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What Have We Learnt from the European Union's Emissions Trading System?

Markus Wråke, Dallas Burtraw, Åsa Löfgren, Lars Zetterberg

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Abstract The EU Emissions Trading System (ETS) demonstrated the ability to design and launch a large-scale trading system in a short period of time. The path from initial reticence about emissions trading to implementation of the world's largest program is an important history. Three issues play a large role in the evaluation of the program to date and its on-going development: allocation plans, cost uncertainty, and leakage of emissions to abroad. Decisions in Phase I and II (2005–2012) were responsive to questions of political feasibility and implementation, but some of these decisions including allocation in particular will be substantially revised in Phase III (2013–2020).

Keywords Emissions trading · Carbon dioxide · Climate change · EU ETS

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). The EU ETS includes some 12 000 installations, representing ~45% of EU emissions of CO_2. It covers 6 gases in total, in 27 countries and 502 million people; making it by far the largest emissions trading system in the world. This article provides a synthesis of the most contentious issues surrounding the EU ETS and background to the implementation of the system. We conclude with a look towards the future, highlighting forthcoming revisions and issues that remain unresolved.

European environmental policy has traditionally been dominated by command and control-policy instruments. Experience with incentive-based instruments has primarily been with taxes.[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 effort met intense resistance from industry and some member states that were anxious to keep exclusive national sovereignty in this area. As a result, the political momentum gradually shifted away from a common tax. At the time, emissions trading were widely regarded with great scepticism in Europe, where the experience with this type of policy instrument was limited due to the unanimity rule imposed in EU fiscal matters that enables one country to block the proposal of a CO_2 tax. In contrast, the ETS was considered a matter of environmental policy and had a comparatively easier way forward.

In this article, we survey the development of the ETS and then present how the program has addressed its most contentious issues. These include the setting of the cap, allocation of emissions allowances, regulation of the electricity sector, uncertainty, and international competitiveness. In concluding remarks, we discuss the continuing evolution of the program.

From Unwanted Idea to Directive

A central factor in the turnabout that ultimately resulted in the creation of the EU ETS 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) (Skjaerseth and Wettestad 2008). The Kyoto Protocol required signatories to show "demonstrable progress" in reducing emissions by 2005 (UNFCCC 1998). The EU, which in the negotiations had

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

been negative to flexible mechanisms, 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 (European Commission 1998).

The 2001 proposal for the EU ETS Directive (European Commission 2001) chose a decentralized approach, giving significant discretion to the member states regarding the number of allowances they could allocate. It also proposed that the initial allowances be allocated free of charge as the basic allocation principle for the first trading period 2005–2007. Concurrently, Denmark and the UK 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 (Zapfel and Vainio 2002).

In the political negotiations that followed, it quickly became clear that the European Parliament (EP) would like to see a larger proportion of allowances allocated by auction and broader coverage of the system, whereas the European Council largely defended the Commission proposal. The mounting political pressure to get a directive accepted during 2003 resulted in an agreement in July, and the final directive was adopted in October of the same year. Its key features were a largely decentralized approach to allocation with at least 95% of allowances allocated free of charge. The system covered CO_2 emissions from four main "activities" (European Union 2003, Annex I):

- Energy, including combustion installations with a rated thermal input above 20 MW, 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.

In sum, in less than a decade the idea of emissions trading in the European Union developed from seemingly politically impossible, to practical implementation.

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

Several general characteristics of the ETS have attracted the concern of scholars, but perhaps also have been central to its success, including the degree of autonomy left to member states, the exclusion of sectors with fully half of total emissions, and insufficient linkage with those sectors and with other opportunities for low-cost emissions reductions. These characteristics shaped several specific features of the program.

Setting the Cap

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

In phases I and II of the EU ETS each member state has been responsible for spelling out in a National Allocation Plan (NAP) the allocation of allowances to the emissions-producing installations in its territory that was to be included in the trading program. The tradable assets in the ETS are denoted European Union allowances (EUA), each permit representing 1 ton of CO_2 emitted. The total emissions cap in the trading system is the total number of EUAs, which 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 (European Union 2003, Annex III).

In the first trading period, the European Commission aimed to ensure that allocations were not too generous using two principal criteria. First, the total number of allowances 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.

