national allocation plans for the allocation of greenhouse gas emission allowances in the second period of the EU Emissions Trading Scheme,” Brussels.

European Commission (2006b), “Community Independent Transaction Log: National reports on verified emission and surrendered allowances,” Brussels.

European Commission (2007), “Decision on Bulgaria’s National Allocation Plan for 2008-2012,” IP/07/1614, Brussels.

European Commission (2008), “Commission Staff Working Document Impact Assessment,”

European Commission (2009), “Results of the quantitative assessment of sectors at NACE 4 level (state of 29-04-09),” Brussels.

European Environment Agency (2004a), “Annual European Community greenhouse gas inventory 1990–2002 and inventory report 2004,” Technical report No.2/2004, Copenhagen.

European Environment Agency (2005), “Annual European Community greenhouse gas inventory 1990–2003 and inventory report 2005,” EEA Technical Report No. 4/2005.

European Environment Agency (2006), “Greenhouse gas emission trends and projections in Europe 2006,” Report No 9/2006, Copenhagen.

European Environment Agency (2006b), “Annual European Community greenhouse gas inventory 1990–2004 and inventory report 2006,” EEA Technical Report No. 6/2006.

European Environment Agency (2007), “Annual European Community greenhouse gas inventory 1990–2005 and inventory report 2007,” Technical Report No. 7/2007, Copenhagen.

European Environment Agency, (2009), “Annual European Community greenhouse gas inventory 1990–2007 and inventory report 2009,” Technical Report No. 4/2009, Copenhagen.

European Environmental Agency (2004b), “Greenhouse gas emission trends and projections in Europe 2004,” EEA Report, Copenhagen.

European Parliament (2002), “Report on the Proposal for a European Parliament and Council Directive Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC,” Final A5-0303/2002 Par1 (RR/477361EN.doc), Brussels.

Faure M. (2008), “Designing Incentives Regulation for the Environment,” *Maastricht Working Paper Series* 08-7.

Faure M. and Grimeaud D. (2003) "Financial Assurance Issues of Environmental Liability," in M. Faure, ed. *Deterrence, Insurability and Compensation in Environmental Liability*. ECTIL, Vienna: Springer.

Faure M. and Nolakaemper A. (2007), "International Liability as an Instrument to Prevent and Compensate for Climate Change," *Symposium: Climate Change Risk*, Vol. 26A/43A:123.

Faure M., Gupta J. and Nentjes. A. (2003), "Key Instrumental and Institutional Design Issues in Climate Change Policy," in M. Faure, J. Gupta and A. Nentjes, eds. *Climate Change and the Kyoto Protocol: The Role of Institutions and Instruments to Control Global Change*. Cheltenham: Edward Elgar, 3-24.

Fehr, N-H von der, and Harbord D. (1993). "Spot market competition in the UK electricity industry," *The Economic Journal* 103: 531-546.

Finus, M. (2003), 'International Cooperation to Resolve International Pollution Problems', in M. Cogoy and K. Steininger (eds), *Economics of Sustainable Development: International Perspectives, EOLSS, The Encyclopedia of Life Support Systems*, ch. 1.21.4.3.,

Fischer C. and Newell R. (2005), "Environmental and Technology Policies for Climate Change and Renewable Energy," Resources for the Future, RFF DP 04-05.

Fisher C. (2008), "Emissions Pricing, Spillovers, and Public Investment in Environmentally Friendly Technologies," *Energy Economics*, Elsevier, vol. 30(2), 487-502.

Fon V and Parisi F. (2003), "Reciprocity Induced Cooperation," *Journal of Institutional and Theoretical Economics* 159 (1): 76-92.

Frey B.S. (1999), "Morality and Rationality in Environmental Policy," *Journal of Consumer Policy* 22: 395-417.

Frey, B.S. (1997), "Not Just for the Money: An Economic Theory of Personal Motivation," Cheltenham UK, Edward Elgar Publishing.

