Tradable Carbon Allowances:

The experience of the EU and lessons learned

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Contents

Summary of EU ETS experiences, achievements and lessons learned

This section provides a bullet-point summary of the major experiences, achievements and lessons learned by the EU ETS during the first 3-5 years of its existence under the following theme headings:[1]

1. Allocation system;
2. Carbon abatement;
3. EUA market development;
4. Impact on growth, competitiveness and carbon leakage;
5. EU ETS overall performance.

1. Allocation system

- Reliable emissions data and good projections at the installation level are essential for (avoiding over-)allocation of free allowances.
- The system of decentralized and free allocations of emission allowances during the first and second phase of the EU ETS facilitated acceptance and introduction of the scheme.
- On the other hand, this system of decentralized and free allocation has caused a variety of inefficiencies, competitive distortions and equity problems which threaten the long-term cost-effectiveness, integrity and acceptability of the scheme.
- Phase I allocation was a useful experience: some findings and lessons learned during this trial period were used to improve the performance of the allocation system, albeit modestly for the second phase, but more fundamentally for the third phase and beyond through a decisive revision of the EU ETS Directive post 2012.

2. Carbon abatement

- A few studies indicate that some abatement of CO_2 emissions occurred during the first phase of the EU ETS, despite an overall modest cap and wide-spread over-allocations of allowances at the installation, sector and country levels.
- Besides some small energy efficiency improvements across the scheme (induced by relatively high EUA prices in 2005-2006), carbon abatement during the first phase of the scheme was most likely restricted to short-term fuel switching in the power sector of some countries, i.e. Germany and the UK.
- Emission reductions appear occasionally where they are not expected, e.g., through switching from lignite to coal or from coal to gas or biomass (Germany), or through improvement of coal generation by increasing biomass use or enhancing energy efficiency (UK; Convery et al., 2008).

3. EUA market development

- Since 2005, the EU allowance market has developed strongly, resulting in some major achievements, in particular (i) the EUA market infrastructure - i.e., trading platforms, registries, etc. - is in place, (ii) the EUA market has expanded rapidly in terms of both volume and value of transactions, (iii) the EUA market has strongly encouraged the development and growth of the JI/CDM market (i.e., through the linkage or use of JI/CDM credits to meet EU ETS compliance), (iv) the EUA market has established one single EU-wide, transparent carbon price and, perhaps most importantly, (v) the EUA market made stakeholders aware that carbon emissions have a price to be internalized in their decision-making.

[1] Similar and other experiences, achievements and lessons learned by the EU ETS have been discussed and reviewed by, in particular, Convery et al. (2008), Ellerman and Joskow (2008), Convery (2008), Fujiwara and Egenhofer (2007), EAC (2007), Ellerman et al. (2007), Kruger et al. (2007), Buchner et al. (2006), and Betz and Sato (2006).

- Timely and reliable information on verified emissions and (long-term) EU ETS cap, as well as opportunities for banking (and borrowing) of allowances within and between (adequately long) trading periods are essential for market efficiency, EUA price stability and proper investment decisions affecting carbon emissions.

4. Impact on growth, competitiveness and carbon leakage

- For the years 2005-2008, there are no significant empirical signs that the EU ETS has exerted an adverse effect on economic growth or industrial competitiveness of participating sectors, or that it resulted in carbon leakage to other countries.
- The impact of the EU ETS on economic growth, industrial competitiveness and carbon leakage, however, may be larger in the long run when EUA prices are higher (while outside competitors do not face similar costs), world markets are less buoyant (compared to 2005-2007) and/or free allocation of allowances - including closure conditions - are less favorable to incumbents and new entrants.

5. EU ETS overall performance

- The introduction of a short pilot phase was useful: lessons learned were, to some extent, already applied to phase 2 and, more importantly, largely incorporated in the drastic revisions of the EU ETS Directive for phase 3 and beyond.
- Despite several problems, shortcomings and poor conditions during the trial phase, the system performed surprisingly well during the first years of its operation, in particular in terms of EUA market development, raising carbon cost awareness and internalizing EUA pricing in stakeholders'operational decisions (Ellerman and Joskow, 2008).
- Up to now, the performance of the EU ETS has been low (or largely unknown) in terms of encouraging R&D and implementation of new, carbon-saving technologies.
- Over the past five years, the EU ETS has become both the cornerstone and the flagship of EU climate policy.
- A major lesson of the first years of the EU ETS is that not everything has to be perfect to get started: although imperfections were reflected in EUA price volatility - or other market inefficiencies - they did not really hinder the development of the EUA market, whereas the existence of this market was actually the best stimulus to address these imperfections.
- The EU ETS experience with the so-called'dynamics of harmonization versus differentiation', i.e. centralized versus decentralized policy control and implementation, offers useful lessons for other regional/global ET systems or other regional/global mitigation policies (Kruger et al., 2007; Ellerman, 2008).
- Perhaps one of the main'achievements'of the EU ETS is that it reflects and establishes a'cultural change': while during the Kyoto Protocol negotiations the EU was still opposed to emissions trading, within a decade both the idea and practice of emissions trading - and market-based environmental policy instruments in general - were widely and increasingly accepted within the EU.
- Overall, despite a variety of shortcomings of the EU ETS up to now, the European Commission - in particular the officials of DG Environment designing, implementing and revising the EU ETS Directive - did an amazingly good job.

1. Introduction

In January 2005, the European Union (EU) introduced an Emissions Trading Scheme (ETS) in order to reduce greenhouse gas emissions in a cost-effective way. Since then, the EU ETS has become the cornerstone of EU climate policy, which has aroused a lot of attention and debate both inside and outside the EU.

The main purpose of the present paper is to evaluate the performance of the EU ETS during the first 3-5 years of its existence and to draw some lessons from its experience. These lessons may be useful, in particular for other regions or countries interested in setting up and developing their own emissions trading scheme.[2]

The content of this paper is structured as follows. First of all, Chapter 2 outlines some main features of the EU ETS up to 2012. Subsequently, Chapter 3 up to Chapter 6 discuss different aspects of the performance of the EU ETS since early 2005, including the performance of the allocation system (Chapter 3), the question whether the scheme has already led to some carbon abatement (Chapter 4), the development of the market for trading EU emission allowances (Chapter 5), and the impact of the EU ETS on economic growth, industrial competitiveness and carbon leakage (Chapter 6). Next, Chapter 7 discusses some important changes in the fundamentals of the EU ETS, which have been adopted recently and will be implemented post 2012. Finally, Chapter 8 provides a summary of some achievements and lessons learned during the past five years of the EU ETS.

[2] Recently, some interesting studies and papers have evaluated the performance of the EU ETS during its pilot phase (2005-2007). See, in particular, Convery et al. (2008), Ellerman and Joskow (2008), and Ellerman et al. (2007). The present paper builds on these publications as well as on own publications and other references mentioned in this paper.

2. Main features of the EU ETS up to 2012

As part of the Kyoto Protocol, the Member States of the European Union (EU) have agreed to reduce their annual greenhouse gas emissions over the period 2008-2012 by, on average, 6 percent compared to a reference level of the early 1990s[3]. In order to meet this commitment - and even more ambitious GHG mitigation targets beyond 2012 - the EU decided to establish an Emissions Trading Scheme (ETS), which started to operate from January 2005. The main features of this scheme up to 2012 are outlined below.

Type of system and operational rules

The EU ETS is a so-called cap-and-trade system including the following characteristics and operating rules:

- An absolute quantity limit (or cap) is set on the total CO_2 emissions of the participating installations over a certain period. This limit or quantity of emission *allowances* is allocated among these participants, which are allowed to trade these allowances among each other.[4]
- Participants have to monitor and annually report their carbon emissions, verified by external parties.
- On the 30th of April of each year, participants have to surrender a quantity of allowances equal to their verified emissions in the preceding calendar year.
- Non-complying participants have to pay a penalty for each tonne of CO_2 not covered by surrendered allowances. This penalty amounts to 40 €/tCO_2 during the first phase of the EU ETS (2005-2007) and 100 €/tCO_2 during the second phase (2008-2012). In addition, the names of these non-compliers are listed (‘naming-and-shaming’), while they have to surrender allowances for the non-complied emissions after all in the next year.

Timing, trading, banking and borrowing

Up to 2012 the EU ETS is distinguished by two trading periods:

- Phase 1 (2005-2007). The primary purpose of this pilot or trial period was to develop the EU ETS infrastructure and to gain experience to improve the system in subsequent periods.
- Phase 2 (2008-2012). This phase corresponds to the commitment period of the Kyoto Protocol.

Within any trading period, there is effectively no restriction on trading, banking or borrowing of allowances. Although allowances are issued annually, they are valid for covering emissions in any year within the trading period. Between the first and the second trading period, however, neither effective banking nor borrowing was possible. For the second and subsequent trading periods, on the other hand, unrestricted *inter*-period banking - but no borrowing - is allowed (EC, 2003; Ellerman and Joskow, 2008).

3 When the Kyoto Protocol was agreed (1997), the EU consisted of 15 Member States (EU-15). Since then, the EU has expanded to its present number of 27 Member States (EU-27), including several countries from Central and Eastern Europe.

4 In the EU ETS, a distinction is made between an *allowance* and a *permit*. An EU ETS allowance gives the right to emit one tonne of CO_2. It is the system’s tradable unit, called ’EU Allowance’ or ’EUA’. On the other hand, each installation in the EU ETS must have a permit from its competent authority. It is a kind of (non-tradable) license, which sets certain conditions on an installation’s operation, in particular that the operator is capable of monitoring and reporting the plant’s emissions.

Coverage

During the first phase, the EU ETS covered only CO_2 emissions from specified sectors and activities, including:

- All large installations in the power and heat sector with a thermal input of greater than 20 MW as well as all other combustion plants (>20 MW_{th} input) regardless of the sector in which they are found, including commercial and institutional establishments.
- Specified installations, meeting certain input or output capacity thresholds, in selected energy-intensive industries, including oil refineries, coke ovens and plants making iron and steel, cement, lime, glass, bricks, ceramics, paper and pulp.[5]

Overall, the EU ETS covers about 11,000 installations which are collectively responsible for approximately 2 Gt of CO_2 emissions, i.e. nearly half of the EU's CO_2 emissions and some 40 percent of its total GHG emissions.