Setting up the NAPs turned out to be complex and sometimes controversial, characterized by lobbying and strategic interaction between industry, member states, and the European Commission (Ellerman et al. 2007). In the end, the European Commission decided to reduce the proposed totals in 14 of the 25 proposed phase-I NAPs, representing about 5% of the total cap. Still, Zetterberg et al. (2004) and others indicate that 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 relation to the EU Kyoto target compared with sectors outside the trading system. Consequently, the trading system was criticized for not being stringent enough even before it was launched.

Nevertheless, the first year of trading saw prices of emission allowances that were higher than many observers had expected, peaking at over 30 € per ton early in 2006 (Fig. 1). This sparked calls from energy intensive industries to scrap the system.

Source: Point Carbon

Most of these calls fell silent as the first verified numbers of emissions for 2005 were published in April 2006 showing

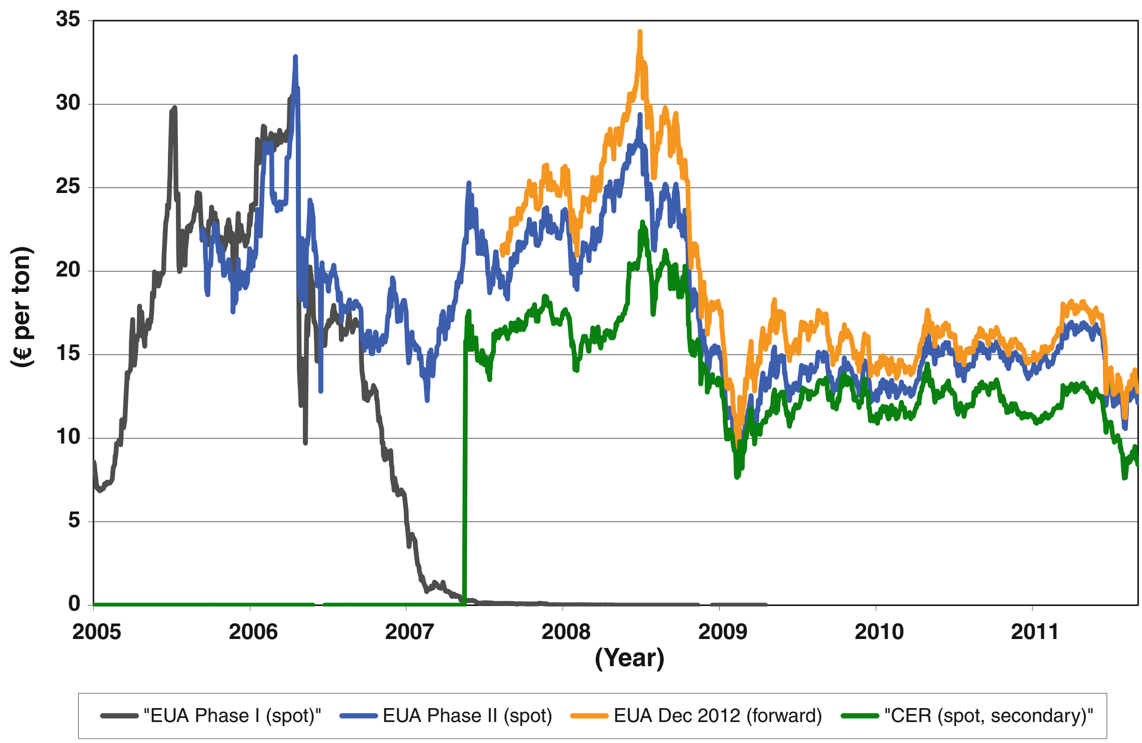

Fig. 1 Price of EU allowances (EUA) in the EU ETS (daily prices)

that the market held too many allowances. This information caused EAU prices to fall dramatically and by mid-2007 they reached near-zero levels. The empirical literature assessing the effect of the EU ETS on abatement is still scarce, but some level of abatement is known to have occurred. It seems unlikely that phase I of the EU ETS led to significant reduction in CO_2 emissions compared with business-as-usual; however, it is difficult to determine to what extent abatement measures were implemented (Ellerman and Buchner 2006; Widerberg and Wråke 2009; Ellerman et al. 2010).

Very low allowance prices in phase II (2008–2012) would have seriously jeopardized 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 to reach their reduction targets, although this option is limited by the Kyoto Protocol, which stated that JI and CDM should be "supplementary" to domestic action. As a final resort, a member state could buy Kyoto emission credits (AAUs) from countries outside the EU ETS (for instance, Russia or Ukraine), but that would be politically controversial.

