REPORT

Emissions Trading:

The Ugly Duckling in European Climate Policy?

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1 Introduction

The initial years of the European Union's Emissions Trading System (EU ETS) have been a large-scale testing ground for trading a new environmental commodity, carbon dioxide (CO_2). In its current form, the EU ETS includes some 12 000 installations, representing approximately 45% of EU emissions of CO_2. It is by far the largest emissions trading system in the world. This paper provides an overview of the origins and characteristics of the EU ETS and analyses the most contentious issues surrounding it in the economics literature and in public debate. It concludes with a look towards the future, highlighting some major forthcoming revisions of the EU ETS and what issues remain unresolved.

European environmental policy has traditionally been dominated by command and control-type policy instruments. When market-based instruments have been used, they have primarily been taxes. Most countries in Europe have high fuel taxes (which are at least partly motivated by environmental considerations), and some countries have taxes or charges on waste, sulphur, nitrogen, and other emissions. Alternative market-based instruments, such as refunded emission payments, deposit refunds, and subsidies, among others, are used in various areas.[1]

As concern about climate change rose on the political agenda in the early 1990s, the European Commission made efforts to set up a common European carbon tax, but this work met intense resistance from industry and some member states, as well as from many finance ministries which were anxious to keep exclusive national sovereignty in this area. As a result, the political momentum gradually shifted away from a common tax and no strong agreement was reached. Emissions trading was widely regarded with great scepticism in Europe at the time, and the experience with this type of policy instrument was limited. The political turnabout that ultimately resulted in the creation of the EU ETS has been reviewed extensively in the political economy literature.[2]

A central factor in the shift in the EU position was the adoption of the Kyoto Protocol in 1997, which included emissions trading as one of the "flexible mechanisms" along with the Clean Development Mechanism (CDM) and Joint Implementation (JI). Although the EU strongly opposed the US-led push to include flexible mechanisms in the Protocol, the final outcome of the negotiations in Kyoto propelled emissions trading into the mainstream political debate in Europe. In the five years that followed, the discussion of how and when to implement an emissions trading system for private entities evolved from narrow academic circles to a much broader set of stakeholders

The remainder of the paper is structured as follows. Section 1 describes the motivation and decision-making process for setting up the EU ETS, as well as the fundamental characteristics of the system. Section 2 discusses some of the most contentious issues that have emerged in the EU ETS to date. Section 3 looks towards the future and what lies ahead for the EU ETS, and concludes.

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[1] For an overview, see for instance the OECD Environmentally Related Taxes database, www.oecd.org/env/policies/database (accessed June 2009).

[2] See, for instance, Skjaerseth and Wettestad (2008) and Christiansen and Wettestad (2003) for accounts from a political science perspective.

2 From Unwanted Idea to Directive

The Kyoto Protocol[3] required signatories to show "demonstrable progress" in reducing emissions by 2005. The EU quickly determined that an internal emissions trading system could potentially show such progress and the first official EU document indicating the possibility of a European pilot trading system appeared in 1998.[4]

Basing an emissions trading system on article 17 of the Kyoto Protocol, which lays out the principles for emissions trading between countries, was quickly identified as an option. This structure would delegate the trading of assigned amount units[5] to private entities and the principles, rules, and protocols of the trading regime would be decided by the Conference of the Parties (COP).[6] Such a set up seemed to offer more advantages, particularly regarding harmonisation and compatibility, but given the likely difficulties in achieving consensus across all parties on such a detailed level, it was discarded as unrealistic for Europe.

Another early design proposed setting up individual member-state emissions trading systems with the option of linking them into a common European system.[7] The rules and provisions of each system would be decided by each member state, with article 17 of the Kyoto protocol serving as a loose framework. Member states would have significant flexibility to accommodate national circumstances and interests, but this would also create potential problems with harmonisation and compatibility. Although support for this option persisted into the 2000s, most observers agreed that a common EU approach would be preferable to linking a large number of individual national systems.[8] Two member states, Denmark and the U.K., went ahead and set up their own national emissions trading systems for greenhouse gases, partly to gain experience before a common European system came into play. Some firms also tested internal emissions trading systems several years before the start of EU ETS. BP's system received extensive public attention. Its design and function deviated in many respects from a textbook cap-and-trade system, and no money actually changed hands, but the system effectively raised awareness of the opportunities to save money with emissions reduction and how emissions trading could work in practice.[9]

In 2000 the EU published its "Green Paper on Emissions Trading."[10] It analysed the critical factors for an EU trading system and outlined some preferred design options. In less than two years, the EU Commission published its proposal for the EU ETS Directive,[11] which differed in two principal

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[3] UNFCCC (1998). The Kyoto Protocol can be downloaded from http://unfccc.int/resource/docs/convkp/kpeng.pdf.

[4] European Commission (1998).

[5] Parties with commitments under the Kyoto Protocol (annex B) have accepted targets for limiting or reducing emissions. These targets are expressed as levels of allowed emissions, or "assigned amounts," over the 2008–2012 commitment period. The allowed emissions are divided into "assigned amount units" (AAUs), each equal to 1 ton of CO_2 equivalent.

[6] The COP is the collection of nations which have ratified the UN Framework Convention on Climate Change (UNFCCC). The primary role of the COP is to oversee the implementation of the Convention. The first COP took place in Berlin, March 28–April 7, 1995.

[7] This is basically the approach taken for trading green and white certificates (renewable electricity and energy savings, respectively).

[8] Zapfel and Vainio (2002) give an insider's perspective on the early development of the EU ETS.

[9] See Victor and House (2006) for an interview based analysis of BP's system.

[10] European Commission (2000).

[11] European Commission (2001).

ways from the Green Paper's recommendations on allocation procedures. First, it chose a decentralised approach, giving significant discretion to the member states regarding the number of allowances they could allocate. Second, it proposed that the initial allowances be allocated free of charge as the basic allocation principle for the first trading period 2005–2007.

In the negotiations between the European Parliament (EP) and the European Council that followed, it quickly became clear that the EP would like to see a larger proportion of allowances allocated by auction and broader coverage of the system, whereas the Council largely defended the Commission proposal. The mounting political pressure to get a directive accepted during 2003 resulted in an agreement in July 2003, and the final directive was published in the *EU Official Journal* on October 25, 2003. The outcome was close to the original proposal, and its key features were a largely decentralised approach to allocation and at least 95% of allowances allocated free of charge. The system covered CO_2 emissions from four main 'activities':[12]

- Energy, including combustion installations with a rated thermal input above 20MW, mineral oil refineries, and coke ovens
- Production and processing of ferrous metals, including metal ore and production of pig iron and steel
- Mineral industry, including production of cement, glass, and ceramic products
- Other activities, including pulp and paper production

When it adopted the EU ETS Directive, the European Union went from the drawing board to practical implementation of an idea that, less than a decade earlier, had seemed impossible in Europe.

3 Contentious Issues in Phase I and II of the EU ETS (2005–2012)

This section briefly analyses some important features of the EU ETS. Although this account is by no means comprehensive, it offers an overview of the most contested issues and the arguments put forward in discussions about the design of the EU ETS.[13]

Setting the Cap

The environmental effect of a cap and trade system is governed by the total allocated volume of allowances.[14] The price of emissions and the resulting economic incentives for firms to reduce emissions are determined by the scarcity of allowances.

In the EU ETS (phases I and II), each member state is responsible for allocating allowances to the emissions-producing installations in its territory. The number of allowances given to each installation is spelled out in a National Allocation Plan, (NAP). The total cap in the trading system,

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[12] For exact definitions, see annex I of the EU ETS Directive (European Union 2003).

[13] Omitted questions, in particular, include monitoring, reporting and verification, compliance and enforcement, and potential linkage of the EU ETS to other emerging trading systems.

[14] In practice, as Tietenberg (2002) notes, the level of the cap is determined not only by what may be socially optimal, but is also a function of the design of the trading system.

thus, is the aggregate of all member state allocation plans. Member states have considerable discretion in deciding allocation methodology, but their NAPs must conform to a number of criteria set by the EU.[15]

In the first trading period, the European Commission aimed at ensuring that allocations were not to generous using two principal criteria. First, the total number of allowances proposed by the member state should be lower than business-as-usual projections, and second, the member state had to show that the intended allocations would achieve its target reduction set by the EU burden-sharing agreement or the Kyoto Protocol. (Both of these criteria had qualitative dimensions and were susceptible to different interpretations.)

The process of setting up the NAPs turned out to be complex and sometimes controversial, characterised by lobbying and strategic interaction between industry, member states, and the EU Commission.[16] An unfortunate consequence of the decentralised allocation procedure was that member state governments faced incentives that could lead to decisions that were not efficient for the trading program as a whole—the 'prisoner's dilemma'.[17] When a government decides on the rules for allocation, it is likely to consider the tax base and the job opportunities that installations provide. For instance, it may be rational, from a member state's point of view, to reward continued production in the own country or attempt to enhance the competitiveness of its own industry through the allocation, even though such measures may raise the overall social cost of the trading system.

Concerns over a 'race to the bottom' between member state allocations were augmented by the fact that not all NAPs were submitted at the same time. For example, the U.K. NAP was published early and judged to be relatively stringent. Once other member states published their NAPs—which turned out to be more lax—the U.K. filed a request to adjust its NAP and increase its allocation volumes. Although the request was disallowed by the Commission, this example indicates that the allocation process likely contained elements of strategic behaviour by member states. A centralised allocation at a European level, or at least a common decision on the total volumes to be allocated, would mitigate this problem. However, such an approach had little support among member states, several of which reluctantly endorsed the creation of the trading system.[18]

The European Commission decided to reduce the proposed totals in 14 of the 25 phase-I NAPs that were submitted by the member states, representing some 5% of the total cap.[19] Still, assessments by Zetterberg et al. (2004) and Gilbert, Bode, and Phylipsen (2004) indicated that the allocation was generous. Installations were given more allowances than their historical emissions warranted and they were also given more allowances than needed to carry an equal burden in

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[15] See annex III of the EU ETS Directive.

