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Tradable rights to emit air pollution*

Dallas Burtraw and David A. Evans[†]

The use of cap-and-trade to regulate air pollution promises to achieve environmental goals at lower cost than traditional prescriptive approaches. Cap-and-trade has been applied to various air pollutants including sulphur dioxide, nitrogen oxides and volatile organic compounds in the United States and carbon dioxide (CO₂) in the European Union. This corresponds to what is likely to become the most expensive environmental undertaking in history – the effort to reduce the heating of the planet. However, the efficacy of a cap-and-trade policy for CO₂ depends in large part on the design of the program. In addition to the level of the cap, the most important decision facing policymakers will be the initial allocation of emissions allowances. The method used to allocate tradable emissions allowances will have significant influence on the distributional impact and efficiency of the program.

Key words: allocation, auction, cap-and-trade, carbon dioxide, climate change, emission allowances, global warming, grandfathering.

1. Introduction

The expanded use of incentive-based approaches to environmental regulation promises that environmental goals can be achieved at less cost than traditional prescriptive approaches. This evolution in policy and its corresponding promise is timely, as society considers undertaking what will likely be the most expensive environmental initiative in history – the effort to reduce the heating of the planet. Because the cost could be so great, it is important for the success of climate policy that it be achieved in an efficient manner. This imperative places incentive-based approaches at centre stage in the design of climate policy.

For a variety of reasons, an incentive-based approach, in particular the use of cap-and-trade, seems especially well suited to climate policy. Carbon dioxide (CO₂) is a uniformly mixing pollutant in the atmosphere, and its damage is not related importantly to the location or timing of its emissions. Consequently, the administration of a cap-and-trade system is much simpler for CO₂ than

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for a pollutant that has an important spatial or temporal dimension (Tietenberg 2006). Furthermore, there is tremendous variation in the cost of emissions reductions among agents in the economy, and indeed among nations. The gains from trade are greater the more heterogeneous are the control costs of affected sources, and therefore a cap-and-trade program leads to much lower overall compliance costs than traditional pollution control methods (Newell and Stavins 2003).

Incentive-based regulation describes a variety of approaches, such as cap-and-trade, emissions taxes, deposit-refund systems, fee-bates and even some types of subsidies. In this paper we focus on the use of cap-and-trade to achieve reductions in air pollution emissions in general, and draw lessons from the literature and previous experiences with emissions allowances markets to identify desirable qualities of a cap-and-trade program for CO₂. Most of our focus is on the United States, which has substantial experience with cap-and-trade and where such policies are currently being considered for regulating greenhouse gases (GHGs). We also draw on lessons from the European Union, which launched the world's largest cap-and-trade program in 2005. The next section broadly describes the evolution of cap-and-trade programs for air pollution. This is followed by an introduction to the conceptual reasons that cap-and-trade can be an advantageous approach for climate policy, and a discussion of how the architecture of cap-and-trade for CO₂ should differ from that used to control other air pollutants.

The size of the emissions cap is the most visible and important aspect of cap-and-trade policy, but the most critical issue facing policymakers in the design of the policy is the initial distribution, or 'allocation' of emissions allowances. In the United States, the allocation of emissions allowances under a CO₂ program would constitute the largest creation and distribution of new property rights in over a century. The assignment of the value of these rights affects both the efficiency and distributional consequences of the program. How allocation will occur, and how other aspects of climate policy in the United States might be organised, may be determined by the legal authority created by previous legislation. Thus, we conclude with a survey of the institutional factors that influence future policy in the United States. These influences could lead to dramatically different approaches to climate policy and to the organisation of markets under a cap-and-trade program, and there is a range of possible outcomes.

2. Background

Incentive-based approaches, such as cap-and-trade, work by providing the regulated entity with incentives to change behaviour, but leaving it up to the entity to decide how, where and when to do so. These approaches contrast with prescriptive regulations, which include various types of policies sometimes described as 'command-and-control' because they direct regulated parties to take specific actions. Incentive-based approaches are relatively innovative,

while prescriptive regulation includes the vast majority of extant environmental regulations, including those governing facility permitting and operation, and standards that require the use of particular pollution-control technologies.

As the name implies, a cap-and-trade approach has two elements. The emissions cap represents the maximum allowable emissions that can occur in the aggregate over all regulated emissions sources. Emissions allowances are denominated per unit of emissions (e.g. per ton), and every regulated source is required to surrender an emissions allowance on every unit it emits. While both the regulator and regulated sources view the surrender of allowances as a requirement to the regulated sources, an allowance also presents a valuable and scarce right to emit.

The second element of cap-and-trade is that emissions allowances can be bought and sold, and if banking is allowed they can be saved for use in future periods. Each firm must decide whether to comply with the law by holding more allowances and pursuing less emissions reduction, or by selling allowances and pursuing greater emissions reduction. Firms with relatively high marginal costs for pollution control are expected to compensate firms with low marginal costs for extra emissions reductions through purchase so that together they meet the emissions cap. The scarcity of emissions allowances determines their market price.

The key attraction of emissions trading is the expectation that giving firms the flexibility to trade emissions allowances will lead to a distribution of emissions reductions that equates the marginal cost of emissions reductions among all the firms regulated under the emissions cap, and thereby minimises the overall compliance cost of meeting the cap. The environmental goal remains the prerogative of policymakers, but once the cap is set, emission trading promises a cost-effective way to achieve that target and requires little information of the regulator regarding compliance costs.

Emissions trading took a long time to come to fruition in public policy. Pigou (1920) was the first economist to suggest that incentive-based environmental policies, specifically an emissions fee, would be a way to internalise the environmental costs of pollution into private decisions. Emissions trading was identified as an alternative far later when Crocker (1966) proposed that the government set a cap on aggregate emissions and let the market determine the degree of abatement at individual facilities and the price of emissions, rather than having the government set the price through an emissions fee.

The earliest application of trading emissions rights simply introduced flexibility to the traditional way of implementing environmental regulation. In the late 1970s, the U.S. Government began to impose sanctions such as restrictions on highway funds on areas of the country that were in 'non-attainment' with local ambient air quality standards.¹ It was also recognised

¹ Despite being standards for local air quality, these standards are set by the federal government. They are called National Ambient Air Quality Standards.

that these standards and sanctions might restrict economic growth in regions in violation of the standards. The introduction of emissions trading provided a way for localities violating these air quality standards to continue to enjoy economic development without further increasing emissions. To accomplish this, the U.S. Environmental Protection Agency (EPA) designed a system whereby new emitting sources could pay existing sources to reduce their emissions sufficiently to 'offset' any increase in emissions. Related programs included the 'bubble' policy that allowed a facility to comply with a standard defined over multiple sources, rather than having to comply with individual restrictions for each source. In the 1977 Clean Air Act Amendments, Congress recognised the offset policy in law and also made it possible for existing sources to bank emissions reductions for later use. While an improvement from the status quo, these programs constituted an informal market in which property rights were not well defined. Trades had to be preapproved by the environmental regulator. There was limited ability to bank, some unused emissions reduction credits expired, and the transaction costs for each trade approached 50 per cent of the value of the trade.