In order to avoid this situation, the European Commission repeatedly stated its intention to tighten the cap during the second trading period. It laid out new principles for the NAPs, making verified emissions for 2005 the basic yardstick for the assessment. The European Commission again required significant cutbacks in several of the proposed allocation plans, averaging about 10% of the proposed allocation volumes. During phase II the EUA price has been fairly stable indicating that information on emissions and allocations is more readily available and better understood.

Free Allocation or Not?

A central question that grew in visibility and importance over time is how the emission allowances are initially distributed among participants. A fundamental choice is whether firms should receive allowances for free or if they should have to pay for them through an auction. Most economists have argued that an auction is crucial for an efficient allocation of emissions rights, for equity reasons and for implementing the polluter-pays principle (Cramton and Kerr 2002; Goeree et al. 2010). This is now also well recognized by the EU (European Commission 2008). Since background on this issue and the efficiency and equity properties of each option are covered in depth by Zetterberg et al. (2012 [this issue]), we mention here only one aspect; the relevance of allocation for changes in downstream prices. This issue became especially relevant for electricity consumers.

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 politically controversial. To many energy intensive industries, the indirect effects of increased electricity price have a greater economic consequence than the direct costs of allowances. Studies of 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 increase in electricity prices are significantly higher than direct costs for emission allowances. 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, adding to political sensitivity. 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. Concerns over negative effects on energy intensive industries and criticism related to equity and fairness have featured prominently, and 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.

If markets are competitive, the change in product prices should not depend on whether the allocation is free of charge or not. Since allowances can be traded in a market, their price represents their opportunity cost when they are used; hence, their opportunity cost does not depend on whether they were initially purchased or received for free. Under the assumption that markets are competitive, the opportunity cost of allowances will be reflected in the downstream price of electricity or other products equally in either case (Wråke et al. 2010).

Nevertheless, many people disapprove when product prices increase, especially if it means that regulated firms profit under the trading program. Although, economists may discount the argument, free allocation is frequently put forward as a means of reducing downstream price effects. Occasionally, industry has reinforced this view.

When electricity prices appeared to rise to reflect the opportunity costs of allowances, as anticipated by economic theory, many consumers including electricity-intensive industrial entities observed that electricity firms were charging customers for allowances that had been received for free. This inflamed concerns about "windfall profits" for electricity generators, which became one of the most contentious issues in the ETS.

There are two kinds of "windfall profit". Firms make *direct* windfall profits when they are given more allowances than they need, and then sell their excess on the market. Firms also incur costs in reducing emissions, which makes the calculation of windfall profits a complex exercise. However, *indirect* windfalls may be more important. Because electricity prices in competitive markets are determined by marginal production—which in Europe is dominated by fossil fuel—electricity prices that include the opportunity cost of emissions allowances determine the revenue for all generated electricity, including that from nuclear, biomass, and hydro.

There remain strong, opposing views regarding how the EU ETS interacts—or should interact—with electricity markets. Pricing in electricity markets is complicated by the special character of these markets, particularly their network externalities, and by the concentration of some markets. Furthermore, many of the large European energy companies are publicly owned, which increases the possibility that their pricing strategies may deviate from pure profit maximization. In this case, indeed electricity prices might be affected by the way allowances are distributed initially.

Studies on price effects of emissions trading include the econometric time series analyses of Bunn and Fezzi (2007) in the UK 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, leading to increased revenues to electricity generators whether they receive allowances for free or at auction. This evidence has contributed to the rationale for changing the allocation process during the third phase of the ETS.

Uncertainty and Price Volatility

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 predictability to market actors. Uncertainty over prices in products or inputs will, on average, delay investments (IEA 2007; Laurikka 2006; Philibert 2006). 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. This is particularly relevant in capital-intensive sectors where investment cycles may stretch over several decades. Consequently, many observers have pointed to policy-induced uncertainty as a drag on the effectiveness of the EU ETS.

However, policy-induced uncertainty should be assessed in light of other market factors. 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 in the long run, the total risk of investments will be dominated by fuel price risk, with climate policy contributing relatively little to the total risk profile.

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 at reducing overall costs. An example is strategic public investment intended to reduce the cost impact of emissions trading by lowering marginal abatement costs. Other measures target cost volatility, 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. However, Fell et al. (2011a) find that offsets costs and abatement costs are likely to be negatively correlated so that offset availability may increase the variability in allowance prices and emissions from the regulated sector. Short-term cost variability also might be reduced by expanding the role of the offset market in response to sudden price increases in the domestic market for emissions. However, 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 (Wara and Victor 2008).