Frontier Economics (2006), "CO_2 Trading and its Influence on Electricity Markets: Final Report for DTE," London: Frontier Economics Ltd.

Gandal N. (2002), "Compatibility, Standardization, and Network Effects: Some Policy Implications," *Oxford Review of Economic Policy* 18 (1): 80-91.

Georgopoulou E., Sarafidis Y., Mirasgedis S., Lalas D.P. (2006), "Next allocation phase of the EU emissions trading scheme: How tough will the future be?," *Energy Policy* 34 (18): 4002-4023.

Goldsmith J.L. and Posner E. (2005) "The Limits of International Law," New York: Oxford University Press, 2005. 272pp.

Goldsmith J. L. and Eric A. Posner (2004), A Theory of International Law (mimeo).

Goldsmith, Jack L. and Eric A. Posner (1999), "A Theory of Customary International Law," University of Chicago Law Review 66: 1133-77

Goldsmith, Posner, *The limits of international law*, Oxford University Press US, 2005, p. 100-104.

Gollier, C., Jullien, B., and Treich, N. (2000), 'Scientific Progress and Irreversibility: An Economic Interpretation of the Precautionary Principle', *Journal of Public Economics*, **75**, 229–53.

Grafton R.Q. and Devlin R.A. (1996), "Paying for Pollution: Permits and Charges," *Scandinavian Journal of Economics* 98(2), 275-288.

Graichen J. and Graichen V. (2007) "The EU Emissions Trading Scheme in numbers," *ETC/ACC Technical Paper 2007/2*, Oko Institut.

Green R. J.; Newbery D. M. (1992), "Competition in the British Electricity Spot Market," *The Journal of Political Economy* 100 (5): 929-953.

Grubb M. (2000), "The Kyoto Protocol: an Economic Appraisal," *FEEM Working Paper* No. 30.2000.

Grubb M. and Ferrario F., (2006), "False confidences: forecasting errors and emission caps in CO_2 trading systems," *Climate Policy* 6 (4): 495-501.

Grubb M., Vrolijk C. and Brack D. (1999), "The Kyoto Protocol: a guide and assessment," Earthscan / Royal Institute of International Affairs, London.

Guzman A. (2008), *How International Law Works: A Rational Choice Theory*, Oxford University Press: Oxford,

Guzman A. (2006), "Reputation and International Law," *Georgia Journal of International and Comparative Law*

Guzman, A. (2002), "A Compliance-Based Theory of International Law," California Law Review 90: 1823-87.

Haar L. N. and Haar L. (2006), "Policy-making under Uncertainty: Commentary upon the European Union Emissions Trading Scheme," *Energy Policy* 34: 2615–2629.

Hanemann, W. M. (1989), 'Information and the Concept of Option Value', *Journal of nvironmental Economics and Management*, **16**(1), 23–37.

Hardin G. (1968) "The Tragedy of the Common," *Science* 162. Vol. 162. no. 3859, pp. 1243 - 1248

Hargrave T. (2000), "An Upstream/Downstream Hybrid Approach to Greenhouse Gas Emissions Trading," Washington: Center for Clean Air Policy (CCAP).

Hargrave, T., Helme N., Denne T., Kerr S. and Lefevere J. (1999) "Design of a Practical Approach to Greenhouse Gas Emissions Trading Combined with Policies and Measures in the EC," Washington: Center for Clean Air Policy (CCAP).

Harrison, D. and Radov D.B. (2002), "Evaluation of Alternative Initial Allocation Mechanisms in a European Union Greenhouse Gas Emissions Allowance Trading Scheme," National Economic Research Associates (NERA).

Hart H. L. (1994), "*The Concept of Law*," Second edition, Oxford: Oxford University Press.

Helm D. (2005), "The Assessment: The New Energy Paradigm," *Oxford Review of Economic Policy* 21 (1) : 1-18.