The first large application of cap-and-trade began with the 1990 Clean Air Act Amendments that launched the sulphur dioxide (SO₂) trading program (Burtraw *et al.* 2005). The program was introduced in two phases with the annual distribution of SO₂ emission allowances ultimately capped at 8.95 million tons, which is roughly half of the level emitted by electricity generators in 1980. In the early years of the program, annual emissions were expected to be less than the annual introduction of new allowances in order to build the allowance bank. This was followed by a period when emissions exceeded allocations as the bank was drawn down. Prior to the introduction of new regulations on SO₂ under the 2005 Clean Air Interstate Rule, by 2010 annual emissions were expected to fall to a level approximately equal to the annual allocation of allowances. The administrative performance of the SO₂ program has been nearly perfect, with virtually 100 per cent compliance and unexpectedly little litigation.

The economic performance of the program also attracts attention. One frequently cited measure of the SO₂ allowance market's success has been the observation that allowance prices are substantially lower, by a factor of four, than the EPA and others predicted at the time the program was adopted. This difference stemmed not directly from trading, but primarily by the expanded availability and reduced cost of low-sulphur coal due largely to changes in shipping costs. However, trading deserves substantial credit because every other approach used previously under the Clean Air Act, and nearly every other approach used in the 1990 amendments, would have likely precluded affected sources from fully capitalising on this advantageous trend in fuel prices. Although a number of studies used engineering estimates to project cost savings from trading, two major studies used empirical methods. Carlson *et al.* (2000) used econometric estimates, while Ellerman *et al.* (2000) used survey methods. These two studies are largely in agreement, finding savings of 43–55 per cent compared to a uniform standard that would have

regulated the rate of emissions at a facility. However, if compared to a mandate to use post-combustion controls, as earlier legislative proposals would have imposed, Carlson *et al.* estimate the savings are twice this amount.

The second major application of cap-and-trades was in the regulation of nitrogen oxides (NO_x). One notable program began in southern California in 1994, while another was adopted by several north-east United States beginning in 1999. These NO_x programs are unlike the SO₂ program because they have been implemented at the local or state level (Burtraw *et al.* 2005). Estimates of cost savings from these programs have been based on engineering and simulation models rather than ex-post measures. Johnson and Pekelney (1996) expected the southern California program to yield cost savings of \$347 million (1987\$). Farrell *et al.* (1999) predicted compliance cost savings in the north-east program to be \$900 million (1996\$) over the period 1999–2000. The north-east NO_x program was incorporated into a federal program and expanded in 2004 to include 19 states and the District of Columbia, a region covering 70 per cent of United States summertime NO_x emissions. The market value of the annual allocation of allowances under this program is comparable to that of the SO₂ program. In 2005 the EPA adopted a cap-and-trade program for annual NO_x emissions under the Clean Air Interstate Rule, which would have taken effect in 2010.² Other smaller trading programs for NO_x as well as for volatile organic compounds also have proliferated across the United States (Evans and Kruger 2007).

The most significant development in the use of cap-and-trade has been the introduction of the Emissions Trading Scheme (ETS) for CO₂ in the European Union, which began in 2005 and now covers carbon emissions from major point sources in 27 nations. The value of the annual allocation of emissions allowances is in the range of €30–60 billion (2007€), depending on allowance prices. The second application of cap-and-trade to reduce CO₂ is the Regional Greenhouse Gas Initiative (RGGI), which will cover electricity generation in 10 north-eastern United States in 2009. Other initiatives are in development in New Zealand, Australia and Japan.

In previous trading programs the majority of emissions allowances were distributed without cost (grandfathered). A significant aspect of the new generation of cap-and-trade policies for CO₂ is the growing role of auctions for initially distributing CO₂ emissions allowances. In RGGI six of the participating states have committed to auctioning 100 per cent of their allowances, and all states are required to auction at least 25 per cent of the allowances. In the first phase of the ETS (2005–2007), 99 per cent of allowances were given away for free, and in the second phase (2008–2012) 96 per cent will be given away for free. However, in the third phase (2013–2020), over two-thirds of

² The Rule was vacated by an appellate court on July 11, 2008 in *North Carolina v. EPA*. The EPA is appealing the ruling while the Administration is pursuing the adoption of the major components of this rule through legislation.

allowances will be distributed through auction, including 100 per cent of the allowances distributed to the electricity sector. Auctions also will play an important role in New Zealand and Australia (Garnaut Climate Change Review, 2008).

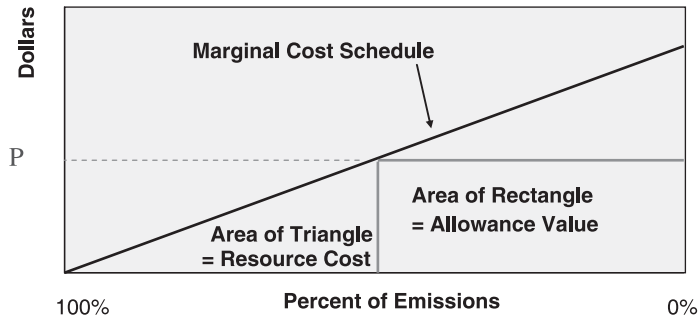
Allowances are an asset of significant value, and their value reflects the opportunity cost of emissions. The way allowance value is reflected in prices for goods and services throughout the economy is an especially important feature of the way cap-and-trade works, especially for CO₂.

3. Opportunity cost in emissions markets

There are at least two ways that incentive-based policies are thought to be more efficient than prescriptive regulation. One is that these policies are thought to promote technical efficiency by overcoming the informational constraints faced by regulators. In the abstract, one might imagine that regulators could identify the least-cost set of actions to be taken by regulated parties to achieve an environmental goal and that then the regulators could simply prescribe those actions. However, given heterogeneity among emissions sources, and private information available to firms that they may not readily reveal to the regulator, the informational problem facing regulators is enormous, and they cannot be expected to develop an efficient portfolio of prescriptive policies. Incentive-based approaches aim for incentive compatibility, such that each regulated party has an incentive to find and reveal through their behaviour the approach that minimises their own cost, and thereby the overall social cost of attaining the cap. The regulator does not need information about the cost functions or technology options of individual firms to ensure that the aggregate emissions target is achieved. Another reason that incentive-based approaches advance technical efficiency has to do with the reward to innovation. While a prescriptive policy may achieve a given level of environmental quality, it does not provide incentive to improve further beyond the prescribed policy. In contrast, to varying degrees, incentive-based approaches inherently reward ongoing technological improvement (Milliman and Prince 1989; Fischer *et al.* 2003).