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. Increasing the length of the trading periods would reduce regulatory uncertainty, but would also limit politically the maneuvering room. Allowing firms to bank allowances, which was not permitted between phase I and II 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 minimize the 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 rationalize 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, and its analog a "price floor" that would be implemented as a reserve price in an allowance auction. The EU has been firmly opposed to such a mechanism. However, it features prominently in the US discourse on cap and trade. Some kind of safety valve has been included in an overwhelming majority of the proposals for a federal US trading system that have been put before Congress to date. Consequently, 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 a pre-determined ceiling. If the allowances are additional to the cap, the emissions target would effectively be relaxed. If, instead, allowances are borrowed from future allowance periods, the short-term problem of price spikes may be mitigated, but not the potential long-term problems of escalating prices and costs (Pizer 2002; Kopp et al. 2002; Murray et al. 2008).

The safety valve has been criticized from several perspectives. If the safety valve introduces additional allowances, it 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, and to date the problem in emissions trading systems has not been unforeseen price rallies, but rather much lower prices than expected. Lower-than-expected costs are, of course, not a problem if the cap is the optimal one. However, the intention of the EU is to gradually tighten the cap, striking a balance between increasing stringency and limiting costs. In this situation, a safeguard not only against higher-than-expected costs but also against lower-than-intended prices may be called for.

Burtraw et al. (2010), Philibert (2008) and Palmer et al. (2008) show how a political commitment to a price floor would work in the opposite direction of a safety valve and analyze 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 with 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 resulting in maintained investments and emissions. 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, and the uncertainties in prices and abatement costs are replaced by uncertainties in emissions. Fell et al. (2011b) show that a limited commitment to sell allowances at the price ceiling or to withdraw allowances at the floor captures the lion's share of benefits of a price regulation, while preserving the appeal of a quantity target (Fig. 2).

To summarize, 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. Hence, 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.

Competitiveness Issues: Myth and Reality

Modern history has plenty 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. The debate in EU related to competitiveness has primarily been focused on European industry vis-á-vis the outside world. In the literature on the impact of environmental policy on trade flows 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, the "Porter hypothesis" (Porter and van der Linde 1995),