Allowance allocation

Up to 2012, both cap-setting and the distribution of allowances at the installation level are the primary responsibility of individual Member States, which have to design National Allocation Plans (NAPs) for each trading period based on criteria and guidelines set by the European Commission (EC). Allowances should be allocated free of charge, but Member States have the option to auction up to 5 percent of allowances in phase 1 and up to 10 percent in phase 2. Based on the EU-wide allocation criteria and guidelines, the NAPs have to be judged and approved by the European Commission, which has the option to suggest NAP adjustments to Member States before giving its final approval.

External linkages

In order to meet their obligations under the EU ETS, participants may convert a limited amount of offset credits from JI/CDM projects into additional EU allowances. This amount is restricted to a certain percentage of the allocated allowances, which may vary between Member States and sectors. All types of JI/CDM credits are allowed for conversion, except credits from nuclear facilities and carbon sinks. In addition to links with JI/CDM markets, the EU Directive on emissions trading offers the opportunity to set linkages between the EU ETS and other (future) schemes across the world in order to develop and stimulate a more cost-effective, global carbon market.

Allowances transaction registries

Allowances are not printed but held in electronic accounts in national registries set up by Member States. Through legislation, the European Commission has set up a standardised and secured system of registries based on UN data exchange standards to track the issue, holding, transfer and cancellation of allowances. Provisions on the tracking of JI/CDM credits in the EU system are also included (EC, 2007).

At the EU level, the system of national registries is overseen by a central administrator and connected to a central registry in Brussels, called the Community Independent Transaction Log (CITL). In addition to recording transactions of EUAs among installations in different Member States, the CITL also provides data on free allocations and verified emissions at the installation level as reported by the Member States. Finally, the EU registries system is connected to and will be further integrated with the international registries system under the UNFCCC.

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[5] In addition, during the first phase, Member States were allowed to opt-in installations below capacity limits in ETS sectors, while from 2008 on they could also opt-in certain other activities, installations and/or GHGs (notably N_2O-emitting facilities from the chemical industry). In general, however, the size of these options was relatively small in terms of total GHG emissions.

3. The performance of the allocation system

This section evaluates the allocation system of the EU ETS up to 2012. To provide a frame of reference for our evaluation, we start with a brief discussion of the standard ('ideal') allocation system from the textbook literature. Subsequently, we outline some actual characteristics of the EU ETS allocation system during its first and second trading periods, indicate some of its differences (compared to the standard system) and, finally, discuss some implications of these characteristics and differences for the performance of the EU ETS allocation system.

3.1 The standard allocation system

In the standard cap-and-trade system, a central authority imposes a cap on total emissions and then allocates the total number of emission allowances to the participants, where the cap equals the number of allowances. Basically, two reference cases of allocating emission allowances can be distinguished, i.e. auctioning versus perfect free allocation. In an auctioning system, allowances are initially allocated by selling them at an auction (or market). On the other hand, the ideal (textbook) type of perfect free allocation is characterized by:

- A one-off initial allocation of free allowances to existing installations (incumbents), usually for a long time frame, based on (i) a fixed baseline or historic reference period of actual emissions at the installation level ('grandfathering'), or (ii) a standard emission factor multiplied by an ex-ante fixed quantity or activity level, for instance a certain input, output or capacity level ('benchmarking').
- At closure, installations retain their allowances.
- New entrants do not receive allowances for free, but have to buy them on the market.

The resulting market equilibrium price of an allowance will determine the actual pattern of emissions and abatements among the sources covered by the scheme. A cost-minimising source will purchase (or sell) allowances until its marginal abatement costs (MAC) equal the market price of an allowance. This implies that, in equilibrium, the MAC of all sources will be equal, which satisfies the necessary condition for minimising the total abatement costs of realising the cap (Kruger et al., 2007).

Moreover, as the initial distribution of emission allowances in a perfect free allocation system is independent of a plant's operation, closure and investment decisions, it creates the same set of conditions for abatement efficiency as an auctioning system (Harrison et al., 2007). Hence, both allocation systems result in the same level of the allowance price, the same level and type of abatement, the same marginal and total abatement costs, and the same level of passing-through costs to output prices. The only difference between auctioning and perfect free allocation concerns the transfer of economic rent due to the initial allocation of emission allowances. Whereas this wealth accrues to the central authority in the case of auctioning, it is transferred to the recipients of allowances in the case of perfect free allocation (Neuhoff et al., 2006b).

3.2 Characteristics of EU allocation up to 2012

During the first and second trading periods, the allocation system of the EU ETS showed some differences compared to the standard outline above, in particular (i) the decentralised structure of EU allocation decision making, (ii) the incidence of some specific free allocation provisions, and (iii) the relatively short duration of the allocation periods. More specifically, the major characteristics of the EU allocation system up to 2012 include:[6]

A decentralised structure of EU ETS allocation decision-making. Up to 2012, some key parts of EU decision-making on allocation issues are rather decentralised as both national cap-setting and allocation of allowances to installations are the primary responsibility of individual Member States, which have to address these issues in National Allocation Plans (NAPs) for each trading period. These NAPs, however, have to be judged and approved by the European Commission, notably whether they meet certain EU-wide allocation criteria and guidelines (which to some extent restrict the room for national decision-making).[7] This more decentralised structure of the EU allocation system is due to some factors inherent to the EU, including (i) the still high degree of autonomy of EU Member States to decide on economic or environmental issues, (ii) the lack of a commonly acceptable methodology and database to allocate allowances to installations in a harmonised way across the EU and, above all (iii) the large diversity or heterogeneity among EU Member States, notably the major differences in efforts needed to meet their Kyoto targets (including differences in sharing this target between trading and non-trading sectors as well as in differences to rely on imports of JI/CDM credits).

1. *Relatively short allocation periods*. The allocation periods of the EU ETS, which corresponded to its trading periods, were relatively short, i.e., only three years during the trial phase (2005-2007) and five years during the second phase (2008-2012).
2. *Free allocation based on grandfathering and projections*. Although Member States had the option to auction up to 5 percent of their allowances in phase I and up to 10 percent in phase II, only a few countries auctioned a tiny share of their allowances.[8] Almost all Member States allocated up to 100 percent of their allowances for free. For existing installations (incumbents), free allocation was usually based on recent historical emissions and projections of growth rates of business-as-usual emissions (in order to allocate as many allowances as needed to internationally competing, non-power sectors). Expected shortages of allowances were usually allocated to the power sector, notably during phase II, based on the assumption that - compared to other trading sectors - this industry generally has cheaper abatement options and is highly protected from outside competition and, hence, is better able to pass on its ETS costs to output prices.
3. *Specific free allocation provisions for new entrants and plant closures.* All Member States have set up reserves for allocating free allowances to new entrants, and most require closed facilities to forfeit post-closure allowances allocated for free. In contrast to the reference standard (or other, comparable schemes elsewhere), these provisions are highly novel. They have been adopted in order to prevent disfavouring the EU in competition for new investments and to eliminate an incentive to shut down facilities and move production elsewhere (Convery et al., 2008; Sijm et al., 2008a). Among the Member States concerned, however, the specific rules of the free allocation provisions - notably for new entrants - varied widely. This resulted in significant differences in the amount of free allowances allocated to similar new investments across EU countries (Ahmed and Holmgren, 2006).
4. *Specific problems.* During the allocation process for the first trading period, Member States faced some specific problems, including (i) tight time schedules in preparing their NAPs,

[6] For more details on the EU ETS allocation system up to 2012 in general and the National Allocation Plans during the first and second trading periods in particular, see Gilbert et al. (2006), Neuhoff et al. (2006c), Ellerman et al. (2007), or the special website of the EC: http://ec.europa.eu/environment/climate/emission/index_en.htm.

[7] The Commission made some major adjustments to the draft NAPs proposed by the Member States. Overall, the Commission reduced the amount of CO_2 allowances in 15 NAPs for the first allocation period by, in total, 290 Mt annually and in 23 NAPs for the second phase by 242 Mt annually. In addition, the Commission limited the number of JI/CDM credits that participants could import into the ETS during phase 2, while it rejected any ex-post allocation adjustments - and some other specific allocation provisions - in NAPs I and II (Convery et al., 2008).

[8] During the first phase of the EU ETS there were only four small Member States that auctioned a small percentage of their allowances, i.e. Denmark (5%), Hungary (2.5%), Lithuania (1.5%) and Ireland (0.75%). During the second phase, auctioning was used by Germany (8.8%), the UK (7.0%), the Netherlands (4%), Lithuania (2.9%), Hungary (2.3%), Austria (1.2%), Ireland (0.5%) and Belgium (0.3%). Overall, the average percentage of total EU allowances auctioned amounted to only 0.13% in phase I, and 3.0% in phase II (Ellerman and Joskow, 2008).

(ii) unclear definitions of the types of installations to be covered by the scheme, (iii) lack of uniform, consistent and reliable emissions projections and, above all, (iv) lack of reliable installation-specific emissions data (Convery et al., 2008). For the second phase, these problems were largely overcome, mainly due to (i) slightly more relaxed time schedules, (ii) more consistent guidance by the Commission - including clear definitions of coverage, (iii) the availability and use of a single, transparent and consistent model to project growth of emissions for all Member States, and (iv) the availability of 2005 verified emissions data at the installation level. Nevertheless, also for the second period, the whole cycle from first preparations to final approvals of 27 NAPs was a cumbersome process that was highly resource and time-demanding, including the consultations between the Member States and the national stakeholders on the one hand and between the Member States and the EC officials on the other hand.

3.3 Implications of EU allocation up to 2012

3.3.1 Implications of decentralised allocation

The characteristics and underlying conditions of the EU allocation system up to 2012, as outlined above, had some major implications for the performance of the ETS. The major advantage of the rather decentralised structure of allocating EUAs was that it could meet relevant differences in socio economic conditions among Member States, notably major differences in efforts needed to meet differentiated Kyoto targets. On the other hand, this structure also had some adverse implications, as discussed below:

1. Inefficient allocation of abatement targets between trading and non-trading sectors.
The decentralised structure of EU allowance allocation implies that each Member State individually determines what share of its national emissions budget it will allocate to its ETS sectors. Thus, each country is effectively creating a certain number of EU allowances (EUAs) and the aggregate supply of EUAs - i.e., the EU wide cap - is the sum of these allocations over all the Member States. This structure of decentralised EUA supply decisions, however, implies that for any Member State it is hard to predict the EUA market price as they set their own NAP, since one would have to know all the other NAPs in advance. Hence, it is difficult for any Member State to set the most efficient allocation of its national emissions budget between the trading and non-trading sectors (Kruger et al., 2007).