Hepburn C. (2006), "Regulation by Prices, Quantities, or Both: a Review of Instrument Choice," *Oxford Review of Economic Policy* 22 (2). 226-247

Hepburn C., Grubb M., Neuhoff K., Matthes F. and Tse M (2006), "Auctioning of EU ETS phase II allowances: how and why?, " *Climate Policy* 6: 137 – 160.

Hepburn, C., J.K.-H. Quah and R.A. Ritz. (2006b), "Emissions Trading and Profit-Neutral Grandfathering," *Department of Economics Discussion Paper Series* Nr. 295. Oxford: Oxford University.

Hoel M. (1997), "Coordination of Environmental Policy for Transboundary Environmental Problems?," *Journal of Public Economics* 66: 199-224.

Hoel M. and Karp L. (2002), "Taxes versus Quotas for a Stock Pollutant," *Resource and Energy Economics* 24(4): 367-384.

Huntington, H.G. (2005): "US carbon emissions, technological progress and economic growth since 1870," *International. Journal of Global Energy Issues* 23(4): 292-306.

Intergovernmental Panel on Climate Change (2000), “Emissions Scenarios”, Special Report, Eds. N. Nakicenovic and R. Swart, Cambridge: Cambridge University Press.

International Energy Agency (2008), *World Energy Outlook 2008,* Paris: OECD/IEA.

International Panel on Climate Change (2007), “Summary for Policymakers - Climate Change 2007: The Physical Science Basism,” *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

Jaffe A., Newell R. and Stavins R. (2005), “A Tale of Two Market Failure – Technology and Environmental Policy,” *Ecological Economics* 54 (2-3): 164-174.

Johnston A. (2006), “Free allocation of allowances under the EU emissions trading scheme: legal issues,” *Climate Policy* 6: 115 – 136.

Jowit J., Wintour P. “Cost of tackling global climate change has doubled, warns Stern” The Guardian, Thursday 26 June 2008, available at:

Kate T. A., Niels, G. (2005), “To what extent are cost savings passed on to consumers? An oligopoly approach,” *European Journal of Law and Economics* 20: 323–337.

Kaul, I., Grunberg, I., and Stern, M.A., (Eds), 1999, Global Public Goods: International Cooperation in the Twenty-First Century, Oxford University Press, New York.

Kaya, Y. (1990): “Impact of carbon dioxide emission control on GNP growth: interpretation of proposed scenarios,” *Paper presented to IPCC Energy and Industry Sub-Group*, Response Strategies Working Group.

Kehoane N., Revsesz R. and Stavins R. (1998), “The Choice of Regulatory Instruments in Environmental Policy,” *Harvard Environmental Law Review* 22 (2): 313-367.

Kemfert C., Kohlhaas M., Truong T. and Protsenko A. (2006), “The Environmental and Economic Effects of European Emissions Trading,” *Climate Policy* 6: 441–455.

Keohane R. (1984), *After Hegemony: Cooperation and Discord in the World Political Economy* (Princeton University Press).

Kettner C., Köppl A., Schleicher S. and Thenius G, (2007), “Stringency and Distribution in the EU Emissions Trading Scheme –The 2005 Evidence,” *FEEM Nota di Lavoro*. No 22.

Kolstad Ch.D., Ulen Th. S., and Johnson G.V. (1990), “Ex-Post Liability for Harm vs. Ex-Ante Safety Regulation: Substitutes or Compliments?,” *American Economic Review* 80: 888-901.

Koutstaal P.R. (1997), “Economic Policy and Climate Change: Tradable Permits for Reducing Carbon Emissions,” Cheltenham: Edward Elgar.

Krämer L. (2005), “Directive 2004/35 on Environmental Liability and Environmental Principles,” *Tijdschrift voor Milieuaansprakelijkheid* 4: 131-134.

Kronman A., (1985) “Contract and the State of Nature,” *Journal of Legal and Economics Organization* 1: 5-32.

Kruger J. and Pizer W. (2004) “The EU Emissions Trading Directive: Opportunities and Potential Pitfalls,” *Resources for the Future*, Discussion Paper 04–24.