[16] A detailed account of this process lies beyond the scope of this article. See, for example, Ellerman et al. (2007) for illustrative examples from ten member states.

[17] The prisoner's dilemma constitutes a problem in game theory. In the classic form, cooperating is strictly dominated by defecting, so that the only possible equilibrium for the game is for all players to defect, even though each player's individual reward would be greater if they played cooperatively. The term 'prisoner's dilemma' stems from the example used in its original form, with two hypothetical prisoners who were the participants in the game.

[18] Skjaerseth and Wettestad (2008) categorised the member states by their positions on emissions trading into leaders (the Scandinavian countries, the Netherlands, the UK, Germany, and Austria), laggards (Greece, Spain, Portugal, and Ireland), and those in between (Belgium, Italy, Luxembourg, and France).

[19] Ellerman and Buchner (2007)

relation to the EU Kyoto target (compared to sectors outside the trading system). Consequently, the trading system was criticised for not being stringent enough even before it was launched. Nevertheless, the first year of trading saw prices of emission allowances (EUA),[20] which were higher than many observers had expected, peaking at over 30 €/ton early in 2006 (figure 1). This sparked calls from in particular the energy intensive industry to scrap the system, with claims that it was hurting the economy. Most of these calls fell silent as the first 2005 verified numbers of emissions for 2005 were published in April 2006, showing that the market had too many allowances. This information caused EAU prices to fall dramatically. Although the immediate drop slowed and prices stabilised for a while, by mid-2007, they reached near-zero levels. This development supported the view that phase I had an over-allocation. The empirical literature assessing the effect of the EU ETS on abatement is still scarce, but it seems unlikely that phase I of the EU ETS led to significant reduction in CO_2 emissions compared to business-as-usual.[21]

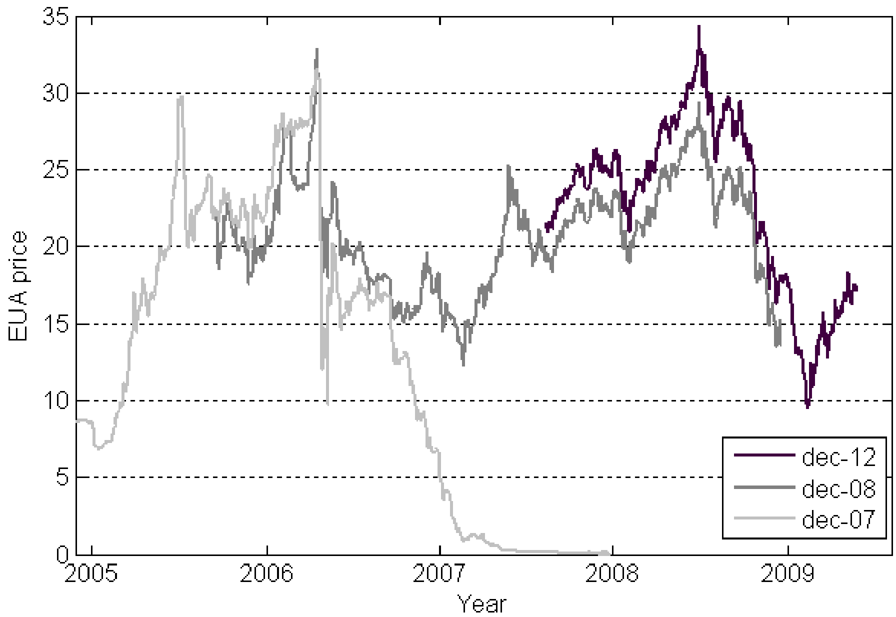

Figure 1 Price of EU Allowances in the EU ETS. “dec -07” is the phase I futures contract for delivery in December 2007, and so on. *Source*: Point Carbon

Repeating this situation—very low allowance prices—in phase II (2008–2012) would have seriously jeopardised the credibility of the trading scheme. Furthermore, as the second phase coincided with the first commitment period in the Kyoto Protocol, a continued liberal allocation would implicitly impose large emission reductions on sectors not included in the trading scheme. Alternatively, the member states might have to make greater use of the CDM and JI in order to reach their reduction targets.[22] As a final resort, a member states could buy Kyoto emission credits (AAUs) from countries outside the EU ETS (for instance, Russia or Ukraine), but that would be politically controversial.

[20] EUA, or European Union allowances. These are the tradable asset in the EU ETS, each permit representing 1 ton of CO_2 emitted.

[21] It is, however, difficult to determine to what extent abatement measures were implemented. See Ellerman and Buchner (2006) and Widerberg and Wråke (forthcoming 2009) for a deeper discussion.

[22] This option is limited by the Kyoto Protocol, which stated that JI and CDM should be “supplementary” to domestic action.

In order to avoid this situation, the EU Commission repeatedly stated its intention to tighten the cap during the second trading period, as member states prepared their NAPs for phase II. In a guidance document,[23] it laid out new principles for the NAPs, making verified emissions for 2005 the basic yardstick for the assessment.[24] But, although this reduced the occurrence of lofty sector growth projections that were widespread in the first set of NAPs,[25] early assessments of NAPs submitted for phase II suggested that allocations continued to be lavish.[26] This lent support to the EU Commission's actions limiting the allocation by requiring significant cutbacks in several of the proposed allocation plans.[27]

Although it is still too early to assess how much scarcity there is in the trading system, current EUA prices are back to the levels of 2005–2006. Market participants should have learnt enough to make the system work and information on emissions and allocations is more readily available and better understood, indicating that the cap is tighter in phase II than in phase I.

Free Allocation or Auction?

Emissions trading rations access to the resource—in this case, the atmosphere—and privatises the resulting access right—in this case, the right to emit CO_2. A central question is how the property rights (here, emission allowances) are initially distributed among participants, and a fundamental choice is whether firms should receive allowances for free or if they should have to pay for them, for example, in an auction. There is considerable discussion in the economics literature about the efficiency and equity properties of each option.

The efficiency[28] of the trading system, in principle, does not hinge on whether the allocation is free of charge or not. The possibility of trading the allowances will ensure that they flow to the participants who value them most, no matter how they were initially distributed.[29] From this perspective, allocation is a matter of distribution of costs, not efficiency. Although the allocation may constitute a significant transfer of assets from governments to firms,[30] the allowance price, the environmental effectiveness of the system, choice of abatement method by firms, and downstream price effects should all be the same whether firms pay for allowances initially or not.[31]

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[23] Communication from the Commission on guidance to assist member states in the implementation of the criteria listed in annex III of Directive 2003/87/EC.

[24] The EU Commission even developed an explicit formula for the assessment: allocation = verified 2005 ETS emissions * GDP growth rates for 2005–2010, based on PRIMES model * carbon intensity improvements rate for 2005–2010 + adjustment for new entrants and other changes, for example in ETS coverage.

[25] See, for instance, the LETS Update (2006) for assessments of the projections.

[26] Rogge et al. (2007) and Neuhoff et al. (2006).

[27] In total, the EU Commission shaved off some 10% of the proposed allocation volumes.

[28] Efficiency, in this context, is defined as the ability to reduce emissions to a predetermined level at minimum abatement cost. This can be interpreted in a static sense, e.g., assuming fixed reduction targets and available technologies, or in a dynamic context, where second order effects and incentives are also considered.

[29] See Montgomery (1972) and a related paper by Baumol and Oates (1971), which demonstrate that a correctly defined tradable allowance system under specific conditions, including a sustainability constraint, can maximise the value received from the resource.

[30] In fact, in the EU ETS, the value of those assets is much greater than the costs that the firms face for compliance. See figure 1 in Åhman et al. (2007).

[31] However, as described by Harrison et al. (2007), certain conditions, such as negligible transaction cost, perfect competition, and low costs of emissions (relative other costs and the overall value of output), are also necessary for this ideal situation to hold.

A vast majority of earlier allowance trading systems implemented to manage fisheries, air pollution, and water resources have used free allocation based on historical activities—usually referred to as 'grandfathering'.[32] Classic grandfathering is a one-off initial allocation of allowances to existing installations, valid for a long time into the future. If these installations close, they still retain their allocation, while new entrants do not receive free allowances.

However, the grandfathering applied in the EU ETS (as in most, if not all, previous trading systems) deviates in many respects from the textbook version. The allocation procedures have been complex and opaque, and have damaged the perceived fairness of the trading system by the public. Further, a large body of research shows that the allocation methodologies used in the EU ETS so far have given perverse incentives to firms regarding how they reduce emissions and have distorted competition between firms, technologies, and member states. Grandfathering encourages regulated parties to engage in (potentially costly) rent-seeking behaviour in order to gain a more generous future allocation. Pointing to their high marginal costs for abatement has been a common strategy used by some industry sectors[33] to receive more allowances in the EU ETS. Some compensation to industries faced with more costly abatement measures or large sunk costs may be justified, but if signalling high abatement costs leads to higher future allocation, then investment in abatement measures may be delayed or guided to suboptimal technologies. Harstad and Eskeland (2007) show that, under conditions with high allowance prices and frequent revisits of the allocation,[34] the distortions can be greater than the gains from trade, implying that non-tradable emission allowances may be better.

Most of the potential pitfalls associated with grandfathering were already known before the EU ETS was launched, but two principal justifications were typically put forward for its use, regardless. First, it increased the chances that participants would agree to the trading system in the first place. Grandfathering would decrease the financial burden on participating firms and would offer a situation closer to the status quo than an auction, thus reducing resistance from incumbent emitters.

Second, free distribution based on historical experience arises from a public policy rationale or desire to compensate incumbent installations affected by the regulation. Schultze (1977) argues that people feel that government should 'do no direct harm' when imposing new public policy. This rationale implies a specific amount of compensation proportional to the change in the economic value of installations caused by the program.

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[32] Notable exceptions are the U.S. SO_2 allowance program, and the Regional Greenhouse Gas Initiative, which rely on auctions to allocate a portion of the allowances.