The other general way that incentive-based policies reduce social cost is by promoting the efficient allocation of resources in the economy. Allocative efficiency hinges on the decisions of millions of agents, including those not directly regulated by the environmental policy. In a market economy, prices are the primary method to signal the relative scarcity of goods and services and to coordinate the actions of agents. Incentive-based approaches successfully achieve an alignment of relative prices in the economy by promoting the internalisation of the full opportunity cost of economic activity (i.e. the opportunity cost of an activity's impact on the environment as well as in its use of privately held resources). However, this efficiency advantage also presents the primary political difficulty with implementing incentive-based policies. Changes in relative prices create winners and losers in the economy,

Panel A: Opportunity cost is represented by allowance value that is roughly twice resource cost of complying with the sulfur dioxide trading program.



Panel B: Opportunity cost represented by allowance value is eighteen times compliance cost with a modest carbon dioxide trading program.

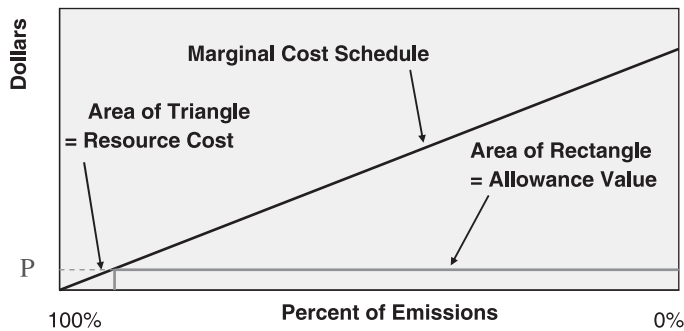


Figure 1 Why CO₂ is special: the role of opportunity cost in cap-and-trade programs.

and in the case of climate policy the changes in relative prices may be significant. This is especially true when the effect of internalising the opportunity cost of emissions on product prices is very large.

The role of opportunity cost in a cap-and-trade program is illustrated in Figure 1, where the horizontal axis is the reduction in emissions (moving to the right implies lower emissions). The upward sloping line denotes the increasing resource costs of a schedule of measures that can be adopted sequentially to achieve ever greater reductions in emissions. The schedule starts at zero, indicating that the first units of reduction are inexpensive, but the marginal cost increases with greater reductions. At the emissions cap indicated by the vertical line, the marginal cost of emissions reduction is the cost of the most recent measure adopted, which sets the allowance price because it represents the willingness to pay to avoid reducing emissions by an additional unit. The triangle that is formed is the sum of the resource costs for each incremental measure adopted.

The rectangle to the right of the emissions target represents the opportunity cost of emissions that are allowed under the cap. The height of the rectangle equals the marginal cost of reduction (or equivalently the allowance price),

Table 1 Internalisation of opportunity costs for achieving social efficiency in investment planning

(Cents/kWh)	Clean technology	Dirty technology (unabated)	Dirty technology (with abatement)
Private cost of production	6.5	4.5	4.5
Private cost of pollution abatement	–	–	1.3
External cost of residual pollution	–	3.25	1.3
Total private financial costs	6.5	4.5	5.8
Total social cost	6.5	7.75	7.1

and the width is the number of emissions allowances under the cap. The price of allowances multiplied by the quantity of emissions allowances equals the value of emissions allowances, or the opportunity cost of emissions that will be reflected in prices in a competitive economy. Panel A in Figure 1 characterises the situation for the SO₂ program created under the 1990 Clean Air Act Amendments, which called for roughly 50 per cent reduction in emissions. In this case, the value of emissions allowances (the area of the rectangle) is roughly twice the resource costs of reductions (the area of the triangle).

Panel B portrays a marginal cost schedule for reducing CO₂, and illustrates why the situation is different for CO₂. Imagine a moderate goal targeting a 10 per cent reduction in the early phase of a federal program. For such a reduction, panel B illustrates that the value of emissions allowances is about 18 times the cost of emissions reductions. Moreover, the value of the allowances (the rectangle) grows faster than the cost of emissions reductions (the triangle) as the emissions cap is tightened until reductions of about one-third are reached.³ Furthermore, because CO₂ is ubiquitous in the economy, the value depicted by the area of the rectangle in panel B is massive. The internalisation of this opportunity cost in other market prices (say for electricity or other energy-intensive goods) is politically unpopular and is one reason that regulators may be tempted to choose prescriptive approaches in place of incentive-based ones.

However, the failure to internalise the opportunity cost of emissions that is reflected in the allowance price into product prices leads to a misallocation of resources in the economy. A stylized example, with numbers taken to approximate the costs of investment in new-generation technology in the United States for wind and coal-fired generation, helps to illustrate the reason that incentive-based policies are essential for efficiency and why prescriptive policies calibrated to achieve the same outcome will not do so. Imagine an investment problem involving three technologies to produce electricity that we label a clean technology, a dirty technology with unrestricted emissions,

³ Most analyses suggest the marginal cost curve for carbon is not linear but convex (upward sloping), in which case the relationships described hold *a fortiori*.

and a dirty technology coupled with abatement technology to reduce emissions. Table 1 illustrates the private costs per kWh of electricity with each, along with the cost of abating pollution and the cost of the environmental damage that results.

Imagine the regulator chooses to use a prescriptive technology-forcing regulation on the dirty technology, described by the right column. Note that Table 1 illustrates smart regulation – if the marginal damages are constant, which is usually assumed to be the case for air pollution, and the marginal abatement cost schedule is linear, then the level of pollution reduction for the dirty technology with abatement is set at a level where the marginal cost of environmental damage equals the marginal cost of additional emissions reductions. Conditional on the choice of the generating technology, this regulation is efficient.

Faced with the choices of investing in the clean technology or the dirty technology subject to the mandate to use the abatement technology, the private investor will adopt the dirty technology because the private cost is lower. In this case the social cost, which is the sum of the private and external costs, is higher with the dirty technology than the clean technology even if it includes abatement technology. The investor does not consider the cost of the residual emissions that remain after abatement. A cap-and-trade approach with an allowance price equivalent to 1.3 cents/kWh would solve this problem. The investor would see that rather than paying both the abatement cost and the cost of allowances it requires for its additional emissions, investing in the clean technology would be less costly. The cap-and-trade program would then yield the outcome that minimises the social cost. This example illustrates that internalisation of social cost is necessary to achieve long-run efficiency in private investment decisions in the economy. This argument is made rigorously in Spulber (1985; see also Goulder *et al.* 1999).

In summary, prescribing technologies to try to achieve the efficient outcome can improve welfare, but will fall short of the efficient outcome because such an approach will not identify the most efficient investment opportunities. Moreover, because product prices are below the efficient level, prescriptive policies will not promote efficient behaviour in other economic decisions, such as the purchasing decisions of consumers who balance the cost of energy with the cost of energy-efficient appliances. Specifically, prescriptive policies fail to internalise the opportunity cost of emissions. In a cap-and-trade program that opportunity cost is embodied in the value of emissions allowances, which is a major advantage from an efficiency perspective.