Landes W., and Posner R. (1981), “The Positive Economic Theory of Tort Law,” *Georgia Law Review* 15: 870.

Levy C. (2005), “Impact of emission trading on power prices. A case study from the European emission trading scheme”. DEA d’Economie Industrielle, Universite´ Paris Dauphine.

Lindzen R., Chou M., Hou A. (2001), *Does the Earth Have an Adaptive Infrared Iris?”*, Bulletin of the American Meteorological Society, Vol. 82, No. 3

Maloney M. and Brady G.L. (1988), "Capital Turnover and Marketable Property Rights," *The Journal of Law and Economics* 31(1): 203-226.

Martin L (1999) “The Political Economy of International Cooperation”, in *Global Public Goods: International Cooperation in the 21st Century* edited by Kaul I. Grunberg I., Stern M. and Gajraj P., published for the United Nations Development Programme (UNDP), New York Oxford University Press

Martinez K and Neuhoff K. (2004), “Allocation of Carbon Emission Certificates in the Power Sector: How Generators Profit from Grandfathered Rights,” *Cambridge Working Papers in Economics*, 49.

Matthes F., V. Graichen and J. Repenning. (2005), “The Environmental Effectiveness and Economic Efficiency of the European Union Emissions Trading Scheme: Structural Aspects of Allocation,” *Report to WWF*. Berlin: Öko-Institut.

McCubbins M.D., Noll R.G., and Weingast B.R. (1989), "Structure and Process, Politics and Policy: Administrative Arrangements and the Political Control of Agencies," *Virginia Law Review* 75(2): 431-482.

McKibbin W. J., and Wilcoxen P. J. (2002), "The Role of Economics in Climate Change Policy," *Journal of Economic Perspectives*, 16(2): 107–29.

McKinsey and Ecofys (2006), "EU ETS Review: Report on International competitiveness," European Commission Directorate General for Environment, Bruxelles.

Meinshausen M. (2006), "What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates," in *Avoiding dangerous climate change*, H.J. Schellnhuber et al. (eds.), pp.265 – 280, Cambridge: Cambridge University Press.

Mendelsohn W, Dinar A. and Williams L. (2006) "The distributional impact of climate change on rich and poor countries," *Environment and Development Economics* (2006), 11(2):159-178.

Motta M. (2004), "Competition Policy. Theory and Practice", Cambridge University Press

Moulin H. (1991), 'Welfare Bounds in the Fair Division Problem', Journal of Economic Theory, 54(2), 321–37.

Moulin, H. (1990), 'Fair Division under Joint Ownership', Social Choice and Welfare, 7, 149–70.

Munari F, Di Pepe schiano L. (2006), "Diritto Internazionale dell'Ambiente e Ruolo dei "Non-State Actors": Alcuni Recenti Sviluppi" in *La Comunità Internazionale* Fasc. 3/2006, pp. 483-507

Nash J.R. (2000), "Too Much Market? Conflict Between Tradable Pollution Allowances and the 'Polluter Pays' Principle," *Harvard Environmental Law Review* 24 (2): 1-59.

Nash, J.R. and R. Revesz. (2007), "Grandfathering and Environmental Regulation: The Law and Economics of New Source Review," *New York University Public Law and Legal Theory Working Paper* 53, New York: New York University School of Law.

Nelson, R., Tietenberg T.H., and M. Donihue (1993), "Differential Environmental Regulation: Effects on Electric Utility Capital Turnover and Emissions," *Review of Economics and Statistics* 75(2): 368-373.

Nentjes, A., P. Koutstaal and G. Klaassen (1995) “Tradeable Carbon Permits: Feasibility, Experiences, Bottlenecks,” *Dutch National Research Programme on Global Air Pollution and Climate Change* (NRP), NRP Report no. 410 100 114, Groningen / Bilthoven: RuG / NRP.

