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THE TRADABLE-PERMITS APPROACH TO PROTECTING THE COMMONS: LESSONS FOR CLIMATE CHANGE

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Tradable-permit approaches for rationing access to the commons have been applied to many different types of resources in many different countries. This essay reviews the experience with three main applications of tradable-permit systems—air-pollution control, water supply, and fisheries management—as well as some unique related programmes. The purpose of the review is to draw together what we have learned about tradable permits in practice that might offer some useful insights for the implementation of the three tradable-permit mechanisms that are part of the Kyoto Protocol.

I. INTRODUCTION

(i) Background

The atmosphere is but one of many commons and climate change is but one example of over-exploitation of the commons. An approach employed increasingly for coping with the problem of rationing access to the commons involves the use of tradable permits. Applications of this approach have spread to many different types of resources and many different countries. A recent survey found nine applications in air-pollution control, 75 in fisheries, three in managing water resources, five in controlling water pollution, and five in land-use control (OECD, 1999, Appendix 1, pp. 18–19). And that survey failed to include many current applications, including those that have sprung up in response to the Kyoto Protocol.

The logic behind this rather remarkable transition is quite simple. One of the insights derived from the empirical literature is that traditional command-and-control regulatory measures, which depend upon government agencies to define both the goals and the means of meeting them, are, in many cases,

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insufficiently protective of the value of the resources.

A principal theorem of environmental economics demonstrates that, under specific conditions, an appropriately defined tradable-permit system can minimize the cost of reaching a predefined environmental target (Baumol and Oates, 1971). In a perfectly competitive market, permits will flow towards their highest-valued use. Those that would receive lower value from using the permits (owing to lower abatement costs, for example) have an incentive to trade them to someone who would value them more. The trade benefits both parties. The seller reaps more from the sale than s/he could from using the permit and the buyer gets more value from the permit than s/he pays for it.

A rather remarkable corollary (Montgomery, 1972) holds that this theorem is true regardless of how the permits are initially allocated among competing claimants, including whether they are auctioned off or allocated free of charge. Furthermore when permits are allocated free of charge, *any* particular initial allocation rule can still support a cost-effective allocation. Again, the logic behind this result is rather straightforward. Whatever the initial allocation, the transferability of the permits allows them ultimately to flow to their highest-valued uses. Since those uses do not depend on the initial allocation, all initial allocations result in the same outcome and that outcome is cost-effective.

The potential significance of this corollary is huge. It implies that with tradable permits the resource manager can use the initial allocation to solve other goals (such as political feasibility or equity) without sacrificing cost-effectiveness. In Alaskan fisheries, for example, some of the quota has been allocated to communities (rather than individuals) to attempt to protect community interests (Ginter, 1995).

As compelling as this theoretical case may seem, these approaches have been controversial. Consider just three examples from the US experience. In air-pollution control, a legal challenge was brought in Los Angeles during June 1997 by the Los Angeles-based Communities for a Better Environment. (Tietenberg, 1995). In fisheries a legal challenge was brought against the halibut/sablefish tradable-permits system in Alaska (Black, 1997) and Congress imposed a moratorium on the further use of a tradable-permits approach in US fisheries (National Research Council Committee to Review Individual Fishing Quotas, henceforth NRCC, 1999). Though both legal cases were ultimately thrown out, they do demonstrate some underlying controversies.

(ii) Policy Context and Overview

The 1992 United Nations Framework Convention on Climate Change (UNFCCC) recognized the principle of global cost-effectiveness of emission reduction and thus opened the way for tradable permits. As it did not fix a binding emission target for any country, the need to invest in emission reduction either at home or abroad was not pressing. In December 1997, though, industrial countries and countries with economies in transition agreed to legally binding emission targets at the Kyoto Conference and negotiated a legal framework as a protocol to the UNFCCC—the Kyoto Protocol. This Protocol will become effective once it is ratified by at least 55 parties representing at least 55 per cent of the total carbon dioxide (CO_2) emissions of Annex I countries in the year 1990.

Together, Annex I countries must reduce their emissions of six greenhouse gases by at least 5 per cent below 1990 levels over the commitment period 2008–12. The six greenhouse gases listed in Annex A are: CO_2, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride.

The Kyoto Protocol authorizes three cooperative implementation mechanisms that involve tradable permits. These include emission trading, joint implementation, and the Clean Development Mechanism (CDM).

- 'Emissions trading' allows trading of 'assigned amounts' (national quotas established by the Kyoto Protocol) among Annex I nations (countries listed in Annex B of the Kyoto Protocol, primarily the industrialized nations and the economies in transition).

- Under 'joint implementation', Annex I Parties can receive emissions-reduction credit when

they help to finance specific projects that reduce net emissions in an Annex I Party country.

- The CDM enables Annex I Parties to finance emission-reduction projects in the countries of non-Annex I Parties and receive certified emission reductions (CERs) for doing so.

These programmes have, in turn, spawned others. The European Parliament passed a bill capping European industry's CO_2 output and letting firms trade the allowed emissions. From January 2005 many plants in the oil-refining, smelting, steel, cement, ceramics, glass, and paper sectors will need special permits to emit CO_2. Individual countries, such as the United Kingdom and Denmark, have created their own national trading programmes. Individual companies are even involved. BP, an energy company, has established company-wide goals and a trading programme to help individual units within the company to meet those goals. Despite the fact that the United States has not signed the Kyoto Protocol, even American companies, states, and municipalities have accepted voluntary caps on CO_2 and methane emissions and are using trading to facilitate meeting those goals. The Chicago Climate Exchange has been set up to facilitate these trades. The unprecedented scope of these programmes breaks new ground in terms of geographic coverage, the number of participants, and the types of polluting gases covered.