4. Allocation of emissions allowances

Keeping in mind the essential role of opportunity cost for internalising social cost, the element that rises above the rest in the design of a cap-and-trade program for climate policy is the initial distribution of the opportunity cost of emissions in the form of tradable allowances. Again, the opportunity cost

is equivalent to the value of emissions allowances. Depending on how the program is designed, the value of emissions allowances for an economy-wide CO₂ program in the United States could be \$130–\$370 billion annually by 2015 (Paltsev *et al.* 2007). This value would grow as the stringency of the program grows over time, at least over the first decades of the program. If allocation is not treated carefully, it could undermine the efficiency virtues of cap-and-trade and could lead to unexpected distributional outcomes. There are not many viewpoints you can get economists to agree on, but one exception is the advantageous role of an auction as a means to allocate emissions allowances under a CO₂ cap-and-trade program.

4.1 Efficiency

The economics literature strongly favours the use of an auction for the initial distribution of emissions allowances in a cap-and-trade program for reasons we group into two categories. Nonetheless the use of an auction approach also brings its own set of potential challenges.

One reason that auctions are favoured in the economics literature is they are viewed as more simple and transparent than administrative approaches to the distribution of allowances, which in turn provides a perception of fairness. These are important characteristics for a new market for an environmental commodity. If emissions allowances are allocated for free through administrative decisions, private parties have strong incentives to argue for an ever-increasing share of allowances, which will lead to rent-seeking behaviour through investment of resources in trying to affect the outcome of the administrative process. Many authors suggest that auctions reduce rent-seeking behaviour, and to the extent that such behaviour continues it is a more apparent play for revenue than for the more obscure entitlement to an emissions allowance. Furthermore, in other applications such as the allocation of licenses for the spectrum auction, evidence suggests that the use of auctions leads to less litigation (Binmore and Klemperer 2002).

One aspect of free allocation that can be especially costly is the use of different allocation rules for incumbent emissions sources, new emissions sources, and/or for old sources that retire. Typically free allocation through grandfathering is based on a historically observable measure such as emissions, fuel use or economic activity. New sources may have to purchase allowances while incumbent sources get them for free. For example, the SO₂ trading program has no provision for allocating allowances to new sources, which is a virtue from an efficiency perspective because the allocation rule does not entice rent-seeking behaviour aimed at increasing one's allocation. By contrast, free allocation to new sources would create a reward for new investment different from what is otherwise efficient. Similarly, if existing sources only received allowances when they remained in operation, retirement would be inefficiently discouraged (Åhman *et al.* 2007), which argues for no adjustment to allocation when a source retires.

Although this is an efficient approach, it is perceived as unfair. For example, free allocation to existing sources in the SO₂ program is now a matter of record through 2037, five decades after the 1985–1987 period on which the allocation formula was based, and some of these facilities have already retired. While good for the sake of efficiency, it seems unfair to many to continue giving sources that shut down allowances but require all sources built after adoption of the program to purchase them.

Unlike the SO₂ trading program, most other trading programs have periodic adjustments to their allocation formulas. In the NO_x budget program, for example, where individual states determine the allocation of allowances, most states have set-asides for new sources, and sources that retire eventually lose their allocations. Adjustments to allocation based on decisions about the level of production also are widespread in the EU ETS, and these adjustments can cause less economic and higher-polluting facilities to be preferred investments (Åhman and Holmgren 2006). Furthermore, eliminating future allocations for sources that retire provides a financial incentive for continuing the operation of existing facilities that may be inefficient and that otherwise would retire, except for the value of the allowances that they earn by remaining in operation. The use of an auction avoids this predicament entirely.

Another approach to free allocation that treats all sources consistently and is somewhat less problematic is updating, which bases the allocation on current or recently observed measures rather than an invariant historic measure. One example is updating output-based allocation, which distributes allowances based on a facility's share of production and which can change over time if the facility's share of production changes over time. Updating allocation automatically gives allowances to new sources and reduces the allocation to sources that reduce their operation.

This approach rewards investment in relatively clean facilities that have emissions rates less than the average by granting allowances in excess of their emissions, which allows for the facility to sell extra allowances to other facilities (Energy and Environmental Analysis Inc. 2003). This approach effectively implements two policies: it provides an output subsidy to production while imposing a cost on emissions. Unfortunately, theoretical and simulation modelling show that the consequence of the subsidy is that product prices are lower than the efficient level (Burtraw *et al.* 2001; Fischer 2003). Again, although this may be a political virtue, it raises the overall cost of the program because prices do not reflect accurate signals about the relative scarcity of CO₂ in the economy, eroding the incentive to achieve efficiency by downstream consumers of energy-intensive goods. Moreover, output-based updating is problematic because of the lack of a common measure of output across industries, and other measures such as fuel use would bring their own incentive problems.

However, updating allocation could be a useful tool if applied surgically in industries that are exposed to international competition from countries that do not regulate CO₂ emissions. These exposed industries constitute only a small share of value added in the economy, but nonetheless there is nothing

accomplished if regulatory policy leads production to move offshore in order to escape regulation in the United States. Free allocation that is regularly updated, based on continuing production onshore, would reduce the incentive to move offshore. If the allocation were indexed to a formula that reflects best practice in reducing emissions for a given sector it would also provide an incentive for facilities to improve efficiency. Morgenstern *et al.* (2007) suggest that the total share of allowances necessary to provide free allowances to these sectors would be only a very small per cent of total allowances.

In the electricity sector in particular, another reason that an auction has efficiency benefits is that it tends to reduce the difference between price and marginal cost for electricity generation – a source of inefficiency that is endemic to the electricity industry worldwide. Free allocation of allowances typically will amplify the gap between regulated prices and efficient prices. This result is attributable in part to the fact that electricity prices are set by cost-of-service regulation in parts of the United States (as in many other countries).

In regulated regions, the opportunity cost of an emissions allowance given to a firm for free is not directly reflected in the price of electricity because in the cost-of-service calculation it is valued at its original cost of zero. However, the cost of allowances acquired through an auction (or from the market) is reflected in regulated electricity prices, and therefore the opportunity cost of emissions is reflected in the firm's total cost upon which electricity prices are calculated. Furthermore, the absence of time-of-day pricing even in competitive regions also reinforces the difference between price and marginal cost. Palmer and Burtraw (2004) find that free allocation has relatively little effect on the efficiency of the policy to cap emissions of conventional pollutants such as SO₂, NO_x or mercury, although an auction would be the most economically efficient approach. However, analysis of CO₂ policy in the United States finds that free allocation would substantially amplify the difference between price and marginal cost, leading to a large efficiency cost, while the use of an auction to allocate emissions allowances results in substantially lower social costs of reducing CO₂ emissions (Beamon *et al.* 2001; Burtraw *et al.* 2001, 2002; Parry 2005).