[33] See, for example, "Position Paper of the Alliance of Energy Intensive Industries on 'further guidance on allocation plans for 2008 to 2012'", February 2, 2006 (http://www.cembureau.be/Cem_warehouse/AEII-FINAL POSITION-GUIDANCE ON ALLOCATION PLANS-2008 TO 2012.PDF [accessed May 2009]).

[34] See the next subsection, "Updating, New Entrants, and Closures" for further discussion.

Both of these arguments carry some weight. Auctions are (and are still) opposed by important sectors of industry, as well as by some member states. The steel and cement industries, in particular, have actively voiced their concerns over the additional costs an auction would force on them. Both individual companies and their business associations argue that auctions would be economically detrimental to them, referring to the international competition that they face from firms outside the EU ETS.[35] Considering the lobbying power and economic importance of these industries in Europe, it would be difficult politically to introduce auctions for all allowances in the first phase of the EU ETS. The argument for compensation is also correct in principle, but begs the question 'how much is enough'. The answer depends on how the policy affects the profitability of the firm, which in turn depends on the change in firm (total) revenues and costs. Empirical evidence suggest that the amount of revenue needed, in the form of free allocation, to avoid losses to firm shareholders, is only a fraction of the total revenues returned from auctions (Bovenberg et al. 2000; Bovenberg and Goulder 2001; Burtraw et al. 2006; Hepburn et al. 2006b).

The economic literature broadly supports auctions as a more efficient way to distribute allowances, compared to free allocation.[36] Auction revenues can be recycled in ways that may enhance the efficiency of the economy as a whole, for example, by reducing distortionary taxes.[37] Sometimes, it is argued, that there is a 'double-dividend', meaning that not only can the trading system achieve the environmental objective, but the efficiency gains made possible by the recycled auction revenues can make the net cost of the policy negative.[38] Even though the support for the double-dividend argument in the literature is ambiguous, it is clear that auctions give the regulator more flexibility to reduce other distortions in the economy or increase investments in areas important for climate policy (e.g., research and technology).

Auctions also promote innovation, relative to grandfathering, since the incentives to innovate (and thereby reduce abatement costs and ultimately allowance prices), are higher if firms do not receive any rents from free allowances.[39] The effect is true in the aggregate and the difference between auctions and free allocation decreases as the time between the innovation and the allocation grows. This is because, as Cramton and Kerr (2002) point out, the incentive to innovate depends on who owns the allowances at the time of innovation.

In addition, if markets are not fully competitive, free allocation can move consumer prices away from the marginal social cost of production and, therefore, may direct (via distortion) resource allocation away from an efficient outcome. This effect may be more significant in electricity

[35] See, for example, "EUROFER position paper on ETS, October 2008" (http://www.eurofer.org/index.php/eng/content/pdf/776); the press release from the Swedish Steel producers association, Elisabeth Nilsson, "Gratis utsläppsrätter är än så länge en förutsättning för stålindustrins globala konkurrenskraft" [Free allowances are still a prerequisite for the steel industry's global competitiveness], *Jernkontoret*, May 4, 2009 (http://www.jernkontoret.se/jernkontoret/pressmeddelanden/2009/vdkommentar_090504_utslappsratter.pdf [accessed June 2009]); and the Cembureau position paper, "Climate Change: CO2 Emissions Trading—Points of Convergence within the Cement Industry" (http://www.cembureau.be/Cem_warehouse/POINTS%20OF%20CONVERGENCE%20WITHIN%20THE%20CEMENT%20INDUSTRY.PDF [all accessed May 2009]).

[36] See, for instance, Cramton and Kerr (2002), Hepburn et al. (2006a), Dinan and Rogers (2002), and Lange (2005) for discussions about carbon emissions trading and the EU ETS.

[37] See, for example, Parry (1995) and Parry et al. (1998).

[38] The incidence of the cost of the trading system depends crucially on how the revenues are distributed, as shown by Burtraw et al. (2009).

[39] Milliman and Prince (1989), Fischer et al (2003)

markets, which are key to reducing carbon emission, but often are not fully competitive.[40] Furthermore, an auction may improve administrative transparency and the perception of fairness, compared to grandfathering, which are crucial to the formation of a new market for an environmental commodity.

In sum, it seems clear that the grandfathering applied in the first two trading periods of the EU ETS has affected not only the distribution of costs, but also the economic efficiency and the environmental effectiveness of the system. A transition to auctions can resolve many of these problems since the case for continued grandfathering, in its current form, is weak. Although the proportion of allowances auctioned in the EU ETS is still very low (<5%), small but important steps have been taken to phase out free allocation. In several member states, the energy sector still receives a significantly reduced allocation in the second phase—an indication that free allocation is not necessary in the system.[41]

Updating, New Entrants, and Closures

In principle, pure grandfathering should be a 'one time only' gift that does not affect firm behaviour, but experience in the EU ETS and previous trading systems shows that such a model is politically difficult to implement. Instead, explicitly or implicitly, various forms of updating are usually applied, implying that future allocation is based on current firm behaviour (for example, output, input, or emissions). It is clear that such an allocation mechanism does influence firm incentives.

The official position of the EU Commission has, from the outset, been that the EU ETS should not contain any updating. This view has not always been shared by all member states or industries. For example, Germany included updating in its first NAP, seeking to adjust the allocation to firms whose emissions changed significantly during the trading period. This was contested by the EU Commission in a legal process that forced Germany to change its NAP and remove the updating clause.

The efficiency characteristics of updating depend on whether the market is open or closed to outside participants and on whether the regulator has control over the allocation of all emissions in the market.[42] There is significant support for an open-system approach in the analysis of allocation in the EU ETS. Member states face a dilemma when the allowance price, determined by the total allocated volume of all member states, can be regarded as exogenous. Furthermore, since the EU ETS only covers a fraction of the economy, there is interplay between the allocation to firms under the EU ETS and the emissions that the rest of the economy is allowed to produce. The EU ETS also has an explicit link to the outside through the CDM and JI. Finally, experience shows that it is tricky for a regulator to disregard the past when future caps are set and, thus, the cap is likely to be flexible rather than absolute.

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[40] For a detailed analysis of this in a U.S. context, see Burtraw et al (2001).

[41] The reduction of free allowances to the energy sector is also closely linked to the discussion of windfall profits, see separate discussion below. The total share of auctioning is low in phase II - approximately 4 % of the total volume of allowances – although that number does not include the zero-allocation to some energy firms (they have to buy allowances on the secondary market rather than in an auction.

[42] For example, Böhringer and Lange (2005) suggest that if there is an absolute cap on emissions and the market is closed to trading with the outside, basing the allocation on past emissions with updating can also produce a first best solution. Rosendahl (2008), however, argues that even under closed market conditions an efficient solution may be infeasible and permit prices will significantly exceed marginal abatement costs.

In this setting, distortion from updating moves incentives away from optimum. Consider a firm that in period t produces output q_t as a function of input h_t. Production generates emissions e_t, and the firm has abatement opportunities a_t. The firm sells the produced good at price p_t^q. The firm's aggregated cost function is $c_t = c_t(q_t, h_t, a_t)$. At the start of each time period t, the firm receives an allocation $\bar{e}_t$ and the firm can comply with the cap either by buying allowances at price p_t^e or by reducing emissions through abatement. Solving the first order conditions for the firm's maximising problem gives $p_t^q = c'_{t,q_t} + p_t^e e'_{t,q_t}$, where c'_{t,q_t} is the marginal cost of production and $p_t^e e'_{t,q_t}$ is the opportunity cost of the marginal emissions. Sterner and Muller (2008), by applying this model[43] in a two-period setting, show that updated allocation methodologies have a suboptimal price (and output) effect. For example, if the allocation in the second period, $\bar{e}_{t+1}$, depends on the production in the current period, q_t, solving the first order conditions of the firm's profit maximising problem yields the solution $p_t^q = c'_{t,q_t} + p_t^e e'_{t,q_t} - \frac{\varepsilon}{1+r} p_{t+1}^e$, where ε is the emission intensity of production and r is the discount rate. Put differently, the expectation of increased allocation in period $t+1$ increases the value of output in period t. The allocation, thus, acts as an output subsidy, lowering the price of the produced good and diminishing the output effect of the policy.

Nevertheless, updating is both explicitly and implicitly part of the design of the EU ETS—explicitly through the renewed allocation for each trading period, and implicitly through the treatment of new entrants and installations that close. The debate on this issue has been focused on whether new entrants should receive any allowances at all and, if so, what specific allocation rules are appropriate. A parallel discussion on whether a closed installation should retain its allocation exists, although it receives less political attention. In addition, the definitions of a 'new entrant' and 'closure' are not clear cut.[44]

All member states have set aside a reserve of free allowances to allocate to new entrants; it is clearly a political priority. The sizes of the reserves differ, as do exact allocation methodologies, although most member states use some set of benchmarks to allocate allowances to new entrants. For installations that close, the prevailing policy is to withdraw the allocation. In some member states, the allocation can be transferred to a new installation or for an increase in capacity in an existing one.

The energy sector is worth a special note. Most member states allocate more allowances to high emitters than low emitters, for both existing and new facilities. For instance, a coal-fired power plant often receives more allowances than one that runs on natural gas. This reduces incentives to develop low-carbon technologies, particularly by new entrants and closures. Åhman et al. (2007) use a two-period model, similar to Sterner and Muller (2008), but provide additional context in order to illustrate the potential effects of the rules in the EU ETS. By introducing representative fixed and variable costs of electricity generation for different plant types, they calculate costs going forward for firms considering investment and for firms contemplating closing installations. The findings show that the treatment of closures and new entrants in the electricity sector, during the first two

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43 In their model, Sterner and Muller also include an input that is unrelated to emissions in order to capture potential effects on the relative factor use under different allocation schemes. That part of the analysis is not central here and has been omitted from this discussion.