Each Member State, on the other hand, will be inclined to protect its internationally competing (ETS) sectors and, hence, allocate free allowances amply to these sectors (in particular as it is uncertain on what competing Member States will do but, most likely, will also treat these sectors favourably). Therefore, the decentralised structure of the EUA allocation system is likely inclined to result in an over-allocation of allowances to the ETS sectors and, hence, in less efficiency in overall abatement (notably as abatement options in the trading sectors are generally assumed to be cheaper than in the non-trading sectors).

Over-allocation of EU allowances to the (internationally competing) ETS sectors seems indeed to have happened in most Member States particularly during the first phase of the scheme, even after the Commission had reduced the amount of CO_2 allowances in 15 NAPs by, in total, 290 million tons annually (Clo 2009; see also Chapter 4 below). Apart from the decentralised character of the EUA allocation process, however, this over-allocation was due also to the fact that the first trading period was a trial phase in which the abatement target of the scheme was not ambitious and, at least for this period, there was no Kyoto or other national mitigation target for the Member States.

However, also for the second trading period (in which the Kyoto targets applied), most of the draft NAPs proposed by Member States showed indications of major over-allocations of EUAs to ETS sectors compared to non-ETS sectors, based on certain proportional standards between these two groups of sectors (Clo, 2009). However, only after the Commission had reduced the amount of EUAs in 23 NAPs-II by, in total, more than 240 million tons annually, there seems to be a reasonably proportional sharing of the overall abatement burden between the trading and the non-trading sectors.[9]

2. Race-to-the-bottom effect

Due to the decentralised structure of the EUA allocation process, each Member State was largely unknown and uncertain about the allocation decisions by other Member States. Hence, it was inclined to take the safe side of its own decisions based on national considerations rather than on the most optimal outcome for all Member States as a whole (i.e., the so-called'prisoner's dilemma'or'race-to-the-bottom'effect). This applies not only to decisions to allocate national emissions budgets favourably to (internationally competing) ETS sectors, as discussed above, but also to decisions to allocate up to 100% of the allowances free of charge (and not or hardly to auction at all) as well as to the widely accepted free allocation provisions for new entrants and plant closures.

3. Equity and competitive distortions

On the other hand, the decentralised EUA allocation structure and the large differences among Member States in socio economic conditions, particularly in meeting their Kyoto targets, led to significant differences in allocation to similar installations in different countries. In turn, this resulted in (widespread complaints on) competitive distortions among these installations - notably with regard to decisions on plant closures and new investments - as well as in uneven equity and liquidity effects among existing installations.

3.3.2 Implications of free allocation

The most important advantage of the provision to allocate at least 90-95% of the allowances up to 2012 free of charge was that it facilitated the introduction of the EU ETS as it made the scheme more acceptable to both Member States and stakeholders. On the other hand, free allocation resulted also in some contentious or adverse effects including:

1. *Windfall profits*. Free allocation led to the (putative) incidence of so-called'windfall profits'due to either (i) the over-allocation of free allowances to industrial installations (which they could sell on the market) or, more particularly, (ii) the pass-through of the opportunity costs of free allowances, notably in the power sector, resulting in higher electricity prices and generators'profits (Sijm et al., 2006 and 2008b). This incidence of windfall profits, which led to sometimes fierce controversies, undermined the widespread acceptability and credibility of the EU ETS (notably as some questioned also the environmentally effectiveness of the scheme (see also Section 4 below).
2. *Perverse incentives*. Emissions trading with free allocation provisions for new entrants and/or plant closures can be regarded as a subsidy toward the investors'fixed costs, coupled with an emissions tax on their variable costs. While the tax encourages cleaner production, the subsidy gives an incentive to invest in additional dirty capacity and/or to refrain for closing existing, more polluting capacity. Moreover, as these provisions during the first and the second phase of the EU ETS were usually fuel-specific (i.e. dirty installations get more free allowances), they actually provide a perverse incentive for higher emissions, thereby undermining the carbon efficiency and environmental integrity of the scheme (Sijm et al., 2008a).
3. *Rent-seeking*. Free allocation encourages all kinds of lobbying, gaming and other rent-seeking activities - including promoting demands for all kinds of special allocation rules and

[9] See Clo (2009). His findings, however, are not based on (the equalization of) marginal abatement cost between ETS and non-ETS sectors, but rather on two benchmarks or'proportional Kyoto targets', determined by multiplying, for any Member State, its Kyoto target by the pre-2005 and 2005 ETS share in its total emissions, respectively.

exemptions for particular groups - thereby further enhancing the diversity, complexity and lack of transparency of national allocation plans.

3.3.3 Implications of short allocation periods

One of the major disadvantages of the relatively short allocation periods of the EU ETS up to 2012 (i.e. 3-5 years) is that it offers little certainty on allocation issues beyond these periods to investments in the power and energy-intensive industries, which often have a lifetime of 30 to 50 years or more. Another disadvantage is that it enhances both the need and risk of frequently updating the baseline period for allocating free allowances to existing installations. This provides an incentive to these incumbents to inflate their present emissions in order to receive more free allowances in the future and, hence, reduces the carbon efficiency of the scheme.

On the other hand, while phase I allocation was characterised by a number of problems, it is important to note that the relatively short first phase of the EU ETS was above all a trial period aimed to gain lessons, insights and data which could be used to improve allocation during subsequent periods. Indeed, some findings and lessons learned during the first phase were already used to improve allocation in the second phase. In particular, besides using the verified 2005 emissions database, the Commission harmonised certain allocation rules, strengthened certain allocation guidelines and tightened the carbon constraint in phase II (Convery et al., 2008). More importantly, the lessons from the review of phase I were used to drastically revise the EU ETS Directive for the third period and beyond, in particular to substantially improve the performance of allowance allocation post 2012 (see Chapter 7).

4. Abatement or over-allocation?

The ultimate aim of the EU ETS is to reduce emissions. This raises the question whether the scheme has already resulted in some carbon abatement during its trial phase or that this period was too short and the allocation of allowances too generous - leading to low and falling carbon prices up to zero by the end of this phase - and, hence, induced hardly any CO_2 reduction. This question of'abatement or over-allocation'is addressed in the present section. First of all, Section 4.1 deals briefly with the definition of the concept over-allocation. Subsequently, Section 4.2 summarises some findings on the balance of allocated allowances and verified emissions at the installation, sector, country and EU-wide level during the first two years of the scheme (2005-2006). Next, Section 4.3 reviews some recent studies on allocation and abatement in the EU ETS during phase I. Finally, Section 4.4 ends with a discussion and some conclusions.

4.1 Defining over-allocation

As noted by Ellerman and Buchner (2008), over-allocation is usually not a well-defined concept. It refers to the notion that too many allowances were allocated, but the standard by which 'too many' is to be determined is rarely specified. They suggest two standards of reference. The first is what emissions would have been without the trading scheme, i.e. the so-called'counterfactual'or what is termed 'Business as Usual' (BAU) emissions in modelling exercises. According to this standard, issuing more allowances than BAU emissions would constitute over-allocation.

The second standard refers to a cap that is constraining, i.e., less than the counterfactual, but still judged not sufficiently ambitious. For instance, if the desired degree of ambition were a 5% reduction of emissions from the counterfactual, and allowances were issued such as to require only 2% reduction, the 3% difference might be considered over-allocation (Ellerman and Buchner, 2008). Although sometimes poorly specified, this second definition is often used in much of the current debate, while the first definition seems to be more common in the recent academic literature on analysing and estimating over-allocation in the EU ETS (see Section 4.3 below).

In both definitions, however, over-allocation is hard to estimate as both involve the construction of a counterfactual estimate of what emissions would have been in the absence of the EU ETS. This counterfactual estimate should take into account variables such as economic growth, energy prices, weather conditions and non-ETS policies since all of these variables affect what emissions would have been without emissions trading (Ellerman and Joskow, 2008). Similar difficulties apply to estimating the level of abatement due to the EU ETS as such an exercise also involves a counterfactual estimate of emissions absent the EU ETS. Nevertheless, despite these difficulties, some recent studies have tried to analyse and estimate the level of over-allocation and/or abatement in the first phase of the EU ETS (see Section 4.3).[10]

4.2 Allocated allowances and verified emissions: 2005-2006 results

In a detailed study, Kettner et al. (2008) have analysed the net positions between allocated allowances and verified emissions of almost 10,000 installations in the EU ETS for 2005 and

[10] An alternative and simpler definition of over-allocation could use a standard in which the reference emissions are determined at a certain fixed amount, say minus 10% below an historic baseline level of emissions. Such a definition would avoid the construction of a counterfactual estimate of EU ETS emissions (although such a counterfactual would still be necessary to estimate the level of abatement due to the ETS).

2006, based on data from the Community Independent Transaction Log (CITL). Their major findings include:[11]

- In the two trading years, the EU ETS as a whole was in a net long position, i.e. the number of allocated allowances exceeded verified emissions by, on average, some 70 $MtCO_2$ per annum (about 3.4% of the total allocations in these years).[12]
- Out of the 9,900 installations reported up to May 2007 in the CITL database, almost 2,700 were short. The net positions of installations, however, varied between Member States and sectors.
- Out of the 24 Member States analysed, only five countries were short in 2005-2006, ranging from Austria (-1.1%) to the UK (-17.4%), with intermediate positions for Italy (-7%), Spain (-7.6%) and Ireland (-15.6%). The remaining countries were long up to almost 46% in Lithuania. In absolute amounts, the countries with the largest net long positions in 2005-2006 were Poland (on average, a surplus of 31 $MtCO_2$ per year), Germany (+25 $MtCO_2$), France (+20 $MtCO_2$) and the Czech Republic (+14 $MtCO_2$).[13] Together, these four surplus countries supplied the bulk of the net demand from the five deficit countries, implying significant EUA transfers versus net capital flows between the installations of these countries.
- At the EU-wide sector level, only power and heat was short, with a net position in 2005-2006 amounting to, on average, 44 $MtCO_2$ per year (i.e. 4% of the allowances allocated to this sector). All the other sectors recorded significant net long positions, notably pulp and paper (19.6%), iron and steel (17.5%) and ceramics (17.3%).

A related, interesting finding by Kettner et al. (2008) refers to the pronounced inequality of the distribution of the size of installations when ordered according to their verified emissions in 2005-2006. The smallest three-quarters of all installations contribute only about 5% of all emissions covered by the EU ETS, whereas the biggest 1.8% of all installations account for half of the emissions. The 1,000 biggest installations, or one-tenth of all installations, are responsible for 86% of the EU ETS emissions.