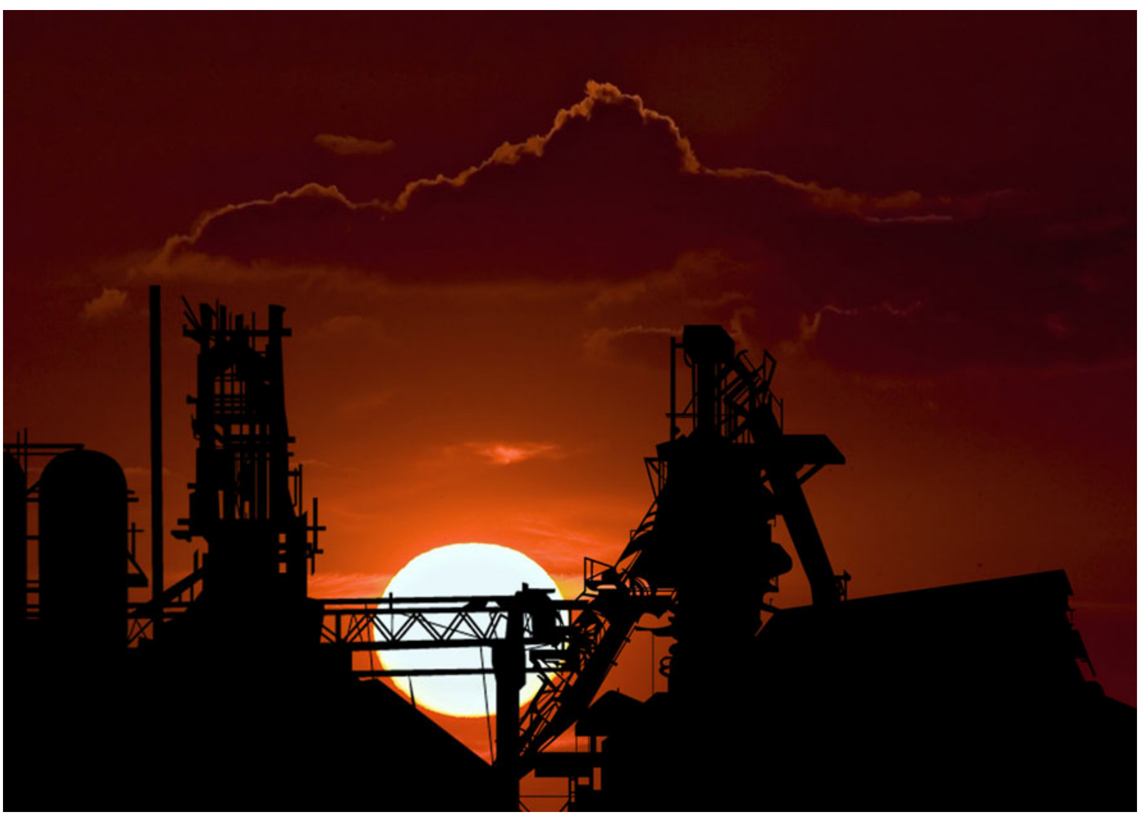

Fig. 2 The European trading system is by far the largest emissions trading system in the world; covering 6 gases, 27 countries and 502 million people

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 rates and labor cost, eventually balancing out gains in competitiveness defined in this way. Consequently, other measures have been put forward (Brännlund 2008) 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.

From a regulator's perspective, it may not be a problem if output in one sector is reduced in favor 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. This effect, often referred to as *carbon leakage*, has raised much concern among EU industry.

Usually carbon leakage is defined as emissions increase in countries outside the policy regime in relation to the reduction in emissions in the region under 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. A more subtle version of this is altered patterns of reinvestments; even if firms keep existing capital stock in place, they may prioritize 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 (Morgenstern et al. 2007).

There is also a general equilibrium effect that has the potential to generate carbon leakage. A 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.

Most empirical studies of the EU ETS have focused on identifying what sectors are at risk for leakage (Reinaud 2005a, 2005b, 2008a, Smale et al. 2006; Hourcade et al. 2007; Graichen et al. 2008; de Bruyn et al. 2008; and Zetterberg and Holmgren 2009). Two factors have received particular attention: exposure to international trade and what allowance values associated with the EU ETS are achieved. 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 analyzing the risk of carbon leakage gives a rough indication of which sectors are most vulnerable although certainly an incomplete picture.

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 is generally ranked among the highest in the EU. However, due to its relative insulation from international competition, 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 found to be most vulnerable to increasing costs of carbon. The chief reason is the high proportion of international trade in these sectors.

To quantify 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 identify causal relationships. 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 name just a few parameters. Furthermore, capital-intensive sectors, such as those identified as most at risk, are typically characterized by a high inertia due to long investment cycles and significant fixed costs.

Hence, it is not surprising that ex-ante studies of both the EU ETS and other planned or potential climate policies display a wide range of results. 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. For example, looking for effects on trade flows, Lacombe (2008) finds no significant changes in petroleum products, Reinaud (2008b) reports no significant effects in aluminum trade, and Demailly and Quirion (2008) find no changes in trade flows in Iron and steel, 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. We 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.'

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.

CONCLUDING REMARKS

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. 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.

The "climate and energy package", which was agreed by the EP and Council in December 2008 and which became law in June 2009, addresses a number of the problems with the initial design of the EU ETS. For the EU ETS, this means that substantial changes will come, as of January 1, 2013, the start of the third trading period which will be 8 years instead of 3 (phase I) or 5 (phase II). The most fundamental change is that the cap is set centrally at the European level instead of each member state drawing up a NAP. This 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 average total quantity of allowances allocated by member states in 2008–2012, decreasing linearly to a 21%-reduction below 2005 levels by 2020. Further the annual reduction rate of 1.74% per year in the traded sectors is legally binding beyond 2020, unless a new decision is made. The cap will be adjusted for changes in the coverage in the system. In 2012, the aviation sector will be included and in 2013 aluminum production and parts of the chemical industry will also be covered. Further, nitrous oxide from fertilizer production and perfluorocarbon emissions from aluminum production will also be included. 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 the EU decide to move to an overall 30% reduction target by 2020, perhaps as part of an international agreement, the cap of the ETS will be adjusted downward proportionally. Nonetheless, these ambitions should be considered in the context of the background framework of the IPCC, which asks for a reduction of 80–95% by 2050.