There are a variety of types of auctions. What type should be used for CO₂ allowances? Binmore and Klemperer (2002) argue the really bad mistake is to take an auction design off the shelf; there is no 'one size fits all' in auction design. The first auction of emissions allowances was part of the SO₂ trading program, which implemented a small annual auction for 2.8 per cent of the allowances, with revenue from the auction returned to industry. That auction uses a discriminatory price format (winning bidders pay their bid). Experience has shown that the auction contributed importantly to price discovery initially and has closely tracked or led changes in price in the secondary market over time (Ellerman *et al.* 2000). However, increasingly attention is given to a uniform price auction for emissions allowances.

Cramton and Kerr (1998) recommend a uniform price multiround ascending (English) auction for CO₂. The state of Virginia used this format in the first

revenue-raising auction for emissions allowances, a small portion of allowances in the NO_x budget program (Porter *et al.* 2008). In a study for CO₂ allowances, Holt *et al.* (2007) recommend a uniform price sealed bid auction for allowances allocated under RGGI, where the first auctions occurred in September, in 2008. Matthes and Neuhoff (2007) recommend a similar design in the European Union. Common among these analyses is the finding that, because allowances are homogenous and storable, an auction for emissions allowances is relatively straightforward compared to auctions for electricity or for the airwave spectrum. Unlike physical commodities, one does not even have to have an allowance in hand in order to conduct emitting activities because compliance periods typically last over one or more years. In sum, although careful design of an auction for allowances is important, it does not appear to be an obstacle.

The second and equally forceful reason that economists favour an auction is that it makes funds available that, depending on how these revenues are used, can help reduce the social cost of climate policy in an important way. For the purposes of minimising the cost of climate policy and promoting economic growth, the best use of revenue from an auction would be to reduce pre-existing taxes. Like any new regulation, climate policy imposes costs on households and firms, and that cost acts like a virtual tax, reducing the real wages of workers. This hidden cost can be especially large under a cap-and-trade program for CO₂ because the pollutant is widespread in the economy. As real wages fall, the pre-existing distortions away from economic efficiency in labour and capital markets due to taxes on labour or capital income are exacerbated (Bovenberg and de Mooij 1994; Parry 1995). Using primarily computable general equilibrium simulation models to estimate the potential efficiency consequences of different approaches to allocation, a number of analyses have examined cap-and-trade programs for CO₂, SO₂ and NO_x in competitive product markets.⁴ These papers find overwhelming results in favour of an auction if auction revenue is used to reduce pre-existing taxes (Bovenberg and Goulder 1996; Goulder *et al.* 1997, 1999; Parry *et al.* 1999; Smith *et al.* 2002).

There are other potential uses for auction revenue as well. A number of analyses argue that efficiency goals can be served by directing allowance revenue raised through an auction to reinforce overall program goals (Economic and Technology Advancement Advisory Committee 2008). A small sliver of auction revenues would provide a relatively substantial infusion of support for research and development of new technologies, or it could provide incentives for investment, such as an investment tax credit aimed at promoting innovative technologies. These purposes seem consistent with climate policy because suspected spillovers and imperfections in markets for research and development are thought to lead to insufficient investments from a social perspective (Goulder and Parry 2008).

⁴ Parry (2005) is the only paper to consider regulated markets explicitly in this context.

The listing of potentially meritorious uses for allowance value makes it clear that there is likely to be ample clamouring over the allocation of auction funds, just as there would be for emissions allowances. For example, proponents of cap-and-auction approaches at the state level in the United States who favour using allowance value to help achieve complementary goals such as support for energy efficiency or renewable technologies often suggest that revenue from the auction be prohibited entirely from going to the general treasury of the state. Such a provision would preclude auction revenue from use in reducing pre-existing taxes, the approach that may offer the most benefit to economic growth.

Clearly, the allocation of auction funds would involve its own form of rent seeking, although arguably in a more transparent manner, and the costs of this activity should be weighed in assessing the overall costs and benefits of using an auction for allocation. However, there would seem to be an important difference when using an auction. To paraphrase Binmore and Klemperer (2002), there may be good grounds for direct allocation to the incumbent industry, but the use of an auction and assignment of allowance value raised in auction requires the regulator to answer explicitly 'Why subsidise this industry rather than others?'

4.2 Compensation

Because the cost of climate policy is likely to be large, there are compelling reasons that auction revenue might be directed to providing compensation. The general rationale for free initial distribution is that it provides compensation to parties that may bear a disproportionate cost under the trading program. The cost is experienced by two groups: producers and consumers.

4.2.1 Compensation for producers

A frequently cited normative principle of public policy is that government should 'do no direct harm' (Schultze 1977) – that is, public policy needs to respond to the direct harm that may be concentrated on severely affected parties. As a form of compensation, free allocation has the advantage, at least from the perspective of the regulated industries, that it keeps value in the regulated industry. Furthermore, the magnitude of the compensation (the value of emissions allowances) moves in direct proportion to the cost, which is evident when emissions allowances gain or lose value.

It may even be the case that adopting a cap-and-trade program and allocating all allowances for free may make the affected sources *even better off than they were without the program*. While the presence of the regulation reduces their profit, the value of the allowances may increase it. This is not an esoteric finding. In a general equilibrium model and assuming widespread competitive electricity markets, Bovenberg *et al.* (2003) found that free allocation under the Bush administration proposal to tighten the cap for SO₂ emissions would overcompensate industry. Palmer and Burtraw (2004), who use a highly

parameterised partial equilibrium model that accounts for variation between competition and cost-of-service regulation that exists in different parts of the country, also find that free allocation in the implementation of caps on SO₂, NO_x or mercury will overcompensate incumbent producers in the electricity sector in the aggregate.

The results hold much more forcefully in the case of CO₂ with respect to the distributional consequences of allocation as well as the efficiency consequences discussed previously. Bovenberg and Goulder (2001) find that a constant \$25 allowance value for CO₂, which they estimate will reduce emissions 18 per cent, would place most of the economic harm on the oil, gas and coal industries, which could be compensated with just 19 per cent of allowance value. Smith *et al.* (2002) estimate the effects of a 14 per cent decrease in emissions to be achieved by 2010, and a 32 per cent decrease by 2030. They estimate the reduction in equity value in the electricity sector only is equivalent to 6 per cent of the total allowance value. Burtraw and Palmer (2007) replicate this estimate using a detailed industry model. Overall, one can reasonably conclude that the economy-wide harm in the United States, measured as a potential loss in the market value of industries most affected by climate policy, is likely to be equal to or less than 30 per cent of the value of emissions allowances.⁵

These findings from simulation analyses are consistent with the fundamental insight from economic theory that in a competitive economy the incidence of a policy does not depend on where the policy is applied. Rather, the degree to which firms are actually able to charge customers for a change in cost depends on the relative elasticities of demand and supply. As a corollary, the introduction of emissions allowances constitutes a change in the cost of production, and the ability of firms to pass on this cost does not hinge on how they received the allowances initially. In most markets economists would not expect to see consumers receive the benefit from free allocation to firms. Consequently, free allocation of CO₂ emissions allowances is likely to dramatically overcompensate firms at the expense of consumers and of economic efficiency (Bovenberg and Goulder 2001; Burtraw *et al.* 2002; Burtraw and Palmer 2007).