44 The formal definitions of new entrants and closures applied in the EU ETS are found in the EU ETS directive.

trading periods, can affect what types of new plants are built and which old plants are retired, and that high-emitting plants have an advantage over low-emitting ones.[45]

Thus, both theoretical analyses and applied research indicate that the current rules on new entrants and closures create distortions between member states, between new and existing installations, and among technologies. The methodologies differ greatly among member states, and prevent a level playing field across the internal market. The policy of withdrawing the allocation from installations that close constitutes an implicit subsidy to existing installations still in operation,[46] thus putting new entrants at a disadvantage. In many cases, the allocation methodologies to new entrants do not encourage low-carbon technologies.

Again, many of these problems would be solved if free allocation were replaced by auctions. But, if free allocation continues, harmonising the rules for new entrants and closures will be a first step towards a more efficient system. Preferably, installations that close should retain their allocation at least long enough to reduce the incentive to keep an inefficient installation in operation just to receive the allocation. This would reduce the implicit subsidy to existing installations and allow a more stringent allocation to new entrants—or even no free allocation at all.

EU ETS and the Electricity Sector

An important objective of cap and trade is to alter relative prices throughout the economy by including the social cost of pollution in product prices. At the same time, higher retail prices for goods, such as electricity, may be a concern to policy makers and politically controversial. Energy-intensive industries are important to several member state economies and possess strong lobbying power. To many of those industries, the indirect effects of increased electricity price are more important than the direct costs of allowances. For example, studies of the British (Hourcade et al. 2007), German (Graichen et al. 2008,) and Swedish (Zetterberg and Holmgren, 2009) industries show that, in the aluminium sector, the paper industry, and the inorganic chemical sectors, the indirect costs in the form of higher electricity prices are significantly higher than direct costs for emission allowances.[47] In addition, low-income households typically spend a higher proportion of their disposable income on energy, which means that changes in electricity prices tend to be regressive,[48] adding to the political sensitivity.

As a result, the debate over effects of the EU ETS on electricity prices has several thorny dimensions.[49] Concerns over negative effects on energy intensive industries and criticism related to equity and fairness have featured prominently, while some observers have questioned whether prices have been—or should be— affected at all, given that allowances in most cases were allocated free of charge.

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[45] For additional analyses of this issue, see, for example, Neuhoff et al. (2007) and Åhman and Holmgren (2007).

[46] One could also impose, equivalently, a tax on closures. This effect is analogous to the output effect studied formally by Sterner and Muller (2008), as discussed previously.

[47] As these sectors are subject to international competition and have limited ability to pass on increased costs to their customers, this is highly relevant to the discussion on competitiveness of European industry and carbon leakage. See sub-section, 'Competitiveness and Carbon Leakage', below.

[48] This effect is part of a broader debate around 'fuel poverty' that has been particularly intense in the UK, where specific measures have been implemented to compensate low-income households for increasing energy prices.

[49] See Åhman et al. (2008) for an overview of the debate and illustrative examples for the Nordic electricity market.

Two kinds[50] of 'windfall profits' are recurring themes in this context. Firms make direct windfall profits when they are given more allowances than they need and then sell their excess on the market. Indirect windfalls may be even more important, however. Because electricity prices in competitive markets are determined by marginal production—which in Europe is dominated by fossil fuel—electricity generators can charge a higher price for all their generated electricity, including that from nuclear, biomass, and hydro.

As discussed earlier, economic theory argues that, at least in competitive markets, retail prices will include the economic value of the allowances, and hence increase under an emissions trading system, whether polluting entities received allowances for free or not. Nevertheless, many people disagree and disapprove when firms raise product prices, especially if it means they reap substantial windfall profits. Although the argument may be discounted by economists, free allocation is frequently put forward as a means of reducing downstream price effects. Occasionally, industry has reinforced this view. For example, one energy company official told Point Carbon, that 'if EUAs are auctioned that will only lead to 100 percent of the carbon price being priced into the electricity price, and thus increase it'.[51]

Similar arguments have also been raised by governmental authorities. For instance, the German Federal Cartel Office (Bundeskartellamt) in 2006 stated that the industrial electricity prices charged by RWE[52] in 2005 were abusive, as the company had passed on more than 25% of the value of its CO_2 emission allowances to consumers in higher electricity prices.[53] In simplified terms, the Bundeskartellamt recognized that, in principle, the opportunity costs should be taken into account as a business calculation. However, the authorities took the view that, since the allowances were necessary for the electricity generation of RWE, they were not actually for sale and, thus, would not have a full opportunity cost associated with them. Because the allowances had been allocated to the firm free of charge, the firm should not be entitled to include their full value in the electricity price.[54]

The list of such examples can go on and on, but there remain strong, opposing views regarding how the EU ETS interacts—or should interact—with electricity markets. Pricing in electricity markets is further complicated by the special character of these markets, particularly their network externalities, and by their role as players with considerable market power. Furthermore, many of the large European energy companies are publicly owned, which increases the possibility that their pricing strategies may deviate from pure profit maximisation. In sensitive issues, such as this one, public relations and the interests of the utility owners are likely to be particularly important.

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[50] In fact, both of these effects are present in other sectors as well, but are most pronounced in the electricity sector.

[51] See "Member states look to deal with windfall profits," *Carbon Market Europe, Point Carbon*, October 14, 2005, 6.

[52] RWE is one of the largest electricity producers in Germany and has received a major share of their allowances for free, according to a grandfathering procedure.

[53] See Bundeskartellamt press release, December 20, 2006 (http://www.bundeskartellamt.de/wEnglisch/News/Archiv/ArchivNews2006/2006_12_20.php [accessed June 2009]).

[54] The Belgian energy market regulator CREG stated that the country's authorities must prevent utilities from making windfall profits by passing on the cost of CO_2 emission allowances to consumers (Reuters, January 21, 2009). CREG referred to estimates that electricity producers in the Belgian market made about €1.2 billion (US$ 1.68 billion) in profits between 2005 and 2007 by charging clients for CO_2 emissions allowances they had received for free.

Studies on price effects of emissions trading include the econometric time series analyses of Bunn and Fezzi (2007) in the U.K. electricity market and Fell (2008) in the Nordic market. Sijm et al. (2006; 2008) have performed simulations of a number of European markets, as well as some econometric analyses. These studies all have similar findings: at least in relatively competitive markets, 60–100% of the CO_2 price is passed through to electricity consumers, more likely at a higher amount the more competitive the market is. This suggests that consumers pay for a significant portion of the value of emissions allowances.

However, econometric studies do not remove the ambiguity about how much pass through is actually observed, which is important for concerns about fairness, compensation, and potential windfall profits.[55] The ambiguity stems from the heterogeneity of technologies within the market. In the electricity sector, technologies differ both with respect to the marginal cost of producing electricity and to their emissions rate. In most wholesale power markets (except where power purchase agreements are in place), each electricity producer receives the same price per unit produced. The price depends solely on the bid of the last generator, i.e., the one with the highest marginal cost needed to meet demand. Figure 2 gives a schematic illustration of pass-through effects in electricity, showing that at peak demand the pass through will be lower than at off peak. The reason is that natural gas, which most often is at the margin in European electricity generation, at peak demand has lower carbon intensity than coal. There are also dynamic effects that are harder to represent in a simple figure. For example, because demand for allowances will be higher at peak demand for electricity, it acts as a driver for higher allowances prices. However, even though electricity companies play an important role in the EU ETS, non-perfect correlation in demand patterns across the EU and the large volume of allowances in the market will make it unlikely that the effect on allowance prices, due to electricity demand spikes, would be a dominant factor.

[55] Wråke et al. (2008) apply an experimental approach, with experiment subjects acting as firms in a controlled economic environment in a laboratory, to analyse the issue of pass-through behaviour.

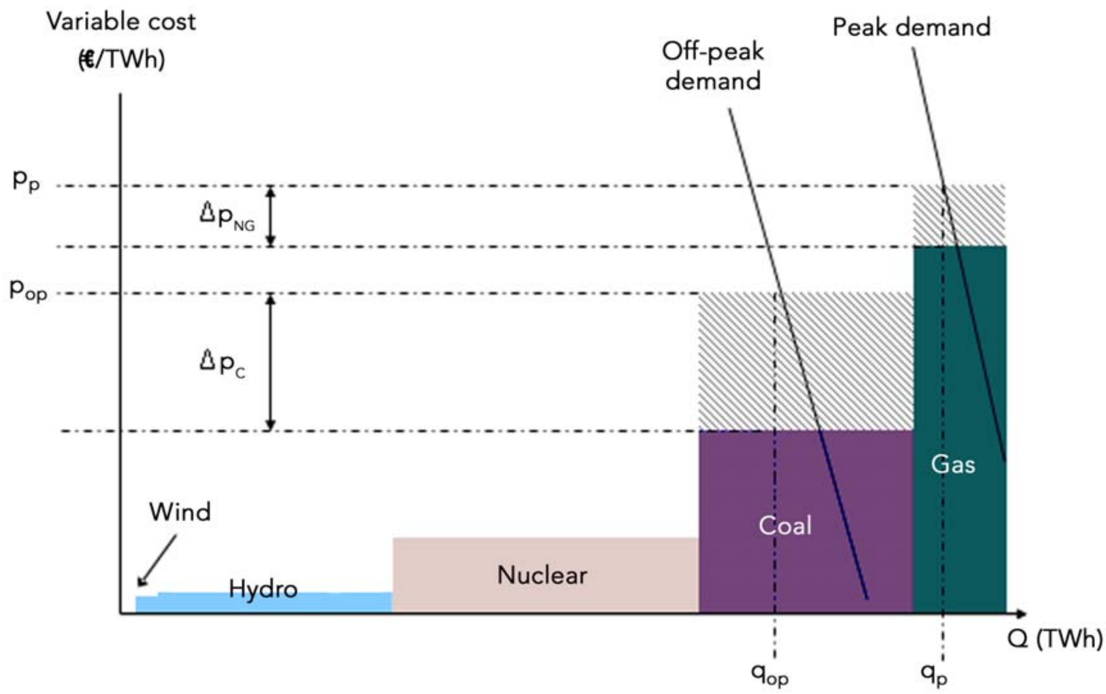

Figure 2 Pass Through of Allowance Cost in Electricity
The figure shows a schematic merit-order curve for electricity. At peak demand, the clearing price would be p_p, including the cost of emission allowances Δp_{NG} required for the marginal unit which is natural gas. Thus at peak demand an operator of a coal-fired plant will not recuperate 100% of the additional variable cost of allowances. At off peak the clearing price p_{op} is lower, but the pass through of allowance cost Δp_C is higher.