Neuhoff K., Åhman M., Betz R, Cludius J, Ferrario F., Holmgren K., Pal G., Grubb M., Matthes F., Rogge K., Sato M., Schleich J, Tuerk A., Kettner C. and Walker N. (2006) “Implications of announced Phase 2 National Allocation Plans for the EU ETS,” *Climate Policy* 6 (5): pp 411-422

Neuhoff K., Ferrario F., Grubb M. (2006), “Emission projections 2008-2012 versus NAPs II,” *Climate Policy* 6(5): pp 411-422

Neuhoff K., Martinez K., Stato M., (2006), “Allocation, incentives and distortions: the impact of EU ETS emissions allowance allocations to the electricity sector,” *Climate Policy* 6: 73 – 91.

Neumayer, E. (2004): “National carbon dioxide emissions: geography matters,” *Area* 36(1): 33-40.

Nordhaus W. (2006) “The Stern Review on the Economics of Climate Change,” NBER Working Paper No. 12741.

Nordhaus W. and Boyer J. (2000), “*Warming the World: Economic Models of Global Warming*,” Cambridge: MIT Press.

Nordhaus W. and J.Boyer (1999), “Requiem for Kyoto: an economic analysis,” *The Energy Journal*, Special Issue.

Nordhaus W., (2005), “Life After Kyoto: Alternative Approaches to Global Warming Policies,” NBER working paper.

Nordhaus, W. D. (2001), “After Kyoto: Alternative Mechanisms to Control Global Warming,” Presentation at the 20^{th} Anniversary Meeting of the International Energy Workshop, IIASA, Laxenburg, Austria.

Oates, W.E. (1990), “Economics, Economists, and Environmental Policy,” *Eastern Economic Journal* 16(4): 289-296.

Oberthür, S. and H.E. Ott. (1999), “*The Kyoto Protocol: International Climate Policy for the 21st Century*,” Springer: Berlin.

Ogus A. (1994), “Standard Setting for Environmental Protection: Principle and Processes,” in M. Faure, J. Vervaele and A. Weale (eds), *Environmental Standard in the European Union in a Interdisciplinary Framework*, Antwerp.

Olmstead S. and Stavins R. (2006), “An International Architecture for the Post-Kyoto Era,” Harvard University – *Faculty Research Working Paper series.*

Olson, M., 1965, The Logic of Collective Action. Harvard University Press, Cambridge, MA.

Organization for Economic Co-operation and Development (1972), “Environment and Economics: Guiding Principles Concerning International Economic Aspects of Environmental Policies,” Annex Par. 1, Doc. No. C(72)128, 1972 WL 24710. Paris.

Organization for Economic Co-operation and Development (1975) “The Polluter Pays Principle: Definition, Analysis, Implementation,” Paris.

Organization for Economic Co-operation and Development (2003), “Competition Issues In The Electricity Sector,” DAFFE/COMP(2003)14.

Pallè E., Goode P. R., Montanes-Rodriguez P.,Koonin S. (2004) “*Changes in Earth’s Reflectance over the Past Two Decades”*, SCIENCE, Vol. 304

Parikh, K.S. “1993) “The Polluter-Pays and User-Pays Principles for Developing Countries: Merits, Drawbacks and Feasibility,” pp. 81-91in Dommen, E. ed., *Fair Principles for Sustainable Development: Essays on Environmental Policy and Developing Countries*. Aldershot: Edward Elgar,.

Pearce D.W., Cline W. R. (1996), “The social costs of climate change: Greenhouse damage and the benefits of control,” in Intergovernmental Panel on Climate Change, Climate Change 1995: Economic and Social Dimensions of Climate Change. Cambridge.

Pearce, D. (1998), “Cost–Benefit Analysis and Environmental Policy,” *Oxford Review of Economic Policy* 14(4): 84–100.

Pearson, C. S. (1994), “Testing the System: GATT + PPP = ?,” *Cornell International Law Journal* 27: 553-575.

Peltzman, S. (1976), “Toward a More General Theory of Regulation,” *Journal of Law and Economics* 19: 211.