4.3 Estimates of phase I over-allocation and abatement

The findings on the net EUA positions of installations during the first phase of the EU ETS as well as the resulting fall of the price of phase I EUAs towards zero in 2007 (see Section 5 below) have fuelled controversies on whether the system was actually'over-allocated'and, in addition, whether and to what extent it has contributed to carbon abatement during this phase. Some recent studies have tried to analyse the level of over-allocation and/or abatement in the first period of the EU ETS. The major findings of these studies are discussed briefly below.

Ellerman and Buchner (2008)

Ellerman and Buchner were the first to analyse whether the 2005-2006 emissions data of the EU ETS reveal over-allocation or abatement. They conclude that both occurred in each year. More specifically, they note that 2005 and 2006 emissions were lower than the historical baseline emissions used in the development of the first NAPs despite continuing economic growth in the EU and increases in oil and natural gas prices that could be expected to increase the demand for coal-fired power generation. Using a simple counterfactual based on the extrapolation of trends in pre-2005 emissions, economic growth, energy use and CO_2 intensity, they conclude that abatement in 2005-2006 was probably between 50 and 100 $MtCO_2$ each of these years (i.e. between 2 and 5 percent of covered emissions). In addition, they find that over-allocation occurred

[11] For similar analyses and findings, see Ellerman and Buchner (2008).

[12] For the first phase as a whole (2005-2007), the net long positions amounted to, on average some 50 million tons CO_2 per year, i.e. about 2.3% of the total allocated allowances over this period (Anderson and di Maria, 2009). As this surplus of allowances during the first phase could not be banked for subsequent trading periods, it implied that these allowances became actually worthless and, hence, ready to be destroyed.

[13] As a percentage of their allocated allowances, these amounts correspond to 13.3% (Poland), 5.0% (Germany), 13.1% France and 14.4% (Czech Republic), respectively (Kettner et al., 2008).

and that its magnitude may have been as much as 6% or 125 million EUAs per annum (Ellerman and Buchner, 2008; see also Ellerman and Joskow, 2008).

Delarue et al. (2008a and 2008b)
Delarue et al. (2008a and 2008b) use a simulation model of the EU power sector ('E-simulate') in order to estimate short-term abatement through fuel switching in this sector in response to the introduction of a CO_2 allowance price during the first phase of the EU ETS. Their estimates of the lower and upper bounds of this type of abatement vary between 34 and 88 $MtCO_2$ in 2005 and between 19 and 59 $MtCO_2$ in 2006. Abatement through fuel switching is shown to depend not only on the EUA price but also, and more importantly, on the load level of the system, the ratio between the natural gas and coal prices as well as the availability of natural gas generating capacity. Delarue et al. show that most of the estimated abatement due to the EU ETS in 2005 and 2006 occurred in the UK and Germany where a significant reliance on coal is coupled with available natural gas generating capacity.

Ellerman and Feilhauer (2008)
The study by Ellerman and Feilhauer (2008) uses top-down trend analysis and a bottom-up sector model to define upper and lower boundaries on abatement in Germany in the first phase of the EU ETS. Differing emission intensity trends and emission counterfactuals are constructed using emissions, power generation and macro economic data. Resulting top-down estimates set the upper bound of abatement in phase I at 122 $MtCO_2$ for all ETS sectors and 57 $MtCO_2$ for the power sector only. Using a tuned version of the model'E-simulate'(similar to the model applied by Delarue et al., mentioned above), a lower boundary of phase I abatement is established at 13 $MtCO_2$, based only on fuel switching in the power sector (which constitutes 61% of German ETS sector emissions).[14]

Widerberg and Wrake (2009)
Widerberg and Wrake (2009) analyse the short-term impact of the EUA price on CO_2 emissions from power generation in Sweden, using an econometric time series analysis for the period 2004-2008. They control for effects of other input prices and hydropower reservoir levels. Their results do not indicate any link between the EUA price and the CO_2 intensity of Swedish electricity production. This result may be explained by a number of reasons, in particular the fuel mix capacity and other structural characteristics of Swedish power generation. Overall, they draw two main conclusions: "First, it seems unlikely that the EU ETS has generated any significant reductions of CO_2 emissions in Swedish electricity generation. Second, it seems unlikely that there are significant volumes of low-cost CO_2 abatement measures with short response times in the Swedish electricity sector. In order to better understand the long-term impacts of the EU ETS on CO_2 intensity, one needs to complement the analysis with studies that have stronger emphasis on investment planning."

Anderson and di Maria (2009)
Anderson and di Maria (2009) used dynamic panel data techniques to assess the level of abatement and over-allocation that took place across European countries during the pilot phase of the EU ETS. In addition to gross over-allocations of 469 $MtCO_2$ for the period 2005-2007 as a whole, they also found under-allocations amounting to 211 $MtCO_2$, resulting in net over-allocations of 258 $MtCO_2$. On the other hand, they estimated total abatement during the trial period at 117 $MtCO_2$ as a whole, i.e. about 40 $MtCO_2$ per annum or, approximately, 2% of the overall cap. However, due to the allocation methodology of the Member States and possible uncertainty about future allocation, Anderson and di Maria also found so-called'emissions infla-

[14] Convery et al. (2008) report preliminary results from more focused research on the German power sector, which support this finding of moderate abatement. More specifically, a shift from higher emitting lignite (brown coal) generation to lower emitting hard coal generation can be observed, as well as an increase in the use of biomass. Also, in the UK, more focused research indicates at a noticeable improvement in the CO_2 efficiency of coal-fired generating plants. This could have been due to increased use of biomass or improved energy efficiency in response to the sharp increase in the cost of using coal to generate electricity (Convery et al., 2008).

tion'estimated at 230 $MtCO_2$ for the years 2005-2007.[15] Hence, they conclude that, on balance, emissions during the trial period of the EU ETS were approximately 113 $MtCO_2$ higher than they would have been in the absence of the EU ETS.

4.4 Discussion and conclusion

The findings of some recent studies on allocated allowances and verified emissions during the first phase of the EU ETS seem to indicate that the scheme most likely resulted in both over-allocation and abatement, up to a few percent of total emissions covered. It is important to keep in mind, however, that this phase was above all a trial period in which the cap was set at a moderate target. Moreover, this phase was characterized by tight time schedules for designing NAPs and lack of reliable data and projections on emissions at the installation or sector level. In that sense, it is not strange that the first phase of the scheme resulted in over-allocation in a number of sectors and countries, particularly in the internationally competing, industrial sectors and in some East European countries.

The incidence of over-allocation, however, is likely to be reduced substantially - or even eliminated completely - during the second or subsequent trading periods due to improved emissions data, a more stringent cap and, on average, a continuing growth of economic activities and related emissions.[16]

Moreover, as noted above, despite signs of over-allocation and a moderate target, there are also indications and study findings showing already some carbon abatement during the first phase of the EU ETS. These findings are supported by the observation that (i) the EUA price was, on average relatively high during 2005 and 2006, i.e. 15-20 €/tCO_2, providing a major incentive for carbon abatement, and (ii) 2005 and 2006 emissions were lower than the historical baseline emissions used in the design of the first NAPs despite continuing economic growth in the EU and increases in oil and natural gas prices that could be expected to increase demand for coal-fired power generation (Ellerman and Buchner, 2008).

Besides some small energy efficiency improvements across the scheme, abatement during the first phase was most likely restricted to short-term fuel switching in the power sector of some countries, i.e. Germany and the UK, including switching from lignite to coal or from coal to either gas or biomass. In the medium and long term, however, when the cap becomes more binding and the EUA price higher, the EU ETS will most likely induce other types of abatement, including new investments in carbon saving technologies (and further R&D) across all ETS sectors and reduced demand for electricity and other carbon-intensive goods due to the pass-through of carbon costs to output prices. Future empirical studies have to reveal whether and to what extent the EU ETS has indeed resulted in these other, more significant types of abatement.

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15 Anderson and di Maria (2009) define emissions inflation as "behaviour that leads to higher emissions levels than what would have occurred in the absence of the trading scheme, i.e. emissions greater than the business as usual levels. This is possible and likely in the context of the EU ETS due to the methodology used for pilot phase allocation and uncertainty about future allocation methodologies. In the pilot phase, most governments allocated total emissions relative to'business-as-usual'projections, and the more detailed distribution [of allowances] has typically occurred in relation to past emissions (Grubb et al., 2005). EU ETS participants may have learned that inflating (historical) emissions leads to more generous future allocations. Grubb et al. (2005) point out that emissions inflation due to the prospect of future allowance distribution being contingent upon recent emissions ('updating') is likely, and gives a direct incentive to industries to inflate actual emissions."

16 Due to the severe economic crisis during the first years of the second trading period, however, a recent study by Sandbag (2009) estimates that overall a total surplus of 700 $MtCO_2$ emission allowances could be available in phase 2 of the scheme, which are then bankable for use up to 2020. Including JI/CDM credits, there could even be a surplus available of 1.6 billion $MtCO_2$ emission allowances and credits, all bankable for use into the future.

5. The development of the EU allowance market

5.1 Market infrastructure and transactions

Over the past five years, the market for trading EU allowances (EUAs) has developed strongly in terms of market infrastructure and transactions. Bilateral forward trades in EUAs began already in the spring of 2003, amply before the official start of the scheme in January 2005. The spot market was launched in early 2005 when the first national registries entered into operation.[17] Trading in standardized contracts for spot or forward markets started in mid-2005, when the first organized marketplaces were set up, followed by trades in futures such as swaps or options in subsequent years. Unlike registries, the development of these marketplaces was the result of voluntary, private initiatives undertaken primarily by energy market managers (Convery et al., 2008). Six marketplaces were launched in 2005, including the European Climate Exchange (EXX), Nordpool, Powernext (now Bluenext), the European Energy Exchange (EEX), the Energy Exchange Austria (EEA) and Climex. Besides offering standardized contracts for spot or future delivery with public bids and asks, they also provide clearing services that may be used in confidential Over-the-Counter (OTC) transactions, i.e. bilateral transactions between participants or transactions via banks or brokers such as Natsource, Evolution Markets or CO2e.com.