Sijm et al. (2006) refer to the pass-through behaviour of the individual generator as 'add-on' and the increase of the bid for the marginal unit, which will determine the electricity price, as 'work-on'. The work-on rate can be calculated from market observations, but the add-on cannot be calculated without knowing which kind of technology is on the margin at any given point in time. A marginal pass-through rate (work-on rate) of 100% does not indicate whether the industry is earning revenue that is more or less than 100% of its cost[56]. The cost to industry depends on the emission rates of infra-marginal generators, which may on average be more than or less than the emissions rate of the marginal unit.

Uncertainty and Price Volatility

There is extensive economic literature on what type of policy is most efficient when there is uncertainty about both benefits and costs of regulation.[57] Much of this literature revolves around the relative merits of cap and trade versus emissions taxes. Here, we focus on the EU ETS and do

[56] Indeed, the "60-100% pass through rate mentioned earlier refers to average effect under specific assumptions of marginal capacity and does not say much about the work on.

[57] For example, see Weitzman (1974), Roberts and Spence (1976), Kolstad (1996), Pizer 2002, Hoel and Karp (2002), Montero (2002), and Mandell (2008). The key point made by Weitzman and elaborated by others is that the expected efficiency of the policies will depend on the relative slopes of the curves for marginal costs and marginal benefits of emissions reductions, as well as the associated uncertainties in these curves.

not deal with the choice of trading versus taxes, although much can be learnt from the more general discussion on policy design under uncertainty.

There is an inherent trade-off between flexibility and certainty in any policy design. On the one hand, there are benefits of retaining the options of adjusting policies to changing priorities and information, for instance, new developments in climate science and in the international climate policy negotiations. On the other hand, there is a need to provide certainty to market actors. Uncertainty over prices in products or inputs will, on average, delay investments, compared to a situation under certainty.[58] The greater the level of policy uncertainty, other things held equal, the less effective the climate change policies will be at providing incentives for investment in low-emitting technologies. The closer in time a change in policy is expected, the higher the option value will be for a company. This is particularly relevant in capital-intensive sectors where investment cycles may stretch over several decades.

Critics of the EU ETS have argued that the market for emission allowances is artificial, in the sense that there is no underlying physical commodity being traded. Fluctuations are closely linked to variations in policy, which are difficult to predict. In addition, price volatility in inputs can be amplified by the allowance market.[59] A potential consequence could be that the trading system, instead of offering incentives for long-term investments based on expectations of higher future prices of carbon emissions, only stimulates changes based on short-term marginal costs. This would make it less effective in driving investment in low-carbon technologies and in research and development of new technologies.

Real option models are frequently used to assess the effect of uncertainty on firm behaviour, and many studies indicate that uncertainty will reduce the efficiency of climate policy.[60] For example, IEA (2007) shows that the price of carbon required to make an investment in a hypothetical carbon capture and storage (CCS) facility viable is 37% higher if policy is set only 5 years into the future, compared to policy that is certain 15 years ahead. This is particularly relevant since 5–15 years is a typical time over which a firm needs to recoup the majority of major capital investments—and it also resembles the current cycles in international climate negotiations. Fuss et al. (2009) conclude that scenarios with small and frequent revisions of an emissions cap will result in higher cumulative emissions than if policies are altered less frequently but more drastically. Laurikka and Koljonen (2006), using an extended discounted cash flow model, show that uncertainty regarding the allocation of emission allowances was critical in a quantitative investment appraisal of fossil fuel-fired plants in Finland. These findings are consistent with the rich literature that exists for other environmental areas. A multitude of studies show that the hurdle rates for investments may be multiplied several times when uncertainty is considered compared to evaluations using standard net present value calculations.[61]

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[58] See, for example, IEA (2007), Philibert (2006), and Laurikka (2006). Simply put, the option value is 'the value of waiting'.

[59] See, for instance, Bunn and Fezzi (2007) and Fell (2008) for analyses of price interactions between electricity prices and the EU ETS.

[60]The models build on the option value theory (see, for instance, McDonald and Siegel 1986; and Dixit and Pindyck 1994), which predicts that firms will consider shifting investments in time in order to gain better information. If the (future) information is worth more than owning the asset, investment will be postponed. Real option modelling can be applied both in short-term frameworks focused on operational decisions and in long-horizon valuations of investments over decades or even centuries.

[61] See, for example, Löfgren et al. (2008) for an overview of existing studies.

Assessments of climate policy-induced uncertainty should, however, be made in light of other market factors, which affect investments. For most firms, the carbon price would have to be significantly higher than today to have the same impact on investments and cost variability as, for instance, variations in fuel prices, demand for energy and commodities, currency fluctuations, and political turmoil. IEA (2007) concludes that it is unlikely that climate policy uncertainty would pose a serious threat to overall capacity levels in most electricity markets in the long run. If climate policy is set over sufficiently long time scales, the total risk will be dominated by fuel price risk, with climate policy contributing relatively little to the total risk profile of the investments.[62]

Nevertheless, several proposals have been put forward that address both short-term and long-term aspects of price variability and regulatory uncertainty associated with the EU ETS. Some proposals are aimed primarily at reducing overall costs and, thus, lower the risk of very high prices of emissions. An example is strategic public investments intended to reduce the cost impact of emissions trading by lowering marginal abatement costs. Other measures target cost volatility more directly, while still others attempt to address both aspects in parallel. For example, offset mechanisms (such as the CDM) seek to reduce the overall cost of reaching an emissions target and create a backstop price of emissions by making low-cost abatement opportunities available outside the trading system. Short-term cost variability could also be reduced by expanding the role of the offset market in response to sudden price increases in the domestic market for emissions.[63]

A relatively simple measure to avoid drastic market corrections of the allowance price would be to improve transparency in monitoring and frequency of emissions reporting. Had firms' emissions been published more frequently, dramatic price falls, such as EU ETS experienced in 2006, could probably be prevented. Increasing the length of the trading periods would reduce regulatory uncertainty,[64] but would also limit political manoeuvring room of the EU. Allowing firms to bank allowances, which was not permitted between phase I and phase II, has substantial economic benefits. It increases the inter-temporal flexibility of firms, allowing them to implement low-cost abatement options in one case and postpone higher cost measures in another, so as to minimise net present cost of investments. Furthermore, banking gives firms with a surplus of allowances a vested interest in keeping the allowance market active. Borrowing improves firms' opportunities to rationalise investments over time, similar to banking. However, it also introduces an element of moral hazard; firms that acquire an emissions debt have an incentive to work for a relaxation of the emissions cap or even a suspension of the trading system in order to wipe out that debt.

One of the most debated cost management proposals is the so called 'safety valve', a guard against unexpectedly high allowance prices. The EU has been firmly opposed to such a mechanism and it is not part of the EU ETS. However, it features prominently in the U.S. discourse on cap and trade,[65]

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[62] Some studies, like Zhao (2003), even suggest that uncertainty in allowance markets may help maintain firms' investment incentives, compared with a scenario with fixed emissions charges. Firms factor in a convenience yield for the value of holding allowances over and above the marginal cost of avoided abatement expenditures. This premium leads to additional investment in order to hedge against the uncertainty in the allowance market.

[63] Although, some observers have serious doubts about both the CDM's potential ability to reduce overall compliance costs—the primary reason being the difficulty of ensuring that reductions are additional—and its ability to act as an effective cost-containment mechanism because of the constraints in delivering large volumes of reductions quickly. See, for instance, Wara and Victor (2008) for a discussion.

[64] As discussed by Åhman et al. (2007) and Sterner and Muller (2008), this would also reduce some of the distortions created by the allocation procedures.

[65] Some kind of safety valve has been included in an overwhelming majority of the proposals for a federal U.S. trading system that have been put before Congress to date.

so—in part because of its implications for a future linking of the EU ETS and a US system—considerable attention has been given to the safety valve in the EU as well.

The basic idea of a safety valve is that additional allowances would be released into the market if prices exceed some pre-determined ceiling. If the number of allowances that can be released could is unlimited, the cap is in effect relaxed. If, instead, the allowance pool is limited, the short-term problem of price spikes may be mitigated, but not the long-term problems of escalating prices and costs to stay under a firm cap on emissions.[66]

The safety valve has been criticised from several perspectives. At a general level, such a mechanism may be promoted by parties who want it introduced solely as a way to constrain costs and emissions reductions below what they otherwise would be, given the set emissions reduction targets. In such a circumstance, the safety valve would lower the environmental integrity of the system. More importantly, evidence is that ex post actual costs of government regulation are more often lower than ex ante expected costs (Harrington et al. 2000). In an emissions trading system, this results in falling prices. To date, the problem in emissions trading systems has not been unforeseen price rallies, but rather much lower prices than expected.[67] For instance, in the US SO_2 trading program, market prices fell quickly to one-quarter of the price projections predicted by the US EPA before they launched the system. The EU ETS' prices collapsed in 2006, and even though phase II prices are higher, they are still lower than what many observers projected them to be. Lower-than-expected costs are, of course, not a problem if the cap is the optimal one. However, often the intention is to gradually tighten the cap, striking a balance between increasing stringency and limiting costs. This is the case with climate change, where both the EU and elsewhere expect to reduce emitted volumes significantly in the future. In this situation, a safeguard not only against higher-than-expected costs but also against lower-than-intended prices may be called for.

Figure 3 illustrates the effect that cost management mechanisms will have on expected allowances prices. As expectations of allowance price levels shift, so will the expected returns on investments of various types. Consider the profit function for a firm that uses a non-emitting technology to produce an output q:

$$\pi = qp_q(Q, p_A) - c(q), \qquad (1)$$

where p_q is the market price for the output q, Q is the aggregate quantity in the market, p_A is the price of allowances, and c is the cost function of the firm. The firm maximises profits by choosing quantity. Assuming competitive markets $\frac{\partial p_q}{\partial q} = 0$ and the firm maximises profits, such that marginal revenues equal marginal costs:

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[66] See Pizer (2002), Kopp et al. (2002), Murray et al. (2008).