Peterson S. (2006), “Efficient Abatement in Separated Carbon Markets: A Theoretical and Quantitative Analysis of the EU Emissions Trading Scheme,” *Kiel*

Working Paper 1271, Germany.

Pigou, A.C. (1920), "*The Economics of Welfare*," London: Macmillan.

Pizer W. A. (2005), "The Evolution of a Global Climate Change Agreement," *Resources for the Future working paper.*

Reguant M and Ellerman D. (2008) "Grandfathering and the endowment effect: An Assessment in the context of the Spanish National Allocation Plan," MIT *Center for Energy and Environmental Policy Research*, 08-18.

Reinaud J. (2007), "CO_2 Allowance and Electricity Price Interaction – Impact on Industry's Electricity Purchasing Strategies in Europe," *International Energy Agency Information Paper*, Paris.

Reinaud J., (2008), "Climate Policy and Carbon leakage Impacts of the European Emissions Trading Scheme on Aluminium," *International Energy Agency Information Paper*, Paris.

Revesz, R.L. and R.N. Stavins (2004), "Environmental Law and Policy," in A.M. Polinsky and S. Shavell, eds. *The Handbook of Law and Economics*. Amsterdam: North-Holland/Elsevier Science.

Rogge K., Schleich J. and Betz R. (2006), *An Early Assessment of National Allocation Plans for Phase 2 of EU Emission Trading*," *Fraunhofer Institute Working Paper Sustainability and Innovation* No. S1/2006.

Rose, C.M. (1999), "Expanding the Choices for the Global Commons: Comparing Newfangled Tradable Allowance Schemes to Old-Fashioned Common Property Regimes," *Duke Environmental Law & Policy Forum* 10 (45): 45-72.

Russett B. M. and Sullivan J. D. (1971) "Collective Goods and International Organization", International Organization, Vol. 25, No. 4, pp. 845-865

Sandler, T., 1997, Global Challenges: An Approach to Environmental, Political, and Economic Problems. Cambridge University Press, Cambridge.

Sandler, T., 1998. Global and regional public goods: A prognosis for collective action. Fiscal Studies 19, 221-247.

Schleich J., Betz R., Rogge K., 2007, "EU Emission Trading – Better Job Second Time Around?," Nr., *Fraunhofer Institute Working Paper series* S 2/2007, Germany.

Schmalensee R., Joskow P., Ellerman A.D., Montero J. P.and Bailey E. M. (1998), “An Interim Evaluation of Sulphur Dioxide Emissions Trading,” *Journal of Economic Perspectives* 12 (3): 53–68

SEC(2008) 52, “Commission Staff Working Document Accompanying Document to the Proposal for a Directive of the European Parliament and of the Council Amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system,” Brussels, 23.1.2008.

SEC(2008) 85/3 “Accompanying the Package of Implementation Measures for the EU's Objectives on Climate Change and Renewable Energy for 2020,” Brussels.

Shavell, S. (1980) "Strict Liability versus Negligence," *Journal of Legal Studies* 9 (1), pp. 1-25

Shavell, S. (1984), “Liability for Harm Versus Regulation of Safety,” *Journal of Legal Studies* 13: 357.

Shavell, S. (2006), “On Optimal Legal Change, Past Behavior, and Grandfathering,” *Harvard Discussion Paper* No. 570, 12/2006. Cambridge, MA: Harvard Law School.

Sijm, J., K. Neuhoff and Y. Chen. (2006), “CO_2 Cost Pass-Through and Windfall Profits in the Power Sector,” *Climate Policy* 6: 49-72.

Sorrell, S. and J. Sijm. (2003) “Carbon Trading in the Policy Mix,” *Oxford Review of Economic Policy* 19 (3): 420-437.

Springer, U. (2002), “The Market for Tradable GHG Permits under the Kyoto Protocol: A Survey of Model Studies,” *Energy Economics* 25(5) : 527–51.

Stavins R. (2004), “Environmental Economics,” *KSG Faculty Research Working Paper Series* 04-051.