Table 5.1 *Carbon market at a glance, volumes & values over the years 2005-2008*

	Volume [$MtCO_2e$]				Value [Mln US$]			
	2005	2006	2007	2008	2005	2006	2007	2008
					Allowances markets			
EU ETS	321	1,104	2,060	3,093	7,908	24,436	49,065	91,910
New South Wales	6	20	25	31	59	225	224	183
Chicago Climate Exchange	1	10	23	69	3	38	72	309
RGGI	NA	NA	NA	65	NA	NA	NA	246
AAUs	NA	NA	NA	18	NA	NA	NA	211
Sub-total	*328*	*1,134*	*2,108*	*3,276*	*7,971*	*24,699*	*63,007*	*92,859*
					Project-based Transactions			
Primary CDM	341	537	552	389	2,417	5,804	7,433	6,519
JI	11	16	41	20	68	141	499	294
Voluntary market	20	33	43	54	187	146	363	397
Sub-total	*372*	*588*	*636*	*463*	*2,673*	*6,091*	*8,195*	*7,210*
					Secondary CDM			
Sub-total	*10*	*25*	*240*	*1,072*	*221*	*5,804*	*5,451*	*26,277*
TOTAL	710	1,745	2,984	4,811	10,562	31,235	63,007	126,345
EU ETS as % of total	45	63	69	64	75	78	78	73

Source: World Bank (2007, 2008 and 2009).

Table 5.1 shows that over the years 2005-2008 the EUA market has grown rapidly and that it has by far dominated the global carbon market. In terms of volume of transactions, it has increased almost tenfold from 320 $MtCO_2e$ in 2005 to 3100 $MtCO_2e$ in 2008. In terms of value of transactions, the expansion of the EUA market has even been more impressive over these years, i.e. from almost 8 to 92 billion US$. As a share of global carbon market transactions in

[17] As mentioned in Chapter 2, these registries, in which ETS installations must open accounts, are organized by Member States in order to register the allowance allocations to these installations and track all movements of allowances resulting from market or compliance transactions.

2005-2008, the EU ETS accounted for some 45-69% in value terms and even for 75-78% in value terms.

The EU ETS, however, has been responsible not only for the rapid development of the EUA market but also for the promotion of the JI/CDM market through its provision to meet system compliance by means of JI/CDM credits. Table 1 shows that, besides EUA trades, JI/CDM transactions in 2005-2008 accounted for a major share of the global carbon market in these years. A major part of these transactions is due to forward purchases of JI/CDM credits by EU ETS installations for either phase II compliance or other, risk-hedging and financial purposes.

5.2 Evolution of the EU allowance price

Figure 5.1 shows the evolution of the EUA price on the forward market over the period July 2004 - July 2009. As no banking or borrowing of allowances was allowed between the first and second trading periods, a distinction is made between the forward EUA price for phase I allowances (with delivery in December 2006/2007) and phase II allowances (with delivery in December 2008/2009).

In addition to institutional factors (such as banking or borrowing rules) and market imperfections (e.g. lack of information or the use of market power), the EUA price is governed basically by the balance of EUA supply and demand. As no JI/CDM credits could be traded during the first period and installations could not borrow allowances from the second period, EUA supply during phase I was simply equal to the EU ETS cap of allocated allowances for the years 2005-2007. Due to the inability to bank phase I allowances for the second period, EUA demand was driven by actual and anticipated emissions during phase I of the scheme, which depended on economic growth, weather conditions, relative energy prices, non-ETS policies affecting ETS emissions and marginal abatement costs and potentials of carbon reduction options. These different drivers can largely explain EAU pricing during the first trading period, which was marked by three stages (Convery et al., 2008):[18]

1. *The launch period (January 2005 - April 2006).* During this stage, the power sector immediately started buying the EUAs it needed, whereas many industrial players with surplus allowances were not able or prepared to sell their EUAs. Demand from power producers rose over the period due to increased gas prices during the winter. This created scarcity and increased EUA prices. The information available on the market was very poor, and most of the participants expected an overall short market.
2. *The information shock (April-May 2006).* In April, the European Commission released the 2005 verified emissions data for the installations covered by the EU ETS, which showed a 4% surplus of allowances. This information hit EUA prices hard as the supposed scarcity of allowances confronted the reality of a surplus.
3. *Total disconnection between phase I and II allowance prices (since November 2006).* EUA prices for phase I started to converge towards zero, reflecting the surplus of allowances over 2005-2007 and the inability to bank EUAs for subsequent periods. On the other hand, EUA prices for phase II remained relatively steady and rose to as much as 25 €/tCO_2 in response to the European Commission's stricter review of second period NAPs and the European Council's decision to reduce EU emissions to 20% below 1990 levels by 2020 (compared to 8% below 1990 levels in 2008-2012).

[18] Several studies have analysed the determinants of the EUA price (or the stochastic behaviour of this price). See, among others, Alberola et al. (2007 and 2008) and Chevalier (2009). For recent overviews of these studies, see Bonacina and Cozialpi (2009) and Bonacina et al. (2009).

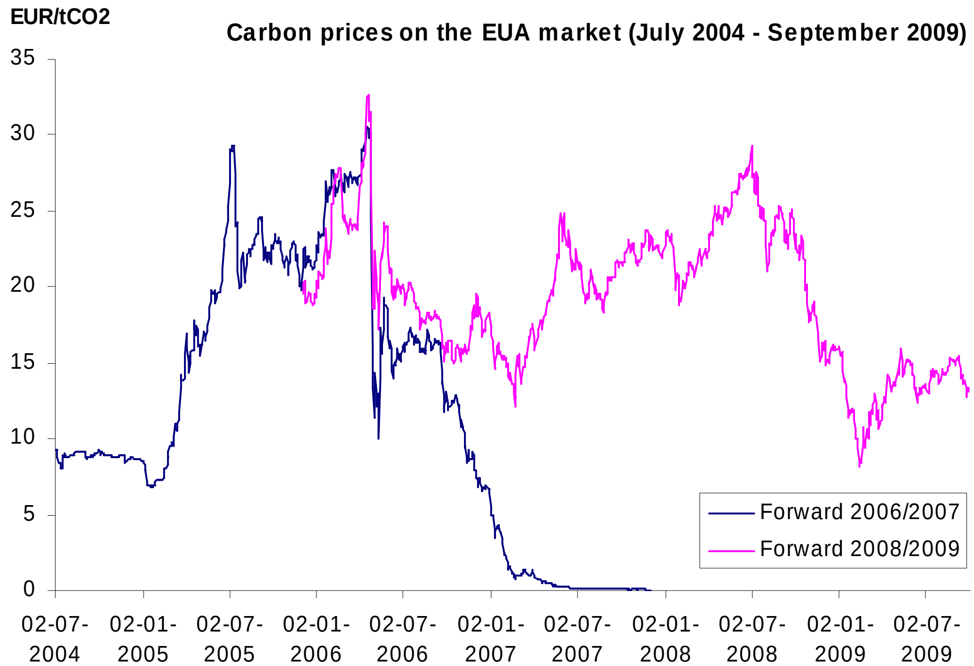

Figure 5.1 *Evolution of the carbon price of an EU allowance*
Source: Nordpool ASA.

5.2.1 Major achievements and lessons

Since 2005, the EUA market has developed strongly in terms of market structure and transactions. Probably its most important achievement during phase I has been that it made stakeholders realize that carbon emissions have a price to be included in their decision-making. In addition, the experience of this phase provides at least the following two lessons: (i) market efficiency and price stability depend on market participants'ability to access timely and reliable information, and (ii) the decision to not allow inter-period banking strongly contributed to price volatility of phase I allowances and resulted in a full disconnection of EUA prices between the first two periods of the scheme (Convery et al., 2008).

6. The impact of the EU ETS on economic growth, industrial competitiveness and carbon leakage

In a specific region or country, emissions trading may have a significant impact on economic growth in general and industrial competitiveness in particular, notably if similar policies are not implemented in other regions or countries. Although up to now the possible impact of the EU ETS on economic growth has received hardly any attention, a major part of the literature and stakeholders'discussions has focussed on the potential impact of the scheme on industrial competitiveness and the related concept of'carbon leakage'. These issues will be addressed in the present section.

More specifically, this section is structured as follows. Firstly, Section 6.1 analyses briefly whether already some impact of the EU ETS on the GDP growth performance of the EU-27 can be observed. Subsequently, Section 6.2 discusses the concepts of industrial competitiveness and carbon leakage. Next, Section 6.3 tries to identify sectors at risk of carbon leakage and loss of competitiveness due to unilateral climate policies. Finally, Section 6.4 evaluates very briefly the evidence on carbon leakage in industrial sectors due to the EU ETS.

6.1 Economic growth in EU Member States

Table 6.1 provides a summary of the average GDP growth performance of the EU-27 and some other OECD countries over the period 2001-2008, distinguished by the 4-year pre-EU ETS period 2001-2004 and the 4-year EU-ETS period 2005-2008. For the EU-27, this performance amounted to an average annual growth rate of 1.8% in 2001-2004 and 2.2% in 2005. In comparison, for the US - which up to now has implemented hardly any similar climate policy - these figures were 2.1 and 2.2%, respectively. Hence, at first sight, these data do not indicate a significant impact of the EU ETS on the growth performance of the EU-27.

Table 6.1 *Average GDP growth in OECD countries in 2001-2008*

	Average 2001-2004	Average 2005-2008
EU-27	1.8	2.2
Japan	1.2	1.4
Korea	4.6	4.1
Mexico	1.5	3.3
United States	2.1	2.2
Total OECD	2.0	2.3

Source: Eurostat (2009) and OECD (2009).

Some qualifications, however, can be added to this finding. Firstly, the EU-27 growth rate for the period 2005-2008 does not show what this rate might have been in the absence of the EU ETS. Although constructing such a counterfactual is quite complicated, it may reveal that the EU ETS had some (negative) impact on economic growth in the EU-27 over the years 2005-2008.

Secondly, the two 4-year periods considered are relatively short and, hence, the average growth rate for these periods may result from incidental or accidental factors, such as one or two years with relatively high (or low) growth rates related to global economic conditions. Rigorous future studies, covering and comparing much longer time periods, may provide a better insight into the possible impact of the ETS on the growth performance of the EU-27 (or on the differentiation of this performance among individual Member States).

Thirdly, during the years 2005-2008 the reduction target of the EU ETS was still modest. Hence, the (negative) impact of this scheme may become more significant in the long run when the cap becomes more binding. However, according to model estimates for the impact assessment of the ambitious EU energy and climate policy package proposed in 2008 for the period up to 2020 (which includes a major revision and strengthening of the EU ETS beyond 2012; see Chapter 7 below), the overall effect of this package would be a small reduction of GDP in the EU-27 by only 0.2-0.5% in 2020 (Delbeke et al., 2009). This result may be due to the fact that, besides negative growth effects, the policy package may also have positive effects due to induced improvements in energy efficiency or the promotion of renewables and other carbon saving technologies.