Researchers analysing the CO₂ trading system in Europe have reached a similar conclusion, finding that free allocation resulted in billions of euros in increased profits for industry, especially in the power sector (UK House of Commons 2005; Sijm *et al.* 2006). The same finding is predicted in the RGGI, which caps CO₂ from electricity generators among ten states in the north-eastern United States. Burtraw *et al.* (2006) and the Center for Energy, Economic and Environmental Policy (2005) find that giving away 100 per cent of the allowances to emitting generators in RGGI will more than compensate generators for the costs of the program. In fact, even under an auction

⁵ Hepburn *et al.* (2006) provide estimates of free allocation necessary to maintain market value on an industry-wide basis in Europe.

Burtraw *et al.* (2006) find that 11 of the 23 largest generation companies, representing 92 per cent of the electricity supply, would actually gain value, suggesting that the need for compensation is low.

The electricity sector has been studied in detail because it constitutes about 40 per cent of the nation's CO₂ emissions. Moreover, it is expected to provide two-thirds to three-quarters of emissions reductions in the first decades of a policy. Burtraw and Palmer (2007) estimate the distribution of gains and losses across firms and find firms that are negatively affected would suffer a loss equal to 11 per cent of allowance value, while other firms gain value equal to 4 per cent of allowance value. On average they find that only a little more than 6 per cent of the allowance value would be sufficient to compensate the industry. However, simple decision rules for delivering compensation turn out to be very imprecise, and consequently the opportunity cost of providing compensation, measured in terms of allowance value that is dedicated to compensation, would be far greater than the actual compensation that is delivered because under even the best decision rule much of the value would be awarded to undeserving parties. For example, under the best of scenarios the cost of delivering full compensation for the last bit of harm equal to 2 per cent of allowance value would require 10 times that amount as a per cent of the allowance value. This cost could be reduced by delivering compensation at the regional level or by compensating at less than 100 per cent, but in any case considerations regarding the difficulty of targeting compensation to its intended recipients and the diversion of allowance value from other purposes might convince policymakers to be critical of free allocation to producers.

Furthermore, the notion of compensating individual firms may have little justification from the public policy perspective suggested by Schultze (1977). Increasingly, shareholders hold few if any stocks in individual companies. Most assets are held in mutual funds – stocks on Wall Street held by mutual funds or institutional investors totalled \$9 trillion in 2005 – suggesting that for many investors, the effect on the industry and the overall economy is more relevant than the effect on individual firms. For this reason, designing the policy as efficiently as possible to lessen its overall cost is perhaps the most effective way to minimise harm to the owners of equity in the economy. In effect, the way to deliver compensation to owners of equity is to design an efficient policy, which is precisely the virtue of the use of auctions.

Although firms own portfolios of facilities, a local community is affected by policies that affect an individual facility. This is a compelling argument for assignment of a portion of allowance value to assist communities that are directly affected by the policy. However, free allocation to shareholders will not benefit the community. In fact, the decisions of managers about operation of the facility will be unaffected by free allocation to shareholders because their opportunity cost is unaffected, unless the allocation is based on continued production at the facility (e.g. updating output-based allocation).

Finally, a plea sometimes heard from the regulated community is to retain allowance value in the regulated industries to help fund major new investments

in low-emitting technology. This view suggests that the requirement to purchase allowances in an auction would direct funds away from new investment. However, at least in the electricity sector, where the major share of new investments are expected in the next couple of decades, the industry generally relies on project-specific financing, meaning that each project is evaluated and financed independently with capital from outside the firm. As a consequence, a change in the cost of operation of existing facilities is not likely to have a direct effect on the availability of capital for financing new projects. Moreover, because the existing fleet of generation facilities is quite old and inefficient compared to new facilities, many types of new investments would be likely to gain value in the presence of an emissions cap.

4.2.2 Compensation to consumers

Although harm to producers may be more concentrated and more visible to the politicians, consumers in the important electricity sector would incur a loss approximately eight times as great as that of producers when measured as changes in economic surplus (U.S. Energy Information Administration 2005; Burtraw and Palmer 2007). Where the market is competitive, product prices will be determined by marginal opportunity cost, which is unaffected by free allocation to producers. In the electricity sector free allocation to generators would trickle down as compensation to consumers only in regulated regions of the country. A different type of free allocation could directly benefit electricity consumers in both competitive and regulated electricity markets. This approach would allocate allowances to 'load-serving entities,' the retail electricity companies that deliver electricity to customers and that could be directed to act as trustees on behalf of consumers. Although retail companies would see the cost of power in the wholesale power market increase under a cap-and-trade program, they would have substantial allowance value to rebate to consumers, and this would reduce the cost impact for their customers in competitive and regulated regions alike.

Unfortunately, free allocation to load-serving entities comes with an important efficiency cost, not just in a general equilibrium context stemming from foregone revenue, but also due to the market dynamics in the regulated industries. As discussed previously, when electricity customers do not see the increase in retail electricity prices, they do not have an incentive to reduce electricity consumption. Across the sector, this effect would lead to more electricity consumption, and under an economy-wide program, it would lead to more emissions from the electricity sector, requiring more reductions from other sectors. Nonetheless, because free allocation to customers has the political virtue of lessening the price effect, it has emerged as an idea for how to construct a transition path to phasing in a full auction in the electricity sector.

In our judgement, it is noteworthy that precisely because the cost of climate policy is large, a good way to achieve broad-based compensation would be through recycling revenue to reduce pre-existing taxes, which achieves both efficiency and equity goals. As this approach reduces the overall

cost of climate policy, it lessens the impact on households overall. However, it would not succeed in compensating lower-income households, who spend a larger portion of their income on energy than wealthier households, who would benefit the most from revenue recycling.

Consumers can be compensated more directly if they, as citizens, receive allowance value directly. This approach has recently been described as ‘cap and dividend’ because the allowance value would be refunded as a dividend on a per capita basis for citizen efforts to reduce CO₂ emissions. This approach would be the most progressive in its distributional consequences of all the approaches that have been suggested (Boyce and Riddle 2007). This approach could be made even more progressive if dividends were targeted to low-income households, but that would erode the apparent political idea of equal ownership of the atmosphere as a natural resource. The Center on Budget and Policy Priorities (2007) identifies another approach that would take advantage of information about household income to target the most disadvantaged households using just a portion of the allowance value.