Stern, N., S. Peters, V. Bakhshi, A. Bowen, C. Cameron, S. Catovsky, D. Crane, S. Cruickshank, S. Dietz, N. Edmonson, S.-L. Garbett, L. Hamid, G. Hoffman, D. Ingram, B. Jones, N. Patmore, H. Radcliffe, R. Sathiyarajah, M. Stock, C. Taylor, T. Vernon, H. Wanjie, and D. Zenghelis (2006), “Stern Review: The Economics of Climate Change,” HM Treasury, London.

Stigler, G.J. (1971), "The Theory of Economic Regulation," *Bell Journal of Economics* 2(1): 3-21.

Sugden R. (1984), “ Reciprocity: the Supply of Public Goods through Voluntary Contributions”, *The Economic Journal*, 94, pp. 772-787

Sykes, A. (2004), “Economics of Public International Law,” *Chicago working paper series* n. 216.

Tietenberg, T., M. Grubb, A. Michaelowa, B. Swift, Z.X. Zhang. (1999), “International Rules for Greenhouse Gas Emissions Trading: Defining the Principles, Modalities, Rules and Guidelines for Verification, Reporting and Accountability,” UNCTAD/GDS/GFSB/Misc.6. Geneva: United Nations Conference on Trade and Development (UNCTAD).

Toman M., J. Anderson and R. Morgenstern (1999), “The Economics of ‘When’ Flexibility in the Design of Greenhouse Gas Abatement Policies,” *Annual Review of Energy and the Environment* 24: 431-460.

UNFCCC (1992), “United Nations Framework Convention on Climate Change,” New York, 31 ILM 849.

UNFCCC (2002), “A Guide to the Climate Change Convention process”, Climate Change Secretariat, Bonn

Verhoef E.T. (1999), “Externalities,” in J.C.J.M. van den Bergh, ed. *Handbook of Environmental and Resource Economics*, pp. 197-214, Cheltenham: Edward Elgar.

Victor D. (2001), “*The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming*,” Princeton, NJ: Princeton University Press.

Weishaar S. (2007), “CO_2 emissions allowance allocation mechanisms, allocative efficiency and the environment: a static and dynamic perspective,” *European Journal of Law and Economics* 24: 29-70.

Weitzman M.L. (1974), “Prices vs Quantities,” *Review of Economic Studies* 41 (4): p.477-491.

Wirth, D.A. (1995), “The Rio Declaration on Environment and Development: Two Steps Forward and One Back, or Vice Versa?,” *Georgia Law Review* 29: 599-653.

Woerdman E., Arcuri A. and Clò S. (2008), “Emissions Trading and the Polluter-Pays Principle: Do Polluters Pay under Grandfathering?,” *Review of Law and Economics*, 4(2).

World Resources Institute (2006), “Climate Analysis Indicators Tool (CAIT)” on line database version 3.0., Washington, DC: World Resources Institute, available at: http://cait.wri.org

Worsley, R. and R. Freedman. (2003), “Europarl Daily Notebook: 02-07-2003,” Brussels: European Parliament.

WRI 2009 Climate Analysis Indicator Tool, available at: http://cait.wri.org/cait.php?page=carbecon&mode=view

Yandle, B. (1999). “Grasping for the Heavens: 3-D Property Rights and the Global Commons,” *Duke Environmental Law & Policy Forum* 10 (13): 13-44.

Zacher, M.W., Sutton B., 1996, *Governing Global Networks: International Regimes for Transportation and Communication,* Cambridge University Press

Zapfel, P. and M. Vainio. (2002), “Pathways to European Greenhouse Gas Emissions Trading: History and Misconceptions,” *FEEM Nota di Lavoro* 85.2002.

Zetterberg, L., K. Nilsson, M. Åhman, A.-S. Kumlin and L. Birgersdotter. (2004) “Analysis of National Allocation Plans for the EU ETS,” Stockholm: *IVL Swedish Environmental Research Institute*.