Nevertheless, regardless of these qualifications, the average growth rate for the EU-27 in the years 2005-2008 does not support the notion that the EU ETS would wreck the overall economy (as some claimed before the start of the scheme). On the contrary, it seems to indicate that an economy can grow moderately even if key parts of its activities are faced by capped emissions.

6.2 Industrial competitiveness and carbon leakage: definitions

Industrial competitiveness
In the context of climate change policies, the term industrial competitiveness is usually defined at the sector level. It refers to the ability of a sector in a certain country or region to maintain its profits and market shares vis-à-vis a similar sector in another country or region (Reinaud, 2008). Within this context, the issue of industrial competitiveness refers usually to the problem that some countries accept and implement GHG abatement policies, while others do not. Consequently, firms and sectors from non-abating parties enjoy a comparative advantage as they are not faced by costs or other constraints due to GHG mitigation.

Carbon leakage
The term carbon leakage refers to the increase in CO_2 (and other GHG) emissions in non-abating countries resulting from the mitigation actions in abating countries, thereby reducing the effectiveness of these actions. More precisely, given the implementation of climate policy in CO_2 abating country A and the resulting rise in CO_2 emissions in non-abating country NA, carbon leakage is usually defined as the ratio between the policy-induced increase of emissions in country NA and the reduction of emissions in country A. For instance if country A implements measures to reduce its emissions by 10 $MtCO_2$ while emissions in country NA increase by 2 $MtCO_2$ due to these measures, carbon leakage is equal to 2/10 * 100% = 20%.

Uneven abatement policies among countries may not only lead to carbon leakage but also to'competitiveness leakage', defined as a mitigation-induced shift in competitiveness - or comparative production and trade advantage - from abating to non-abating countries.

6.3 Identifying vulnerable industries

Several studies have tried to identify the sectors at risk of competitiveness/carbon leakage, based on an assessment of the major determinants of this risk.[19] In general, these determinants can be grouped into three sets of factors, including:
1. Factors affecting the exposure of industries to asymmetric increases in carbon costs.
2. Factors affecting the ability to pass-through asymmetric increases.
3. Other factors affecting industrial competitiveness and carbon leakage

[19] See, in particular, Carbon Trust (2004 and 2006), Stern (2006), McKinsey and Ecofys (2006), Hourcade et al. (2007), Houser et al. (2008), and de Bruyn et al. (2008).

These three sets of factors correspond to a three stage process used by a Climate Strategies study to assess the potential impact of the EU ETS on industrial competitiveness and, more particularly, to identify UK industries at risk of carbon leakage (Hourcade et al., 2007). Both these factors and the three stages are discussed below.

6.3.1 The exposure of industries to asymmetric increases in carbon costs

The extent to which industries are at risk of competitiveness/carbon leakage depends first of all on the impact of asymmetric climate policies on their production costs. In turn, this impact depends mainly on:

- The energy or carbon intensity of the output produced. In addition to the direct cost increases, this factor refers also to the indirect cost impact of climate policy-induced increases in electricity prices, notably for power-intensive sectors such as the aluminium or copper industries.
- The type of climate policy (energy/carbon tax, emissions trading, energy efficiency regulation), as well as the specifics of this policy, including exemptions, free allocation conditions, compensatory measures, etc.
- The stringency of the climate policy, which in case of, e.g., CO_2 emissions trading is a major determinant of the cost per tonne of carbon.

In order to assess the cost exposure of industries to climate policy, different indicators or measures can be used, for instance by expressing energy or carbon costs of specific industries as a percentage of either their total sales revenues, production costs, net earnings or profits (Carbon Trust, 2004; Stern Review, 2006; Houser et al., 2008; de Bruyn et al., 2008).

An alternative indicator is the so-called'*Value-at-Stake*'measure used by Hourcade et al. (2007) in their Climate Strategies (CS) study on the competitiveness impact of the EU ETS. This measure is defined as:

- Value-at-Stake = Increase in total costs after allowance allocation/ Gross Value Added (GVA).
- GVA = Value of goods and services produced - Costs of raw materials and other inputs.

In order to capture both the direct and indirect cost aspects of the EU ETS, the Value-at-Stake concept is distinguished into:

- *Net Value-at-Stake (NVAS)* = Indirect cost impact due to EU ETS-induced increases in electricity prices relative to GVA.
- *Maximum Value-at-Stake (MVAS)* = direct and indirect cost impact of EU ETS relative to GVA, based on full purchasing of EU allowances by firms.

To estimate the Value-at-Stake impacts, the CS study assumes a carbon price of 20 €/tCO_2 and an induced electricity price increase of 10 €/MWh. In the first stage of determining which sectors are at risk of carbon leakage, the study uses a threshold of 2% for NVAS and 4% for MVAS, i.e., those industries for which the NVAS is greater than 2% or the MVAS is greater than 4% are considered to be at risk of carbon leakage. Using 2004 UK data for 159 manufacturing industries, only a few sectors exceeded the NVAS threshold of 2% - notably aluminium, fertilizers, nitrogen, and other inorganic basic chemicals - while 20 sectors recorded a MVAS greater than 4%, in particular industries producing cement, basic iron and steel, refined petroleum, or pulp and paper. All together, 23 sectors exceeded either the 2 or 4% threshold level. Direct emissions from these 23 sectors collectively contributed 11% of total UK GHG emissions, whereas their indirect emissions from electricity use contributed 3%. Their share of UK GDP and employment are 1.1 and 0.5% respectively (Hourcade et al., 2007). Some qualifications, however, can be added to the above-mentioned results. Firstly, the CS study does not explain the choice of the threshold levels. One could argue that they are relatively low, but there appears no clear objective way of identifying these levels.

Secondly, although the assumed carbon price of 20 €/CO_2 corresponds to the average EU allowance price in 2005-2006, future carbon prices may actually be substantially higher. This implies that both the direct and indirect cost impacts of the EU ETS may become more significant and more relevant for a larger number of sectors exceeding critical threshold levels.

Thirdly, the cost impact results depend on the level of (dis)aggregating industrial sectors. If the level of aggregation is relatively high the (average) outcome for a rather heterogeneous sector may hide relevant differences in cost exposure to climate policy at a more disaggregated level. Moreover, even at a rather homogeneous or disaggregated sector level, certain intermediary products or parts of the production value chain may be traded or relocated individually. For instance, semi finished steel, clinker (input for cement), lime, basic glass and perhaps chemicals from steam cracker (ethylene, propylene, butane and aromatics) and ammonia as well as pulp have the characteristics of high carbon intensity, relatively low value added and tend to be rather homogeneous products that are already or can be internationally traded (Neuhoff and Dröge, 2007). Hence, identifying industries at risk of carbon leakage has to be conducted at an appropriate disaggregated level.

Fourthly, the cost impact results are based on 2004 UK data. Although similar results are available for comparable, industrialised countries such as Germany (Hourcade et al., 2007), the US (Houser et al., 2008) or the Netherlands (de Bruyn et al., 2008), these results may vary significantly over time - due to changes in market conditions and resulting output prices, affecting gross added values - as well as between countries depending on the structure and level of their industrial development.

Finally, although the share of the 23 sectors at risk of carbon leakage is relatively small in terms of national GDP or employment, they are generally far more important in terms of socio-economic emanation or political sensitivity at the regional or local level.

6.3.2 The ability to pass-through asymmetric increases in carbon costs

Another factor relevant to identify industries at risk of carbon leakage is their ability to pass-through asymmetric, abatement-induced cost increases to output prices. A simple but popular indicator for this ability is the international trade exposure or trade intensity of industries. This is based on the assumption that sectors with significant volumes of imports from or exports to countries outside the area with high carbon costs are likely to pass not all these costs to output prices.

In the CS study on the EU ETS, the ability of UK industries to pass-through ETS-induced increased in (direct and indirect) carbon costs is identified by means of the so-called'Non-EU trade intensity'measure (Hourcade et al., 2007). This measure is defined as:[20]

$$\text{Non-EU trade intensity} = \frac{\text{Value of exports to non-EU} + \text{Value of imports from non-EU}}{\text{Annual turnover} + \text{Value of imports from EU} + \text{Value of imports from non EU}}$$

Based on 2004 data, the UK trade intensity outside the EU varied from 0% for the power sector to 20-30% for refined petroleum and basic metals (including iron and steel) and even 40-50% for textiles and non-ferrous metals (including aluminium and copper).

[20] In addition, the CS study applies the'EU trade intensity'measure in order to account for the trade exposure to other EU countries. Whereas the'Non-EU trade intensity'measure can be considered primarily as an indicator for the ability to pass-through ETS-induced cost increases and, hence, for the risk of competitiveness/carbon leakage due to the non-abating Party problem, the'EU trade intensity'measure could be regarded as an indicator for the impact on industrial competitiveness within the EU due to the differentiated implementation problem, notably the problem of differential allocations methods and volumes between Member States (as discussed in Chapter 3).

By combining the two metrics on cost and trade exposure, a first quantitative overview can be obtained of which sectors may be at risk, for instance by plotting cost exposure on the y-axis of a chart and trade exposure on the x-axis (see Hourcade et al., 2007, for the UK or Houser et al., 2008, for the US). For the UK study on the EU ETS impact on industrial competitiveness and carbon leakage, this approach shows that for some activities the metrics on both'Value-at-Stake'and'trade intensity outside the EU'are relatively high, in particular for basic metals, non-ferrous metals, and coke oven & refined petroleum. For other sectors, however, the cost exposure due to the EU ETS is relatively high whereas the trade exposure is relatively low (or vice versa), notably for the power sector (zero trade exposure) and the cement, lime and plaster industry (about 5% trade intensity).

Besides the qualifications outlined above with regard to the cost impact metric, some further remarks can be added to the use of the trade exposure measure. Firstly, trade intensity is an imperfect indicator for the ability of sectors to pass on carbon costs to output prices, because trade exposure is a dynamic parameter that may vary significantly between countries but can change substantially over time in response to price changes. For instance, while the level of steel traded outside of the EU is insignificant for Germany, it represents a large share of the UK market (Neuhoff and Dröge, 2007). As noted, however, these trade exposure figures may change substantially within a decade.