Environmental advocates typically take a different view, however, aiming to direct auction revenue to complementary initiatives to reduce emissions. For example, the Model Rule for the 10 north-eastern United States in RGGI specifies that each state must allocate at least 25 per cent of its budgeted allowances to a consumer-benefit or strategic-energy purpose. These ‘consumer benefit’ allowances are to be sold or otherwise distributed to promote energy efficiency, to directly mitigate electricity ratepayer impacts or to promote lower-carbon emitting energy technologies. (Most of these 10 states have indicated their intention to auction 100 per cent of their budgeted allowances.) Ruth *et al.* (2008) found the dedication of 25 per cent of the allowance value to investments in end-use efficiency would offset any increase in retail electricity price from the policy.

A similar plan to direct a portion of allowance value to strategic-energy purposes is part of the European Commission’s proposal for moving to an auction in the EU ETS beginning in 2013. The merits of this strategy rest on the belief that market barriers exist that prevent the realisation of opportunities for improving efficiency in the end-use of energy or to bringing renewable energy sources to market. The merits rest as well on the ability to design institutions that can use allowance value effectively to overcome these barriers. Other claims for allowance value are based on the need to accelerate the adaptation to climate change. Atmospheric scientists tell us that we are already at the point where some climate warming is inevitable and that adaptation will be necessary. Adaptation will involve significant investment by the private and public sectors. An auction provides revenues that can be directed toward these adaptation activities.

In summary, the contest for control of revenue raised by climate policy is likely to become one of the most important issues as policy unfolds. Although efficiency and distributional goals often are in conflict in public policy, there are a variety of strategies for the use of allowance value that at least partially reconcile this conflict.

5. Institutional roles and the direction of U.S. policy

Most discussions assume that regulations directly controlling CO₂ in the United States will eventually be implemented through new federal legislation, but designing legislation to address such a complicated issue is very difficult in the absence of support from the executive branch. The Bush administration has resisted climate policy that would directly cap or price CO₂.⁶ In 2009 a new president will take office, and all leading candidates have spoken in support of strong climate policy; however, the issues remain complicated and legislation may be difficult to achieve. In the absence of federal legislation, recent developments in the courts point to the development of a federal regulatory policy based on existing legislation, which is not well suited to an integrated national policy. One important trend runs as a thread throughout all recent developments in climate policy in the United States and internationally. In federal legislative proposals, policies at the state and regional level in the United States, and in plans going forward in the EU, New Zealand and Australia, the use of an auction is being given an increasingly important role for distributing emissions allowances under cap-and-trade for CO₂.

5.1 Trends toward an auction in legislative proposals

It is difficult to follow the plot in federal legislative proposals. At least 12 major bills are being considered by Congress (Resources for the Future 2007). The leading vehicle in 2008 was the Lieberman–Warner proposal (SB 2191), which would implement an economy-wide approach based on a mix of upstream and midstream compliance responsibilities. This legislation is the reincarnation of the previous McCain–Lieberman proposal (SB 280), which is noteworthy because at the time of this writing Senator McCain is the Republican candidate for the presidential election in November 2008. Over time the evolution of SB 280 to SB 2191 included a growing role for auctioning allowances. SB 280 provided the EPA discretion for the allocation of allowances, while SB 2191 requires that 26.5 per cent of allowances are initially auctioned, rising to 69.5 per cent over time. Meanwhile, the Democratic candidate, Senator Obama, has called for full auction. Whatever might be the outcome of the election, there appears to be growing sentiment for climate policy and also a growing role for an auction within a cap-and-trade program.

5.2 EPA responsibility under the Clean Air Act

A critical decision in the United States is what institution or agency will be in the central role to implement climate policy. In the absence of new federal legislation, that responsibility appears to fall to the EPA. Two questions recently decided

⁶ Instead of directly regulating CO₂, the administration pursued voluntary approaches and subsidies and other incentives for research and development of CO₂ abatement techniques.

by the U.S. courts help to determine the role of the EPA in regulating CO₂, especially if new federal legislation is not passed by Congress that might redefine the role for the agency. These questions rest on the ability of the EPA to use the existing Clean Air Act to regulate CO₂, which is the law that provides the EPA the authority to regulate air pollutants from mobile and stationary sources. Although the Clean Air Act provides broad applicability to different pollutants and sources, the EPA had declined to regulate CO₂ under the Act based on the claim that CO₂ does not fit the Act's definition of an air pollutant.

In April 2007, the U.S. Supreme Court found in *Massachusetts v. EPA* (2007) that 'GHGs fit well within the Act's capacious definition of "air pollutant"' and therefore may be regulated under the Clean Air Act.⁷ The practical implication is that it appears that the EPA is required to make an 'endangerment finding' about whether GHGs are harmful, and if in the affirmative the EPA would subsequently be required to develop and promulgate regulations to mitigate the harm. One important distinction is whether GHGs are found to be directly harmful to human health and separately whether they are harmful to the environment, because this may influence the type of regulation that is developed and the urgency with which it is implemented.

The second recent decision addressed the EPA's ability to adopt cap-and-trade under the Clean Air Act. In *New Jersey v. EPA* (2008) the DC Circuit Court invalidated the EPA's Clean Air Mercury Rule, which would have implemented a cap-and-trade program for mercury. The trading program was premised on the EPA's decision that mercury should not have been classified as a hazardous air pollutant.⁸ It is notable that the decision did not address the legality of cap-and-trade per se, but rather it addressed the procedure through which the EPA reversed a previous formal finding that had classified mercury as a hazardous air pollutant. The EPA was attempting to control mercury under a different section of the Clean Air Act that is reserved for non-hazardous pollutants. The EPA has argued that this

⁷ Massachusetts and other states, along with some environmental groups, sued the EPA after the EPA denied the states' petition to regulate CO₂ from vehicles. The court found the 'EPA can avoid promulgating regulations only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do.' While the ruling of the court focused narrowly on vehicle emissions, it is generally believed that, in the absence of new legislation, the ruling would also affect the regulation of CO₂ emissions from stationary sources through a finding of endangerment from CO₂.

⁸ The regulatory history on mercury is not straightforward. The 1990 Clean Air Act Amendments gave mercury a special status leading to substantial study before finally, in the waning hours of the Clinton administration late in 2000, the EPA listed mercury from coal-fired boilers as a hazardous air pollutant. The listing triggered a prescriptive regulatory approach under Section 112 of the Act. Under the Bush administration, the EPA reversed course by 'delisting' mercury, choosing to regulate the pollutant under Section 111 instead, and to use a cap-and-trade approach to do so. The court found that the EPA unlawfully delisted the pollutant, failing to implement a formal process to reverse the previous finding, and therefore the pollutant must continue to be regulated under Section 112. (The EPA's only recourse through the judiciary is to appeal for a second hearing by a nine-judge panel of the Circuit Court or to the U.S. Supreme Court.)

alternative section allows for cap-and-trade, and it has been suggested that under the existing structure of the Act this section is applicable to the regulation of GHGs from point sources. Given the basis of the court's ruling, the potential to use cap-and-trade for more conventional pollutants remains incompletely addressed by the judiciary.