[67] One exception is the RECLAIM program for NOx emissions in California. In 2001, in hot and dry conditions, a sudden increase in demand for NOx credits was created because coal-fired utilities had to compensate for a lack of hydropower. As a result, NOx credits jumped from less than US$ 1 per pound to over $30 in six months. Due to this, the program was re-examined and amended, resulting in major changes. The first major change was the mandated installation of emissions control technology in major power plants to reduce emissions. The second was legislation to have businesses that produced over 50 tons of NOx annually develop five-year emissions plans based on historic emissions levels from the year 2000, thus improving market transparency. RECLAIM's price levels have since dropped back to prices reflecting those seen before the price spikes.

$$p_q(Q, p_A) = \frac{\partial c}{\partial q}. \qquad (2)$$

As aggregate quantity and allowance price are uncertain variables, thus making market price uncertain, the firm's profit maximising would equal marginal cost to *expected* marginal revenues:

$$E(p_q) = \frac{\partial c}{\partial q}. \qquad (3)$$

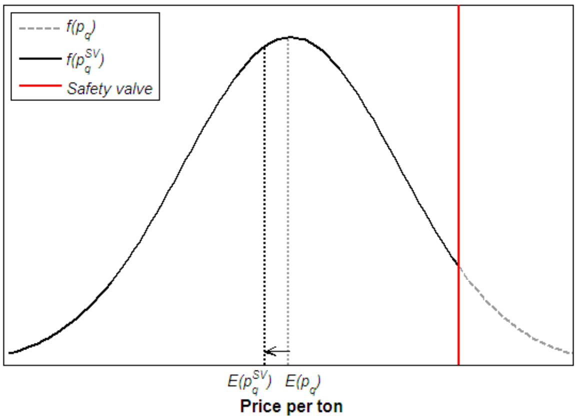
With a safety valve, prices over a given level are precluded, resulting in a lower expected market price $E(p_q^{SV})$ than without the safety valve. Thus, our non-emitting firm would choose a level of output under the safety valve such that:

$$E(p_q^{SV}) = \frac{\partial c}{\partial q^{SV}} < \frac{\partial c}{\partial q} = E(p_q), \qquad (4)$$

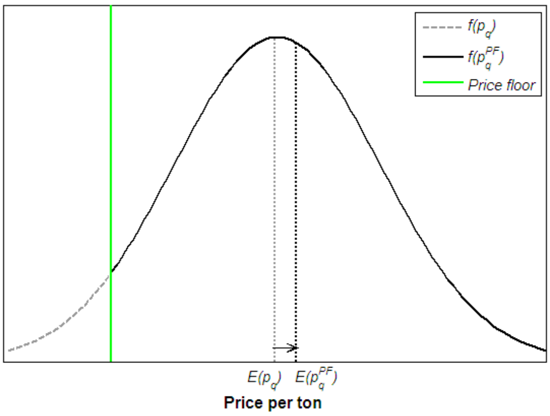
resulting in $q^{SV}<q$. Thus, the consequence of the safety valve is a reduction in investment in low-emitting facilities.

Burtraw and Palmer (2006) and Palmer et al. (2008) show how a political commitment to prices above a certain level would work in the opposite direction and analyse how such a mechanism would affect investment incentives. Because a guaranteed minimum price precludes prices below a certain level, the expected price will be increased, compared to a situation without such a price floor. If a safety valve and a price floor are combined and made symmetric, it would bring the expected prices levels back to conditions without the cost management mechanisms, so that $E(p_q^{SV+PF}) = E(p_q)$, resulting in maintained investments and output $q^{SV+PV}=q$.

Panel A



Panel B



Panel C

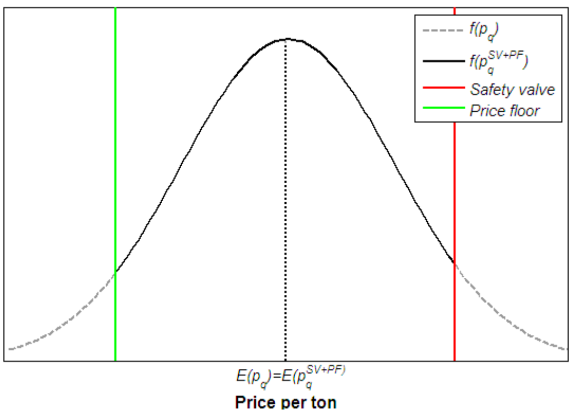


Figure 3 Distribution of Allowance Prices under a Cost Management Mechanism.
Panel A shows a safety valve, panel B shows a price floor, and panel C, the balancing effect of a symmetric cost management mechanism on the expected value of the allowance price.

In the limit, if the level of the safety valve is lowered and the guaranteed minimum price is increased so that the two coincide, the trading system has, in effect, turned into an emissions tax. The original uncertainties in prices and abatement costs are gone, replaced by uncertainties in emissions and damages to the environment. Of course, this brings us back to the discussion on the relative merits of price versus-quantity type regulations.

To summarise, the level and nature of uncertainty are key factors in the design of climate policy and important determinants for the efficiency of the policy. Expectations of high-compliance costs and the interaction of allowance markets with natural price variations are recurring arguments against stringent policies. At the same time, it is imperative to have credible investment incentives that are high enough to bring about the changes needed. If investors perceive climate policy measures as short-sighted and volatile, pursuing traditional high-emitting technologies will be a less risky strategy than investment in new and, in some cases, unproven technologies. Efficient mechanisms to manage uncertainty in incentive structures, overall costs, investor expectations and short-term price fluctuation would strengthen both the political case for climate policy and the efficiency of such policies.

The EU ETS and the Transport Sector

The potential inclusion of the transport sector in the EU ETS has been a frequent topic of discussion. The most obvious reason for including it is that the transport sector alone accounts for more than 20% of EU greenhouse gas emissions (EEA 2009); and some argue that including transport in the EU ETS would be an effective way to curb emissions by the sector.

Fuel taxes in the road transport sector vary in levels and structure across member states. Often they have several components with different names: energy tax, petrol tax, CO_2 tax, etc. Overall, fuel taxes in the EU are high, compared internationally, and far above the current price of CO_2 in the EU ETS. Empirical evidence strongly suggests that these fuel taxes have had a large impact on emissions from road transport across the EU, indicating that the long-term elasticity in fuel demand is significant.[68] However, because demand is more inelastic in the short run, the transport sector (were it in the EU ETS) would most likely be a large buyer of allowances, particularly if inclusion in the EU ETS replaced a large proportion of fuel taxes. This would result in significantly higher allowance and electricity prices for industry, and a radically lower pressure on the transport sector to reduce emissions.[69] Dynamic and secondary effects are difficult to predict, but it is clear that including road transport in the EU ETS is associated with substantial uncertainty and risk regarding both emissions from transport and economic impact on other sectors.

In contrast to road transport, international aviation and maritime shipping are virtually exempt from all climate policies, even though emissions from these sectors are growing rapidly. The European Environment Agency (EEA 2006) forecasts that emissions from EU international aviation will grow by 150% in the period 1990–2012, which alone would offset more than one-quarter of the Community's reductions target under the Kyoto Protocol. Progress on regulating these emissions have been virtually absent in international negotiations, and neither of them are covered by the Kyoto Protocol. In an effort to break the trend of growing emissions, the EU has decided that all flights taking off or landing in the EU will be included in the EU ETS, starting in 2012. This decision has been contested by the International Civil Aviation Organisation (ICAO) on the grounds that it breaches international agreements.[70] Whether ICAO's claim will hold up in a

[68] Sterner (2007).

[69] See Holmgren et al. (2007) for an illustrative discussion.

[70] Current legislation on international aviation is based on the concepts in the Convention on International Civil Aviation (also known as the Chicago Convention), that came into force in 1947. The preamble to the convention states that civil aviation should be established on the basis of 'equal opportunity', a priority that still dominates talks on regulation of international aviation.

judicial review remains to be seen, but a ruling for ICAO could severely limit countries' ability to introduce domestic environmental legislation on international aviation.

The International Maritime Organisation (IMO) has been charged with leading the international efforts to curb maritime emissions. As with international aviation, little progress has been made. Although no formal proposal has been put forward to include shipping in the EU ETS, the EU has stated that if no international agreement is reached under the leadership of the IMO or the UNFCCC by the end of 2011, it will propose including maritime shipping in the EU ETS, as of 2013. A longstanding argument against regulating aviation and maritime transports is that it would be technically and legally difficult to do so. This argument has been discounted by recent research and the absence of international policies and measures seems due to institutional issues and political barriers rather than to technical shortcomings.[71]

Competitiveness and Carbon Leakage

Modern history is full of examples where proposals for environmental legislation have been accompanied by intense debate over their effects on industry, and the EU ETS is no exception. Earlier sections of this paper touch upon how the trading system has affected competition between technologies and new versus existing installations, and how member states may engage in strategic behaviour in order to attract investments. This section deals primarily with the competitiveness of European industry vis-à-vis the outside world.

The literature on the impact of environmental policy on trade flows is extensive. A number of competing theories have been put forward to explain how firms respond to tightening environmental regulation. Copeland and Taylor (1994) helped sort out the conflicting evidence and arguments. They made the distinction between the 'pollution haven effect', which implies that, all else being equal, tightening environmental regulation will drive firms to countries where it is more lenient, and the 'pollution haven hypothesis', which says that this effect is a dominant force for firm location.

Another theory, with roots in the business literature, is the 'Porter hypothesis',[72] which argues that stringent environmental policy will prompt productivity and efficiency improvement of firms to such an extent that the net costs to firms will be negative and their competitiveness enhanced.