In addition, the ability to pass-through cost increases depends not only on exposure to international trade but also to the structure of the market. This refers particularly to (i) the number of firms active in a market (as an indicator for the level of market concentration or market competition), and (ii) the responsiveness of market demand to price changes of own products or substitutes (Sijm et al., 2008 and 2009). Hence, firms in less competitive markets with low demand responsiveness may largely maintain sales volumes, market shares and business profits even if they are faced by asymmetric cost increases and exposure to outside trade. On the other hand, producers in unexposed or protected sectors may loose sales volumes and/or business profits due to high demand responsiveness to carbon cost-induced price increases, with demand - and related emissions - partially leaking to other sectors.

Finally, the impact of carbon abatement policies on industrial competitiveness and carbon leakage depends not only on simple, quantitative measures such as cost or trade exposure, but also on a variety of other, less quantifiable factors. These factors are discussed in the section below.

6.3.3 Other factors affecting industrial competitiveness and carbon leakage

As noted, in addition to the exposure of industries to asymmetric increases in carbon costs as well as their ability to pass-through these increases to output prices, there are a variety of other factors affecting industrial competitiveness and carbon leakage. In general, these factors refer to a variety of barriers to trade and (re)location of production. In brief, these factors or barriers include in particular:[21]

- *Transport costs*. Transport costs may act as a barrier to trade and, hence, to carbon leakage - depending on characteristics such as geographical location, mode of transport, bulkiness or value added of the goods produced. For instance, cement is a relatively bulky, low-value good. As a result, transporting cement by road is rather expensive, while it is much cheaper by international shipping. Therefore, whereas unilateral climate policies may have an adverse impact on the competitiveness of cement industries nearby international shipping facilities, they may hardly affect the competitiveness of more inland cement industries due to the protection resulting from relatively high transport costs (Demailly and Quirion, 2006).

[21] See Hourcade et al.(2007), who in the third stage of their process to assess the impact of the EU ETS on industrial competitiveness conduct a deep-dive study in the cement and steel sectors in order to explore these other factors. See also Neuhoff and Dröge (2007), Cosbey and Tarasofsky (2007), and Reinaud (2008).

- *Transport hazard*. The production of chlorine is a relatively power-intensive activity and, hence, faces high indirect cost increases due to climate policy (just like aluminium or copper). Chlorine, however, is a very hazardous substance, which might restrict its scope for transport and, therefore, its risk of carbon leakage (Neuhoff and Dröge, 2007).
- *Abatement and innovation potential*. The vulnerability of firms and sectors to the cost of mitigation policies and, hence, to the risk of carbon leakage depends also on their abatement potential or, more generally, on their innovation potential to produce less carbon-intensive goods and services.
- *Trade restrictions*. Import tariffs, export duties, technology standards, product labelling, and health or other quality controls may all act as a barrier to trade and, hence, limit the risk of carbon leakage. On the other hand, in order to circumvent trade restrictions such as import tariffs or export duties, firms may decide to (re)locate production into domestic markets. Hence, the incidence of such trade restrictions enhances the risk of carbon leakage via the trade and relocations of production factors (the'investment channel'), while reducing the risk of carbon leakage through the trade of goods (the'output channel').
- *Product and service differentiation*. A major strategy of companies within a certain sector, notably in more developed countries, is product differentiation by offering specialised, more sophisticated or high quality commodities - including brand names - which meet the specific demand of certain industries or end-users. A related strategy is service differentiation, including certainty in product availability and time of delivery, price stability, quality control, information, support, maintenance, etc. In general, such product or service differentiation reduces competition and enhances price margins, thereby lowering the risk of carbon leakage (Hourcade et al., 2007).
- *Complex, capital-intensive investments*. The production of carbon-intensive goods such as steel, cement, chemicals or refined oil products usually requires complex, high capital investments in facilities lasting for several decades. The costs of these investments are covered in years when scare production capacity results in scarcity premiums (Neuhoff and Dröge, 2007). Therefore, as producers in such industries are used to taking long-term perspectives on investment and operational decisions, this reduces the risk of carbon leakage in the short or medium term, while in the long run this risk may be reduced due to the opportunity of multilateral climate policies equalising the global playing field.
- *Other trade and relocation barriers*. In addition, there are a variety of other trade and relocation barriers that limit the risk of carbon leakage. These include production or investment determinants such as proximity to markets, natural resource input availability, labour costs, quality of human resources, political risks, macroeconomic and social stability, adequate legal regimes (e.g., intellectual property rights, contract law, investment law, an independent judiciary), infrastructure (communications, energy, transportation) or other considerations (Cosbey and Tarasofsky, 2007).

Note that the incidence and significance of the trade and relocation barriers outlined above may vary between countries and industries. Therefore, even if industries in abating countries are faced by similar exposures to international trade intensities and mitigation-induced cost increases, the risk of carbon leakage may vary significantly between these countries and industries depending on the incidence and importance of these barriers.

6.4 The incidence of carbon leakage due to the EU ETS

Several (modelling) studies have tried to assess the impact of the EU ETS on industrial competitiveness and carbon leakage.[22] In general, however, the findings of these studies vary widely, depending on the sectors considered and the data, methodology and assumptions used. For instance, at a carbon price of 20 €/tCO_2 in the EU ETS, model estimates of carbon leakage range between 0.5 to 25% in the iron and steel sector and between 40-70% in the cement sector, de-

[22] See Reinaud (2008) for references and a review of these studies.

pending on how allowances are allocated among other parameters (Demailly and Quirion, 2006 and 2008; Ponssard and Walker, 2008).

Empirically, however, there is no evidence of significant carbon leakage for the sectors concerned during the first phase of the EU ETS (2005-2007). Apart from the overall favourable world economic conditions during the years 2005-2007 and the, in general, generous allocations of free allowances to these sectors (including the related plant closure conditions to these allocations), this is probably also due to the relatively short period considered, which does not allow observation of the full potential, long-term effects of the EU ETS on industrial competitiveness and carbon leakage (Reinaud, 2008; Convery et al., 2008). Hence, any impact of the EU ETS on the performance of industrial sectors is likely to become more significant when markets are less favourable, carbon prices are higher and/or allocations of allowances to industries are less generous.

7. Changes in the EU ETS beyond 2012

In January 2008, the European Commission proposed an energy and climate policy package for the period up to 2020 and beyond. The two key objectives of this package are:

- To reduce overall GHG emissions to 20% below 1990 levels by 2020 (possibly scaling up to 30% in the event of a satisfactory international agreement being reached).
- To increase the share of renewable energy sources to 20% by 2020.

In December 2008, an amended version of this package was adopted by the European Council of Ministers, representing the Member States, and the European Parliament. A core element of the policy package is a major revision and strengthening of the EU ETS, starting from 2013 up to 2020 and beyond. The major changes for the EU ETS post 2012 include (EC, 2009; World Bank, 2009):

A more stringent, single EU-wide cap
Sectors and activities covered by the EU ETS have to reduce their emissions by 21% below 2005 levels. Starting from 2013, a single EU-wide cap will be set centrally by the European Commission. For sectors included in the ETS, the cap on emissions is expected to decrease at 1.74% per year rate with the 2010 allocation as a reference. Based on Phase II coverage and allocation (2,080 million EUAs per year, on average), this would correspond to an EU-wide allocation of 1,974 million EUAs by 2013, decreasing to 1,720 million EUAs by 2020.

Harmonised allocation rules
Besides a single EU-wide cap, other elements of harmonised allocation include (i) a sole EU-wide New Entrants Reserve (5% of the entire amount of allowances), and (ii) centralized rules for auctioning and free allocations to installations.

Auctioning
Starting from 2013, about half of all allowances will be auctioned, increasing with time until 70-80% of the allowances are auctioned by 2020. Allowances are to be auctioned by Member States, with national shares largely reflecting Phase I emissions.

Auctioning for electricity producers
Full auctioning will start in 2013 for power producers, with concessions made to some Member States, taking into account the status of their electricity sector and GDP per capita. For existing installations, these Member States will have the option to start auctioning at least at 30% by 2013 reaching 100% by 2020.

Free allocation and phased auctioning for industry and other sectors
EU-wide rules for free allocation will be adopted by December 31, 2010, with the intent of harmonizing these rules across Member States.

- For industry not exposed to global competition, auctioning will be phased in gradually, starting with a modest 20% in 2013 and increasing to 70% by 2020 (with a view to finally reaching full auctioning by 2027).
- For those sectors exposed to global competition, the aggregate number of free allowances for this group will be set in proportion to their historical share of emissions during Phase I and will decline annually in proportion to the overall Phase III cap.
- Free allocation to individual installations in both industry categories will, “to the extent possible”, be based on benchmarking to best available technology. The intent is that free allocation rewards efficient installations more than less efficient installations in any sector.

The sectors and sub-sectors exposed to global competition (and those that are not), will be determined by December 31, 2009, based on an assessment of projected increases in production costs as a result of carbon regulation and degree of openness. The exposure of installations to international competition will be assessed in depth by June 30, 2010, and additional measures to protect these industries may be proposed, as needed (World Bank, 2009).

Coverage

Aviation will already be included in the EU ETS starting from 2012. The next year, i.e. 2013, the scope of the scheme will be further extended by covering CO_2 emissions from petrochemicals, ammonia and aluminium, N_2O emissions from the production of nitric, adipic and glyocalic acid production and perfluorocarbons from the aluminium sector.

Trading period

The third trading period will last 8 years, i.e. from 2013 up to 2020.

References

Ahman, M., and K. Holmgren (2006): “New entrant allocation in the Nordic energy sectors: incentives and options in the EU ETS”, *Climate Policy*, Vol. 6, No. 4, pp. 423-440.

Alberola, E., J. Chevalier, and B. Chèze (2007): *European carbon prices fundamentals in 2005-2007: the effects of energy markets, temperatures and sectorial production,* EconomiX Working Paper 2007-33, Université Paris X Nanterre, Paris.

Alberola, E., J. Chevalier, and B. Chèze (2008): “Price drivers and structural breaks in European carbon prices 2005-2007”, *Energy Policy,* Vol. 36, pp. 787-797.

Anderson, B., and C. di Maria (2009): *Abatement and allocation in the pilot phase of the EU ETS,* Paper presented at the 17th Annual Conference of the European Association of Environmental Resource Economics (EAERE), Amsterdam, June 24-27, 2009.

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

Bonacina, M., A. Creti, and S. Cozialpi (2009): *The European Carbon Market in the Financial Turmoil: some empirics in early Phase II,* Working Paper No. 20, IEFE, Universitá Commerciale Luigi Bocconi, Italy.