The consequence is that the EPA seemingly finds itself on a path of assessing harm from GHGs and developing regulations to mitigate that harm under the existing Clean Air Act. The mercury decision leaves open the possibility that as the agency moves forward it could adopt a cap-and-trade approach for CO₂.

However, there are substantial issues in designing an efficient economy-wide cap-and-trade program that may be outside the agency's purview and outside the set of issues that may be considered when designing CO₂ regulations under the Act. Probably the most central issue is whether the agency has the ability to implement a regulation that fully internalises the opportunity cost of emissions, as we have discussed would occur under cap-and-trade. Furthermore, the agency probably could not require the use of an auction to distribute emissions allowances.

Other outcomes are distinctly possible. A reasonably anticipated approach would be for the EPA to adopt a national cap on CO₂ covering point sources and to delegate responsibility and limited authority to the states to achieve those goals. As under the existing NO_x trading programs, the states could be apportioned a CO₂ 'emissions budget' as a share of a national cap and could allow their sources to participate in a federally managed trading program. The states could then allocate the rights as they wish, or may even choose to opt out of the trading program provided that sources in the state do not emit more than allowed under the state's share of the cap. However, given the structure of the Act, it may be the case that there are multiple caps on CO₂, with each being specific to a sector.

If true, this would reduce the efficiency of the program by violating the 'law of one price.' If sources are separated by their sector, each sector will face a different price for CO₂ emissions, and therefore trading opportunities that reduce overall resource costs will be unrealised. Furthermore, it is also possible that the EPA would revert to the familiar paradigm of prescriptive regulations. For example, the agency might promulgate prescriptive emissions standards for some or all sectors and treat new sources differently from existing ones. Indeed, the most likely outcome is that the EPA would have to borrow from each of these possible strategies if it is to regulate many source categories.

5.3 EU decision for phase 3

The European Union began its cap-and-trade ETS covering the power sector and major industrial sources in 2005. The first phase of the program lasted through 2007 and the second phase stretches through 2012. The program

excludes transportation, small businesses, and direct fuel consumption by firms and households. The major issue in the design of the program was the initial distribution, or 'allocation' of allowances.⁹ In phase 1, 99 per cent of the allowances were given away for free to emitters, and in phase 2 this figure dropped slightly to 96 per cent.

Free allowances to emitters were not free to consumers. As discussed above, the regulated firms that received allowances for free increased the price of their products to reflect the opportunity cost of allowances. Consequently, firms essentially charged customers for allowances that they had received for free, thereby leading to windfall profits totalling many billions of euros. This is especially true in the electricity sector, where power prices rose to incorporate allowance values (UK House of Commons 2005; Sijm *et al.* 2006). As importantly, this revenue was not available for other purposes that would help to reduce administrative costs of the program, and the program's overall economic cost was much higher as a consequence.

The EU has mapped out its plan for the third phase of the ETS, which will begin in 2013. The EU now embraces the principle of auctioning allowances rather than giving them away for free. Full auctioning for the power sector will begin in 2013, and full auctioning for other covered sectors will be phased in through 2020. Overall about 67 per cent of allowances will be distributed by auction between 2013 and 2020.

An important part of the design of the ETS is the delegation of authority to participating nations. Although the EU proposal would call for a substantial auction, the authority for implementing the auction has yet to be decided, and in any event the revenue from the auction will be apportioned to the participating nations. This architecture is similar to both the NO_x budget programs in the United States and the RGGI program, where states play the central role in allocating emissions allowances and retain revenues under an auction.

6. Conclusion

The expanding use of incentive-based approaches such as cap-and-trade for achieving environmental goals promises to achieve these goals at less cost than traditional prescriptive approaches. Cost-effectiveness will be essential for the effort to slow the heating of the planet because that effort is expected to be the most expensive environmental program in history. An introduction to the theory of cap-and-trade emphasises the technological efficiency that results from equating marginal costs of reducing pollution across sources, the

⁹ The other major controversy in the ETS has been the weak level of stringency, which led to minor emissions reductions in the first phase. Much of the problem was that actual country emissions turned out to be lower than expected when accurate inventories were taken for the first time. In the second phase the cap was tightened, insuring that meaningful emissions reductions would be achieved, and banking of allowances into future compliance periods was allowed, thereby creating greater incentives for innovation.

reduced burden on government, and the continuing incentive for innovation. It is important to achieve a law of one price for GHG emissions, which is prerequisite for achieving the efficient allocation of resources in the economy, by making the applicability of the cap as broad as possible. Less well appreciated is that the application of cap-and-trade to climate policy introduces an especially important role for inclusion of the opportunity cost of the remaining allowable emissions in product prices.

As the opportunity cost of emissions is reflected in the value of emissions allowances, the allocation of these allowances has important economic and political implications. In the United States, the annual value of these allowances could total hundreds of billions of dollars. Along with the overall level of the emissions cap, the initial allocation of emissions allowances is the most important feature in the design of a program. The method of allocation will have important implications for efficiency and for the distribution of costs. An auction of emissions allowances is widely recognised by economists to be the most efficient approach, and this approach has begun to find its way into policy debates in the United States, the European Union, New Zealand and Australia.

This review focused on the policy context in the United States. Climate policy enacted through federal legislation can require a particular method of allocation. However, due to parallel legal and institutional developments, regulatory approaches to climate policy are emerging at the state and regional level and under the existing Clean Air Act. Such approaches could offer broad and significant restrictions on carbon emissions, but they are unlikely to lead to an economy-wide cap-and-trade program or wide-spread adoption of auctioning allowances. A national regulatory approach based on the Clean Air Act seems likely to offer sector-specific cap-and-trade programs coupled with a variety of prescriptive measures. Allocation decisions under a national sector-specific cap-and-trade program would almost certainly be delegated to the states. The development of complementary prescriptive policies would be familiar terrain for environmental regulators but would fail to include opportunity cost in product prices, leading to a less efficient policy overall.

While it appears increasingly likely that ambitious climate policy is on the horizon in the United States, it remains uncertain exactly how that policy will take shape. If federal legislation does not emerge, state and regional efforts will continue to proliferate and the EPA will likely proceed along a path leading to regulation of GHGs that will draw from a variety of approaches. In the long run, the institutional structure of a climate policy matters as much as its stringency with respect to its ultimate efficiency, distributional impacts, and overall effectiveness.

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