The term 'competitiveness', often used in relation to effects of the EU ETS, should be interpreted with care. At a microeconomic level, the definition is relatively straightforward, at least in the short term. For example, pollution regulation that affects a firm's costs of production will also alter its competitiveness. A uniform cost increase of emitting carbon, as imposed by the EU ETS, will impact all firms that emit, but the importance of these costs to each firm will differ greatly, depending on the carbon intensity of its production. In the short run, a firm's competitiveness will be negatively affected if it faces a higher cost for polluting than its competitors or if it has higher carbon intensity than its competitors.

On a macroeconomic scale, the term 'international (or national) competitiveness' usually refers to the ability of firms to sell their goods and services on the international market. A potential measure of this is net exports; if they are high, a country or a region has a high international competitiveness. However, in the long run, such differences will be factored into currency exchange

[71] See Åhman (2008) for a discussion.

[72] The hypothesis is named after its proponent, Michael Porter. See Porter and van Linde (1995).

rates and labour cost, eventually balancing out gains in competitiveness defined in this way. Consequently, other measures have been put forward[73] that may be more accurate, but the bottom line is that competitiveness will have different meanings to different stakeholders, at different levels of the economy, on different time scales, and in different contexts. Consider the simple example of a European firm investing in new capacity in China. A European policy maker may interpret this as a sign of decreasing competitiveness of the European economy. For the firm, however, the same investment may result in lower costs, improved competitiveness, and increased market share.

One concern voiced by European industry in particular is the issue of *carbon leakage*. It is important to distinguish between intended and unintended effects that follow from a cap on carbon emissions. From a regulator's perspective, it may not be a problem if output in one sector is reduced in favour of another, or if existing (dirtier) goods are replaced by new (and cleaner) goods. However, if industry activities (emissions production) are simply shifted outside of the EU, it would make the emissions trading system less effective and raise the overall cost of reaching the environmental objective, and could result in reduced employment at home.

The term carbon leakage, itself, has an ambiguous definition. Usually it is defined as the ratio $\Delta E_1 / \Delta E_2$, where ΔE_1 is the emissions increase in countries outside the policy regime, and ΔE_2 is the reduction in emissions in the region under the policy. (Changes in emissions are driven by the policy.) However, this implies that if an inefficient installation is closed due to the EU ETS and its market share is captured by a more efficient plant in another region, it is also defined as leakage, even though total emissions have decreased.

Firm relocation is probably the driver of leakage most commonly referred to in the public debate. The basic argument is simple: given the asymmetries in carbon prices between Europe and the rest of the world, it is rational for European firms, all else being equal, to look for opportunities to shift their activities elsewhere. Empirical evidence suggests that the cost of complying with environmental regulation is generally a small share of a firm's total cost structure. Other factors, such as the cost of capital, trained personnel, etc., also affect a firm's location choice. However, on the margin, it would be rational for firms to relocate production in response to environmental stringency. This is particularly important, given the ambitious emission targets being set by the EU in relation to some of its trading partners. A more subtle version of this is altered patterns of reinvestments; even if firms keep existing capital stock in place, they may prioritise expansions and reinvestments in other places.

Loss of market share to firms outside of the EU is another channel for leakage. In the short run, firms facing higher variable costs will have to raise prices, resulting in declining sales, or reduce their prices, thus eroding their profit margin.[74] In the long run, if cost asymmetries persist, it will affect the use of existing capacity and the returns on investment.

There is also a general equilibrium effect that has the potential to generate carbon leakage. The large-scale reduction in demand for carbon-intensive commodities, such as fossil fuels, in the EU would prompt global prices on those goods to fall. As the prices of these goods fall, other parts of the world economy with less stringent climate policies would increase their consumption of these cheaper goods, thus offsetting some of the European reductions.

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[73] See Brännlund (2008) for an overview.

[74] In the very near term, one could argue that firms do not even have the choice of lowering prices or adjusting production, as does Morgenstern et al. (2007).

Most empirical studies[75] of the EU ETS have focused on identifying what sectors are at risk for leakage. Two factors have received particular attention: exposure to international trade and what values associated with the EU ETS are at stake. High exposure to international trade can reduce a firm's ability to pass on the cost of carbon to its customers. If, in addition, the carbon costs are high, relative to the value added of the firm, there is a greater risk of leakage. Using only these two determinants for analysing the risk of carbon leakage will certainly offer an incomplete picture, but it will likely give at least a rough indication of which sectors are most vulnerable.[76]

In studies of the value at stake, defined as the ratio between the added cost of carbon and the value added by the firm, the cement industry generally rank among the highest. Hourcade et al. (2007) estimates increased costs,[77] due to carbon pricing, of more than 30% of value added in the UK cement industry. Graichen et al. (2008) puts the equivalent number for the German cement industry at over 60%.[78] In Sweden and the Netherlands, the values at stake are generally found to be significantly lower across all sectors, but the cement industry comes out high in those countries as well: 9% in Sweden (Zetterberg and Holmgren 2009) and 8% in the Netherlands (de Bruyn et al. 2008).

However, if trade intensities are considered, the picture changes considerably. For instance, the German cement industry's trade intensity with non-EU countries was approximately 3% in 2005,[79] and only the lime industry ranked lower. Similar results have been reported for the UK. At a global level, only 6% of cement is traded internationally (Reinaud 2005a). In fact, due to its relative insulation from international competition, the cement industry is likely less affected, and domestic substitution is a more relevant threat to the sector than international trade (de Bruyn et al. 2008). Instead, it is the aluminium, iron and steel, and fertilizer industries that are consistently most vulnerable to increasing costs of carbon. The chief reason is the high proportion of international trade in these sectors; in 2007, 40% of global steel production[80] and 77% of global aluminium production[81] was traded internationally.[82]

The next step, quantifying how much carbon leakage will result from the EU ETS, is even more complex. Evidence of carbon leakage includes changes in trade and investments. The multitude of forces driving such activities makes it difficult to establish a counterfactual scenario needed to estimate the effect of climate policy or control for all relevant variables in a statistical model. An accurate analysis would require knowledge of how European and foreign firms respond to fluctuations in carbon prices, what technologies and associated emissions intensities dominate in different regions, cross-elasticities between substituting goods and international trade flows, to

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[75] For example, see Demailly and Quirion (2007), Reinaud (2005a; 2005b; 2008), Smale et al. (2006), McKinsey (2006), Gilbert, Bode, and Phylipsen (2006), Hourcade et al. (2007), Graichen et al. (2008), de Bruyn et al. (2008), and Zetterberg and Holmgren (2009).

[76] These two parameters have also been identified by the EU Commissions as most important in determining which sectors could eligible for free allocation in the EU ETS phase III. See separate section below.

[77] This includes both direct costs for abatement or purchase of allowances, which would depend on the method of allocation (the numbers cited here pertain to 100% auctioning) and indirect costs, resulting from increased electricity prices.

[78] Both studies assume a €20-EUA price. Hourcade et al. (2007) uses 2004 industry data, and Graichen et al. (2008) uses 2005 production data.

[79] German Statistics Office, quoted in Graichen et al. (2008).

[80] Reinaud (2008a).

[81] Baron et al. (2007).

[82] For a more detailed breakdown of trade flows in exposed sectors, see Mohr et al. (2009).

name just a few parameters. Furthermore, capital-intensive sectors, such as those identified as most at risk, are typically characterised by a high inertia due to long investment cycles and significant fixed costs. This further highlights the need for detailed and disaggregated data.

Hence, it is not surprising that ex-ante studies[83] of both the EU ETS and other planned or potential climate policies display a wide range of results. These theoretical studies are often based on general or partial equilibrium models, which may not be deliberately designed for carbon leakage estimates. Demailly and Quirion (2008a) estimate the leakage rate in the iron and steel industry to be 0.5–25 %, with a median value of 6%. Some findings are contradictory in light of analysis of sectors vulnerable to leakage. Ponssard and Walker (2008) estimate leakage rates in the EU cement sector to be around 70% with EUA prices at €20, while Demailly and Quirion (2008b) report 20% leakage rates for the cement sector, assuming a €15 carbon tax in annex B countries (except for the United States, Australia, and New Zealand). Ex post studies based on empirical observations are still scarce, but the results are much more consistent: they show little, if any, evidence of carbon leakage resulting from EU ETS.[84] Naturally, not enough time has elapsed since the EU ETS was implemented for any robust time series of these effects, so any findings should be interpreted with care.[85]

There are some important caveats, however. Modelling studies on sectoral competitiveness is usually based on the assumption that sector characteristics are homogenous. Factors, such as like abatement costs and technologies used, are modelled as identical across firms. At sub-sector or firm levels, this is unlikely to be true and leakage effects may well be different. Further, most studies look at short-term effects and use carbon prices in the range of 10–50€/ton CO_2.

In the long run, conditions can change considerably, which brings us back to a distinction between the pollution haven *effect*, and the pollution haven *hypothesis.* The empirical studies quoted here have not been able to confirm the pollution haven hypothesis. This indicates that any pollution haven effect has not been a dominant force for firm location and trade flows. Should carbon prices increase dramatically, however, their importance will increase and they could potentially become a major factor. Further, many firms have long-term contracts for electricity that have insulated them from increasing carbon costs so far. As these contracts expire, effects of the EU ETS will become more visible. In sum, there are good reasons to revisit the issue of leakage, both empirically and theoretically, over the coming years.

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[83] See Gielen and Moriguchi (2002), OECD (2003), Demailly and Quirion (2006; 2008a; 2008b), and Ponssard and Walker (2008).

[84] Looking for effects on trade flows, Lacombe (2008) finds no significant changes in petroleum products, Reinaud (2008b) reports no significant effects in aluminium trade, and Demailly and Quirion (2008a) find no changes in trade flows in Iron and steel,

[85] I have found no studies that report leakage rates exceeding 100%. Thus, neither the theoretical nor the empirical literature supports suggestions that a cap on European emissions would result in *increased* global emissions.