The reductions imposed on the sectors in the trading program are larger than what an equal burden among sectors (in terms of absolute emission reductions) would imply. The underlying rationale is that the EU expects the trading sectors to have lower abatement costs. This contrasts to phase I and II, when traded sectors received a relatively generous cap imposing the need for greater relative reductions in sectors outside the system. This is further evidence of the political pragmatism that influenced central elements of phase I and 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 as of 2013, although some 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.[2] In other sectors, 20% of allowances will be auctioned in 2013, increasing to 70% in 2020, "with a view to reaching 100% in 2027". This is somewhat different from the original proposal from the Commission that went further, phasing out free allocation completely by 2020. 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, reducing the risk of collusion among firms, and minimizing 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. 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 by the EU to be exposed to a "significant risk of carbon leakage" would receive 100% of their allocated allowances for free, 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. The Directive does not specify to which industries this provision will apply. Instead, the European Commission has assessed 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. The allocation to vulnerable sectors will be based on benchmarks.

Free allocation of allowances is the primary measure proposed by the EU to mitigate carbon leakage. 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.

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 body of research that analyses the effects 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, substitution 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 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.

So far the EU seems to build its climate policy under the assumption that major trading partners will, over time, implement comparable policies. This suggests 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.

[2] 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.

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REFERENCES

Brännlund, R. 2008. *Miljöpolitik utan kostnader? En kritisk granskning av Porterhypotesen* [*Environmental policy at no cost? A critical review of the Porter hypothesis*]. Report to the expert group on environmental studies 2007: 2. Stockholm: Swedish Ministry of Finance (in Swedish).

Bunn, D.W., and C. Fezzi. 2007. *Interaction of European carbon trading and energy prices*. FEEM Working Paper, No. 63, 2007. Milan: Fondazione Eni Enrico Mattei.

Burtraw, D., K.L. Palmer, and D.B. Kahn. 2010. A symmetric safety valve. *Energy Policy* 38: 4921–4932.

Copeland, B.R., and M.S. Taylor. 1994. North–South trade and the environment. *Quarterly Journal of Economics* 109: 755–787.

Cramton, P., and S. Kerr. 2002. Tradeable carbon permit auctions: How and why to auction and not grandfather. *Energy Policy* 30: 333–345.

de Bruyn, S., D. Nelissen, M. Korteland, M. Davidson, J. Faber, and G. van de Vreede. 2008. *Impacts on competitiveness from EU ETS: An analysis of the Dutch industry*. Delft: CE Delft.

Demailly, D., and P. Quirion. 2008. European emissions trading scheme and competitiveness: A case study on the iron and steel industry. *Energy Economics* 30: 2009–2027.

Ellerman, A.D., and B. Buchner. 2006. *Over-allocation or abatement? A preliminary analysis of the EU ETS based on the 2005 emissions data*. FEEM Working Paper No. 139.06. Milan: Fondazione Eni Enrico Mattei.

Ellerman, A.D., B. Buchner, and C. Carraro, eds. 2007. *Allocation in the European emissions trading scheme: Rights rents and fairness*. Cambridge: Cambridge University Press.

Ellerman, A.D., F.J. Convery, and C. de Perthuis. 2010. *Pricing carbon: The European union emissions trading scheme*. Cambridge: Cambridge University Press.

European Commission. 1998. Climate Change: Towards an EU Post-Kyoto strategy. Commission Communication to the Council and the Parliament. COM (98) 353.

European Commission. 2001. *Proposal for a directive of the European Parliament and of the Council establishing a framework for greenhouse gas emissions trading within the European Community and Amending Council Directive 96/61/EC* (23 October).

European Commission. 2008. MEMO/08/35, Brussels, 23 January 2008. Questions and answers on the Commission's proposal to revise the EU Emissions Trading System.

European Union. 2003. Directive 2003/87/EC of the European Parliament and the Council of 13 October 2003 establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and amending the Council Directive 96/61/EC.

Fell, H. 2008. *EU-ETS and Nordic electricity: A CVAR analysis*. Elforsk report 08:57. Stockholm: Elforsk Market Design.

Fell, H., D. Burtraw, R. Morgenstern, K. Palmer, and L. Preonas. 2011a. *Soft and hard price collars in a cap-and-trade system: A comparative analysis*. RFF discussion paper 10–27-REV. Washington, DC: Resources for the Future Discussion Paper.