Bonacina, M., and S. Cozialpi (2009): *Carbon allowances as inputs or financial assets: lessons learned from the Pilot Phase of the EU ETS,* Working Paper No. 19, IEFE, Universitá Commerciale Luigi Bocconi, Italy.

Bruyn, S. de, D. Nelissen, M. Korteland, M. Davidson, J. Faber, and G. van de Vreede (2008): *Impacts on Competitiveness from EU ETS - An Analysis of the Dutch Industry,* CE, Delft.

Buchner, B., C. Carraro, and D. Ellerman (2006): *The Allocation of European Union Allowances: Lessons, Unifying Themes and General Principles,* FEEM Working Paper No. 116.06, University of Venice.

Carbon Trust (2004): *The European Emissions Trading Scheme: Implications for Industrial Competitiveness,* London.

Carbon Trust (2006): *Allocation and Competitiveness in the EU Emissions Trading Scheme,* London, UK.

Chevalier, J. (2009): “Carbon futures and macroeconomic risk factors: A view from the EU ETS”, *Energy Economics,* Vol. 31, pp. 614-625.

Clo, F. (2009): “The Effectiveness of the EU Emissions Trading Scheme”, *Climate Policy*, Vol. 9, pp. 227-241.

Convery, F. (2008): *Reflections on the European Union Emissions Trading Scheme (EU ETS) - What can we learn?,* Presented at Informational Board Workshop on Policy Tools for the AB 32 Scoping Plan, Air Resources Board, California EPA. Sacramento, California, May 28. 2008.

Convery, F., D. Ellerman, and C. de Perthuis (2008): *The European Carbon Market in Action: Lessons from the First Trading Period,* Interim Report, MIT Joint Program on the Science and Policy of Global Change, Report no 162, MIT, Massachusetts.

Cosbey, A., and R. Tarasofsky (2007): *Climate Change, Competitiveness and Trade,* Chatham House, London, UK.

Delarue, E., D. Ellerman, and W. D’haeseleer (2008): *Short-term CO_2 Abatement in* *the European Power Sector,* University of Leuven, Belgium, and MIT, Massachusetts, USA.

Website Eurostat (2009): *Statistics Database, http://epp.eurostat.ec.europa.eu/*

Delarue, E., K. Voorspoels, and W. *D'*haeseleer (2008): "Fuel Switching in the Electricity Sector in the EU ETS: Review and Prospective", *Journal of Energy Engineering,* Vol. 134. No. 2, pp. 40-46.

Delbeke, J. G. Klaassen, T. van Ierland, and P. Zapfel (2009): *The economics of the new EU climate and energy package,* Paper presented at the 17th Annual Conference of the European Association of Environmental Resource Economics (EAERE), Amsterdam, June 24-27, 2009.

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

Demailly, D., and P. Quirion (2008): "European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry", *Energy Economics,* Vol. 30, pp. 2009-2027.

EC (2003): *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC,* Official Journal of the European Union, 25.10.2003, L275/32-46.

EC (2007): *EU action against climate change - EU emissions trading: an open system promoting global innovation,* European Commission, Brussels, Belgium.

EC (2009): *Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 3003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community,* Official Journal of the European Union, 5.6.2009, L140/63-87.

ECA (2007): *The EU Emissions Trading Scheme: Lessons for the Future,* Report by the Environmental Audit Committee (ECA) of the House of Commons, London, UK.

Ellerman, D. (2008): *The EU's Emissions Trading Scheme: A Proto-type Global System?*, CEEPR Working Paper No. 08-013, MIT, Massachusetts, USA.

Ellerman, D., and B. Buchner (2007): "The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results, *Review of Environmental Economics and Policy,* Vol. 1, No. 1, pp. 66-87.

Ellerman, D., and B. Buchner (2008): "Over-Allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005-06 Emissions Data", *Environmental Resource Economics,* Vol. 41, pp 267-287.

Ellerman, D., and P. Joskow (2008): *The European Union's Emissions Trading System in Perspective,* Pew Center on Global Climate Change, Arlington.

Ellerman, D., and S. Feilhauer (2008): *A Top-down and Bottom-up look at Emissions Abatement in Germany in response to the EU ETS,* CEEPR Working Paper No. 08-017, MIT, Massachusetts, USA.

Ellerman, D., B. Buchner, and C. Carraro (2007): *Allocations in the European Emissions Trading Scheme - Rights, Rents and Fairness,* Cambridge University Press, UK.

Eurostat (2009): *Statistics Database, http://epp.eurostat.ec.europa.eu/*

Fujiwara, N., and C. Egenhofer (2008): *What lessons can be learned from the EU emissions trading scheme?,* CEPS Policy Brief No. 153, Centre for European Policy Studies, Brussels, Belgium.

Gilbert, A., G. Reece, D. Phylipsen, K. Mirowska, M. Horstink, and J. Stroet (2006): *Comparative Analysis of National Allocation Plans for Phase I of the EU ETS,* Final report to Government of Ireland, YUES5023, Ecofys UK, London.

Grubb, M., C. Azar, and M. Persson (2005): "Allowance allocation in the European emissions trading system: a commentary", *Climate Policy,* Vol. 5, pp. 127-136.

Harrison, D., P. Klevnas, D. Radov, and A. Foss (2007): *Complexities of Allocation Choices in a Greenhouse Gas Emissions Trading Program,* Report to the International Emissions Trading Association (IETA), NERA Economic Consulting, Boston, Massachusetts.

Hourcade, J., D. Demailly, K. Neuhoff, and M. Sato (2007): *Differentiation and Dynamics of EU ETS Industrial Competitiveness Impacts,* Climate Strategies, London.

Houser, T., R. Bradley, B. Childs, J. Werksman, and R. Heilmayr (2008): *Leveling the Carbon Playing Field: International Competition and US Climate Policy Design*, Peterson Institute for International Economics, World Resources Institute, Washington DC.

Kettner, C., A. Köppl, S. Schleicher, and G. Thenius (2007): "Stringency and Distribution in the EU Emissions Trading Scheme - First Evidence", *Climate Policy,* Vol. 8, pp. 41-61.

Kruger, J., W. Oates, and W. Pizer (2007): "Decentralization in the EU Emissions Trading Scheme and Lessons for Global Policy", *Review of Environmental Economics and Policy,* Vol. 1, No. 1, pp. 112-133.

McKinsey and Ecofys (2006): *EU ETS Review - Report on International Competitiveness,* European Commission, Directorate General for Environment, Brussels, Belgium.

Neuhoff, K., and S. Dröge (2007): *International Strategies to Address Competitiveness Concerns,* SWP, Germany, and University of Cambridge, UK.

Neuhoff, K., K. Keats Martinez, and M. Sato (2006a): "Allocation, incentives and distortions: the impact of the EU ETS allowance allocations to the electricity sector", *Climate Policy,* Vol. 6, No. 1, pp. 73-91.

Neuhoff, K., K. Keats, J. Sijm, F. Matthes, and A. Johnston (2006b): *Allocation matters - so what can we do about it? Strategies for the electricity sector 2008-2012,* Commissioned by Climate Strategies and The Carbon Trust, London.

Neuhoff, K., Åhman, M., Betz, R., Cludius, J. , Ferrario, F. , Holmgren, K., Pal, G., Grubb, M., Matthes, F., Rogge, K., Sato, M., Schleich, J., Sijm, J., Türk, A., Kettner, C., Walker, N. (2006c): "Implications of announced phase II national allocation plans for the EU ETS", *Climate Policy,* Vol. 6, No. 4, pp. 411-422.

OECD (2009): *Economic Outlook - Annual Projections for OECD countries,* Organisation for Economic Cooperation and Development, Paris.

Ponssard, J., and N. Walker (2008): "EU Emissions Trading and the cement sector: a spatial competition analysis", *Climate Policy,* Vol. 8, pp. 467-493.

Reinaud, J. (2008): *Issues behind Competitiveness and Carbon Leakage - Focus on Heavy Industry.* IEA, Paris.

Sandbag (2009): *ETS S.O.S. - Why the flagship'EU Emissions Trading Policy'needs rescuing,* Sandbag Climate Campaign, UK.

Sijm, J., Berk, M., Elzen, M. den, and Wijngaart, R. (2007): *Options for post-2012 EU burden sharing and EU ETS allocation,* WAB Report No. 500 102 009, Netherlands Environmental Assessment Agency, Bilthoven.

Sijm, J., Chen, Y., and Hobbs, B. (2009): *The impact of power market structure on the pass-through of CO_2 emissions trading costs to electricity prices - A theoretical approach*, Paper presented at the 17th Annual Conference of the European Association of Environmental Resource Economics (EAERE), Amsterdam, June 24-27, 2009.

Sijm, J., Hers, S., and Wetzelaer, B. (2008b): "Options to address concerns regarding EU ETS-induced increases in power prices and generators'profits: the case of carbon cost pass-through in Germany and the Netherlands", in: Gulli, F., ed., *Markets for Carbon and Power Pricing in Europe - Theoretical Issues and Empirical Analyses*, New Horizons in Environmental Economics, Edward Elgar, Cheltenham, UK, and Northampton, MA, USA, pp. 101-144.

Sijm, J. (2006): "EU ETS Allocation: evaluation of present system and options beyond 2012", *Zeitschrift für Energiewirtschaft*, Vol. 30, No. 4, pp. 285-292.

Sijm, J., Hers, J., Lise, W., Wetzelaer, B. (2008a): *The impact of the EU ETS on electricity prices*, Final report to DG Environment of the European Commission, ECN-E--08-007, Petten/Amsterdam.

Sijm, J., Neuhoff, K., and Y. Chen (2006): "CO_2 cost pass-through and windfall profits in the power sector", *Climate Policy*, Vol. 6, No. 1, pp. 49-72.

Stern, N. (2006): *The Economics of Climate Change - The Stern Review*, Cambridge University Press, Cambridge, UK.

Widerberg, A., and M. Wrake (2009): *The Impact of the EU Emissions Trading Scheme on CO_2 Intensity in Electricity Generation*, Working Papers in Economics No. 361, School of Business, Economics and Law, University of Gothenburg, Sweden.

World Bank (2007): *State and Trends of the Carbon Market 2007*, Washington, D.C.

World Bank (2008): *State and Trends of the Carbon Market 2008*, Washington, D.C.

World Bank (2009): *State and Trends of the Carbon Market 2009*, Washington, D.C.