4 The Road Ahead: Conclusions and Unresolved Issues

The first years of the EU ETS have demonstrated that it is possible to design and implement a large-scale trading system in a relatively short period of time. Phases I and II have provided opportunities for institutional learning, development of market infrastructure, and empirical assessments, which will be critical to future improvements of the system.[86] Clearly, considerations of political feasibility, special interests, and perceived fairness have been key parameters in the design of the EU ETS, and they will no doubt continue to be so in the future. . A simpler trading system with few distorting elements would be more economically efficient, but pose greater political challenges to implement, in part because it would leave less room for pursuing other policy objectives than least cost emissions reductions, such as stimulating certain technologies, developing new fuels, or including additional industries.

In response to some of the criticism of its current design, the EU is reviewing the EU ETS. In January 2008, the EU Commission published "The EU Energy Package", an extensive proposal for a new, integrated climate and energy policy for Europe.[87] After less than a year of negotiations (which in this context has to be considered remarkably short), the Parliament and the Council struck an agreement in December 2008, and the Energy Package was formally adopted on April 6, 2009. It contains three principal elements:[88]

1) Legally binding greenhouse gas emissions-reduction targets for sectors not covered by the EU ETS (These targets—the so-called 'effort-sharing agreement'—range from -20% to +20%, and in total amount to 10% reduction below 2005 levels.)
2) Differentiated targets for renewable energy sources and a flat rate of 10% biofuels
3) A revision of the EU ETS, including a 21% emission reduction target for the sectors covered compared to 2005

These targets together aim to achieve an overall 20% reduction in total greenhouse gas emissions below 1990 levels by 2020 and a 20% share of renewable sources in final energy consumption.

For the EU ETS, this means that substantial changes will come, as of January 1, 2013. The most fundamental change is centralising much of the allocation process. Instead of each member state drawing up a NAP, the cap will be set at the European level. This change will reduce the risk of a repeat 'race to the bottom', seen in the first two allocation rounds. The cap in 2013 will start at the

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[86] In fact, the first phase was originally a trial period. In addition to the large body of academic research and consulting reports that has been published on the EU ETS, the EU ETS Directive mandated the EU Commission to carry out a review of the trading system, which it did in 2006 and 2007. Documents from this review can be found at http://ec.europa.eu/environment/climat/emission/review_en.htm (accessed June 2009).

[87] The "Energy Package" builds on the Commission proposal of January 2007, *Energy Policy for Europe*, and its twin communication, *Limiting Global Climate Change to 2°C*. Both of these proposals were endorsed by the spring Council in 2007.

[88] The package contained a number of additional documents, including a directive on the geological storage of CO_2 (an 'enabling document' focusing on legal matters), new state aid guidelines, and Commission communications and impact assessments of the proposals. Also, see http://ec.europa.eu/commission_barroso/president/focus/energy-package-2008/index_en.htm#key, for important documents (accessed May 2009).

average total quantity of allowances allocated by member states in 2008–2012,[89] decreasing linearly to a 21%-reduction below 2005 levels by 2020. It is worth noting that the annual reduction rate[90] is legally binding beyond 2020, unless a new decision is made. The EU has, in fact, laid out a default emissions reduction path, not only for the short term, but also further into the future. Should an international agreement be signed that triggers an EU move to an overall 30% reduction target, the cap of the ETS will be adjusted downward proportionally.

The reductions imposed on the traded sectors are larger than what an equal burden between sectors (in terms of absolute emission reductions to reach the 20% overall target) would imply. The underlying rationale is that the EU expects the traded sectors to have lower abatement costs, compared to the non traded sectors. The approach used in phase I and II was rather the opposite, where traded sectors received a relatively generous cap, compared to sectors outside the system. This is further evidence of the political pragmatism that influenced central elements of phase I and phase II, with the EU seeking buy-in of the system from major industry stakeholders through a generous allocation of allowances.

Another central change is that auctions will distribute approximately 50% of the allocations in the revised EU ETS, up from about 4% in phase II. Electricity producers will, by and large, receive no free allocation.[91] In other sectors, 20% of allowances will be auctioned in 2013, increasing to 70% in 2020, 'with a view to reaching 100% in 2027'.[92] The broader use of auctions in phase III is likely to improve the economic efficiency of the EU ETS. The specifics of how the auctions will be structured and implemented are still to be settled, however, and there are potential pitfalls which could undermine some of the positive effects. Making sure that auctions are not used for national interests,[93] reducing the risk of collusion among firms, and minimising administrative costs should be priorities. A reserve price in the auctions would act as a price floor in the market and increase incentives for investments in low-carbon technologies. How the revenues are used will also impact efficiency, as will the way costs, imposed on the economy by the EU ETS, are distributed among member states, industries, and households.[94]

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[89] The cap will be adjusted for changes in the coverage in the system. In 2012, the aviation sector will be included and in 2013 aluminium production and parts of the chemical industry will also be covered. Further, nitrous oxide from fertilizer production and perfluorocarbon emissions from aluminium production will also be included.

[90] Equalling 1.74% per year in the traded sectors.

[91] Certain member states are allowed an optional and temporary exemption from the rule that no allowances are to be allocated free of charge to electricity generators, as of 2013. This option is available to member states which fulfil certain conditions related to the interconnectivity of their electricity grid, the share of a single fossil fuel used in electricity production, and GDP per capita in relation to the EU-27 average. In addition, the amount of free allowances that a member state can allocate to power plants is limited to 70% of CO_2 emissions of relevant plants in phase I and declines annually thereafter. Furthermore, free allocation in phase III can only be given to power plants that were operational or under construction no later than the end of 2008.

[92] As stated in the revised EU ETS Directive. The original proposal from the Commission went further, phasing out free allocation completely by 2020.

[93] At the time of this writing, it seems very likely that each member state will holds its own auctions.

[94] The Directive stipulates that a certain percentage of auction revenues be redistributed among member states, with poorer countries getting a slightly larger share. There are no requirements regarding how member states make use of revenues, although the Directive recommends that at least 50% be used to promote climate change-related activities or investments.

There is an important exception to phasing out free allocation. Installations that 'are found to be exposed to a significant risk of carbon leakage' would receive 100% of their allocated allowances for free.[95] The Directive does not specify to which industries this provision will apply. Instead, the EU Commission will assess the risk of carbon leakage, based on direct and indirect cost increases, in relation to the gross value added for the sector, and on the trade exposure for the sector. Although quantitative criteria[96] have been established for the assessment, it will be sensitive to underlying assumptions. Future prices of allowances, trade flows, technological development, investments in new electricity-generation capacity, and currency exchange rates are all factors that will affect the result of the assessment, to name but a few. By leaving an option open for free allocation and open to discussion, the EU has encouraged lobbying by industry and member-state governments interested in protecting industries that are important to their economies. No matter the outcome of the process, it seems plausible that it will be contested by some dissatisfied stakeholders.

The third trading period will be 8 years instead of 3 (phase I) or 5 (phase II). This will diminish some of the distortions created by the previous allocation methodologies, as discussed above. It will also, however, affect efforts to reduce carbon leakage.

The primary measure proposed by the EU to mitigate carbon leakage is the free allocation of allowances to firms at risk.[97] This is likely to take some of the heat out of this sensitive discussion and silence some of the most vocal opposition to a stringent cap. However, as discussed previously, free allocation does not, in itself, alter the economic incentives that firms face at the margin. Only an expectation that future allocations will be affected by production decisions will increase the incentives for firms to maintain their activities in the EU. That is, there has to be an element of updating in order for free allocation to do more than strengthen the balance sheets of firms, for instance in the form of output-based and updated allocation. The advantage of using such a mechanism should, however, be weighed against the efficiency losses in terms of reduced incentives for conservation it would carry.

The ETS Directive also leaves open the option for border adjustments. For example, the possibility of requiring importers to surrender allowances is explicitly mentioned. There is a large and growing body of research that analyses the efficiency and desirability of such policies from economic, legal, and political science perspectives. The picture that emerges is ambiguous. Using border adjustments in the context of climate change has still not been tried legally, so whether such measures would be compatible with, for instance, the WTO is not clear. The political implications of using border adjustments, even assuming they are legal, are difficult to predict. If they result in less political will to cooperate multilaterally, the measures could prove counterproductive. Analyses of the economic incentives resulting from various kinds of border adjustments require detailed information on firm characteristics, trade sensitivities, substation elasticities between products, etc. Further, as noted by Fischer and Fox (2009), the environmental effectiveness of import adjustments depends on how well they reflect the actual emission intensities of products (sometimes referred to as 'embedded emissions'), while the competitiveness depends on how large the adjustments are for imported

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[95] I.e., their share in the annually declining total quantity of allowances. The share of these industries' emissions is determined in relation to total EU ETS emissions from 2005 to 2007.

[96] The EU Commission states that assessments will be based on 'inter alia, whether the direct and indirect additional production costs induced by the implementation of the EU ETS Directive, as a proportion of gross value added, exceed 5%, and whether the total value of its exports and imports divided by the total value of its turnover and imports exceeds 10%. Further, if the result for either of these criteria exceeds 30%, the sector would also be considered as having a significant risk of carbon leakage'.

goods that may substitute those produced domestically. Finally, import adjustments do nothing to support domestically produced goods that are exported. Export rebates could do this, but that option is not explicitly mentioned in the ETS Directive.

A comprehensive analysis of potential measures to mitigate carbon leakage is beyond the scope of this article, but clearly current EU climate policy expects that major trading partners will implement comparable policies. A situation with significant asymmetries in the price of emissions, and a plethora of policies introduced to adjust for them, is obviously second best. Political signals for more progressive climate policies emerging from countries, such as the United States and China, suggest that measures to mitigate carbon leakage should be transitional rather than long term. Assessments of the efficiency and appropriateness of such measures should be made in this light.

The initial years of the EU ETS have provided a large-scale testing ground for trading a new environmental commodity. The lessons learned are diverse and not all experiences are positive. Further, the future development of the EU ETS is closely tied to the international climate policy regime, and linking the EU ETS to other trading systems could require changes in its design. Nevertheless, invaluable information has been gained from the EU ETS. Policy makers would be wise to make use of it, be they supporters of emissions trading or sceptics of such policies.

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