Fell, H., D. Burtraw, R. Morgenstern, and K. Palmer. 2011b. Climate Policy Design with Correlated Uncertainties in Offset Supply and Abatement Cost, *Land Economics,* forthcoming.

Fischer, C., and A.K. Fox. 2009. *Comparing policies to combat emissions leakage: Border tax adjustments versus rebates*. RFF Discussion Paper 09-02. Washington, DC: Resources for the Future.

Goeree, J.K., K. Palmer, C.A. Holt, W. Shobe, and D. Burtraw. 2010. An experimental study of auctions versus grandfathering to assign pollution permits. *Journal of the European Economic Association* 8: 514–525.

Graichen, V., K. Schumacher, F. Matthes, L. Mohr, V. Duscha, J. Schleich, and J. Diekmann. 2008. *Impacts of the EU emissions trading scheme on the industrial competitiveness in Germany. Report prepared for the Federal Environment Agency*. UBA Climate Change 10/08. Dubai: FEA.

Harrington, W., R. Morgenstern, and P. Nelson. 2000. On the accuracy of regulatory cost estimates. *Journal of Policy Analysis and Management* 19: 297–332.

Hourcade, J.-C., D. Demailly, K. Neuhoff, M. Sato, M. Grubb, F. Matthes, and V. Graichen. 2007. *Differentiation and dynamics of EU-ETS industrial competitiveness impacts. Climate strategies series.*. Paris and Cambridge: CIRED and University of Cambridge Electricity Policy Research Group.

IEA (International Energy Agency). 2007. *Climate policy uncertainty and investment risk*. Paris: IEA.

Kopp, R., R. Morgenstern, W. Pizer, and F. Ghersi. 2002. Reducing cost uncertainty and encouraging ratification of the Kyoto Protocol. In *Global warming in the Asian-Pacific*, ed. R. Mendelsohn, and D. Shaw. Cheltenham and Camberley: Edward Elgar Publishing.

Lacombe, R. 2008. *Economic impact of the European Union Emission Trading Scheme: Evidence from the refining sector*. Master thesis. Cambridge: MIT.

Laurikka, H. 2006. Option value of gasification technology within an emissions trading scheme. *Energy Policy* 34: 3916–3928.

Morgenstern, R., J. Aldy, E. Herrnstadt, M. Ho, and W. Pizer. 2007. *Competitiveness impacts of carbon dioxide pricing policies on manufacturing*. RFF Issue Brief 7. Washington, DC: Resources for the Future.

Murray, B., R. Newell, and W. Pizer. 2008. *Balancing cost and emissions certainty: an allowance reserve for cap-and-trade*. RFF Discussion Paper 08-24. Washington, DC: Resources for the Future.

Palmer, K., D. Burtraw, and M. Wråke. 2008. *Managing Cost Variability in Emissions Allowance Markets*. Elforsk Report 08-56. Stockholm: Elforsk Market Design.

Philibert, C. 2006. *Certainty versus ambition: Economic efficiency in mitigating climate change*. IEA Working Paper Series. Paris: IEA

Philibert, C. 2008. *Price caps and price floors in climate policy*. IEA Information Paper. Paris: International Energy Agency.

Pizer, W. 2002. Combining price and quantity controls to mitigate climate change. *Journal of Public Economics* 85: 409–434.

Porter, M.E., and L. van der Linde. 1995. Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives* 9: 97–118.

Reinaud, J. 2005a. *European refinery industry under the EU emissions trading scheme: Competitiveness, trade flows and investment implications*.IEA Information Paper. Paris: IEA.

Reinaud, J. 2005b. *Industrial competitiveness under the European union emissions trading scheme*. IEA Information Paper. Paris: IEA.

Reinaud, J. 2008a. *Issues behind competitiveness and carbon leakage: Focus on heavy industry*. IEA Information Paper. Paris: IEA.

Reinaud, J. 2008b. *Climate policy and carbon leakage*. IEA Information Paper. Paris: IEA.

Sijm, J., K. Neuhoff, and Y. Chen. 2006. CO_2 cost pass-through and windfall profits in the power sector. *Climate Policy* 6: 49–72.

Sijm, J.P.M, S.J. Hers, W. Lise, and B.J.H.W. Wetzelaer. 2008. *The impact of the EU ETS on electricity prices: Final report to*

Directorate General of Environment of the European Commission. ECN report E-08-007. Brussels: EU.

Skjaerseth, J.B., and J. Wettestad. 2008. *EU emissions trading: Initiation, Decision-Making, and Implementation*. Aldershot: Ashgate Publishing Ltd.

Smale, R., M. Hartley, C. Hepburn, J. Ward, and M. Grubb. 2006. The impact of CO_2 emissions trading on firm profits and market prices. *Climate Policy* 6: 31–48.

Wara, M., and D. Victor. 2008. *A realistic policy on international carbon offsets*. Working Paper No. 74. Stanford: Stanford University.

Widerberg, A., and M. Wråke. 2009. *The impact of the EU ETS on CO_2 intensity in electricity generation*. IVL Report. Stockholm: IVL Swedish Environmental Research Institute Ltd.

Wråke, M., D. Burtraw, C. Holt, S. Mandell, and E. Myers. 2010. Opportunity cost for free allocations of emissions permits: An experimental analysis. *Environmental & Resource Economics* 46: 331–336.

UNFCCC (United Nations Framework Convention on Climate Change). 1998. *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. New York: United Nations. http://unfccc.int/resource/docs/convkp/kpeng.pdf.

Zapfel, P., and M. Vainio. 2002. *Pathways to European greenhouse gas emissions trading: history and misconceptions*. FEEM Working Paper 85, 2002. Milan: Fondazione Eni Enrico Mattei.

Zetterberg, L., K. Nilsson, M. Åhman, A.-S. Kumlin, and L. Birgersdotter. 2004. *Analysis of national allocation plans for the EU ETS*. IVL Report B1591. Stockholm: IVL Swedish Environmental Research Institute Ltd.

Zetterberg, L., and K. Holmgren. 2009. *Sectoral agreements and competitive distortions: A Swedish perspective*. IVL Report B1835. Stockholm: IVL Swedish Environmental Research Institute Ltd.

Zetterberg, L., M. Wråke, T. Sterner, C. Fischer, and D. Burtraw. 2012. Short-run allocation of emissions allowances and long-term goals for climate policy. *AMBIO*. doi:10.1007/s13280-011-0238-1.

AUTHOR BIOGRAPHIES

Markus Wråke (✉) is a Senior Energy Analyst at the International Energy Agency (IEA), where he leads the work on Energy Technology Perspectives, the flagship publication on energy technology at the IEA. Markus Wråke holds a PhD. in Environmental Management and Economics from the University of Gothenburg and a M.Sc. in Environmental Engineering from Uppsala University. He has worked on energy policy, technology and climate change for over a decade, and has published numerous scientific papers and book chapters, as well as a large number of reports and working papers.
Address: International Energy Agency, 9 rue de la Féderation, 75239 Paris, France.
e-mail: markus.wrake@iea.org

Dallas Burtraw is Senior Fellow and Darius Gaskins Chair at Resources for the Future in Washington DC. Burtraw holds a Ph.D. in economics and a master's degree in public policy from the University of Michigan and a bachelor's degree from the University of California, Davis. Burtraw's research includes the design of environmental regulation, the costs and benefits of environmental regulation, and the regulation of the electricity industry. Burtraw has published numerous academic papers, as well as a large number of reports and working papers.
Address: Resources for the Future, 1616 P Street NW, Washington, DC 20036, USA.
e-mail: Burtraw@rff.org

Åsa Löfgren is Associate Professor at the Department of Economics at the University of Gothenburg. Löfgren's research covers issues related primarily to the economics of climate change, in particular different aspects of policy instruments, fairness, and industrial investment behavior. She has published numerous academic papers, working papers, book chapters and reports and serves as a referee for several academic journals. Löfgren also teaches environmental economics both at the undergraduate and graduate level.
Address: University of Gothenburg, P.O. Box 640, 405 30 Göteborg, Sweden.
e-mail: asa.lofgren@economics.gu.se

Lars Zetterberg is a Senior Scientist and director Business Development at IVL Swedish Environmental Research Institute. Zetterberg holds a Ph.D. in Physical Geography from the University of Gothenburg and a M.Sc. in Engineering Physics from Chalmers University of Technology. Zetterberg's research focuses on design and economic analyses of emission trading systems, pathways to low carbon economies and the role of bioenergy in climate mitigation. Zetterberg has published several academic papers and written a large number of reports and policy briefs.
Address: IVL Swedish Environmental Research Institute, P.O. Box 210 60, 10031 Stockholm, Sweden.
e-mail: lars.zetterberg@ivl.se