This article attempts to draw together what we have learned about tradable permits in practice that might offer some insights to the climate-change implementation process as it unfolds. It reviews the experience with three main applications of tradable-permit systems—air-pollution control, water supply, and fisheries management—as well as some unique programmes such as the US programme to mitigate the loss of wetlands and the programme in the Netherlands to control the damage from water pollution owing to manure spreading. The purpose of this review is to exploit the large variation in implementation experience that can be gleaned from this rich variety of applications. This experience provides the basis for formulating some general lessons about the effectiveness of these systems in practice and their application to the general problem of climate change.

II. A REVIEW OF *EX-POST* EVALUATIONS OF TRADABLE-PERMIT SYSTEMS

This assessment of the outcomes of these systems focuses on three major categories of effects. The first is implementation feasibility. A proposed policy regime cannot perform its function if it cannot be implemented or if its main protective mechanisms are so weakened by the implementation process that it is rendered ineffective. What matters to policy-makers is not how a policy regime works in principle, but how it works in practice. The second category seeks to answer the question 'How much environmental protection did it offer not only to the targeted resource, but also other resources that might have been affected either positively or negatively by its implementation?' Finally, what were the economic effects on those who either directly or indirectly use the resource?

(i) Implementation Feasibility

Until recently, the historic record on tradable permits seemed to indicate that resorting to a tradable-permits approach usually only occurred after other, more familiar, approaches had been tried and failed. In essence, the adjustment costs of implementing a new system with which policy administrators have little personal experience are typically perceived as so large that they can only be justified when the benefits have risen sufficiently to justify the transition (Libecap, 1990).

Most fisheries that have turned to these policies have done so only after a host of alternative input and output controls have failed to stem the destructive pressure being placed upon the fishery. A similar story can be told for air-pollution control. The offset air-pollution control policy, introduced in the USA during the 1970s, owes its birth to an inability to find any other policy to reconcile the desire to allow economic growth with the desire to improve the quality of the air.

It is also clear from the historical record that not every attempt to introduce a tradable-permit approach has been successful. In air-pollution control, attempts to establish a tradable-permits approaches have failed in Poland (Zylicz, 1999) and Germany

(Scharer, 1999). The initial attempts to introduce a sulphur-dioxide (SO_2) trading system also failed in the United Kingdom (Sorrell, 1999), although recent attempts to establish a CO_2 programme there have succeeded. Programmes in water-pollution control have generally not been very successful (Hahn and Hester, 1989).

On the other hand, it does appear that the introduction of new tradable-permit programmes becomes easier with familiarity. In the USA, following the very successful lead phase-out programme, new supporters appeared and made it possible to pass the sulphur-allowance programme. The introduction of the various flexibility mechanisms into the Kyoto Protocol was facilitated by the successful experience with the US sulphur-allowance programme, among others. And the recent introduction of tradable-permits systems in several European countries and the EU itself was precipitated by the opportunities provided by the Kyoto Protocol.

It also seems quite clear that, to date at least, using a grandfathering approach to the initial allocation has been a necessary ingredient in building the political support necessary to implement the approach. Existing users frequently have the power to block implementation, while potential future users do not. This has made it politically expedient to allocate a substantial part of the economic rent that these resources offer to existing users as the price of securing their support. While this strategy reduces the adjustment costs to existing users, it generally raises them for new users.

One tendency that seems to arise in some new applications of this concept is to place severe restrictions on its operation as a way to quell administrative fears about undesirable, unforeseen outcomes. As Shabman (2003) points out, this is precisely the case with the US wetlands credit programme. In some cases, and the wetland programme may well be an example, these restrictions are so severe that they cripple the programme, thereby preventing its ultimate evolution to a smoothly operating system. Although with increased familiarity (and comfort) restrictions initially imposed tend to disappear over time, they can severely diminish the early accomplishments of the programmes.

(ii) Environmental Effects

One common belief about tradable-permit programmes is that their environmental effects are determined purely by the imposition of the aggregate limit, an act that is considered to lie outside the system. Hence, it is believed, the main purpose of the system is to protect the economic value of the resource, not the resource itself.

That is an oversimplification for several reasons. First, whether it is politically possible to set an aggregate limit at all may be a function of the policy intended to achieve it. Second, both the magnitude of that limit and its evolution over time may be related to the policy. Third, the choice of policy regime may affect the level of monitoring and enforcement and non-compliance can undermine the achievements of the limit. Fourth, the policy may trigger environmental effects that are not covered by the limit.

Setting the limit

In general, the evidence seems to suggest that, by lowering compliance costs, tradable-permit programmes facilitate the setting of more stringent caps. In air-trading programmes, the lower costs offered by trading were used in initial negotiations to secure more stringent pollution-control targets (acid-rain programme, lead phase-out, and RECLAIM) or earlier deadlines (lead phase-out programme). The air-quality effects from more stringent limits were reinforced by the use of adjusted offset ratios for trades in non-attainment areas. (Offset ratios were required to be greater than 1.0, implying a portion of each acquisition would go for improved air quality.) In addition, environmental groups have been allowed to purchase and retire allowances (acid-rain programme). Retired allowances represent pollution that is authorized, but not emitted.

In fisheries, the institution of individual transferable quotas (ITQs) has sometimes, but not always, resulted in lower (more protective) total allowable catches (TACs). In the Netherlands, for example, the plaice quota was cut in half over time (and prices rose to cushion the income shock; Davidse, 1999).

Meeting and enforcing the limit

In theory the flexibility offered by tradable-permit programmes makes it easier to reach the limit,

suggesting the possibility that the limit may be met more often under a tradable-permits system than under the systems that preceded it. In most fisheries this expectation seems to have been borne out. In the Alaskan halibut and sablefish fisheries, for example, while exceeding the TAC was common before the imposition of an ITQ system, the frequency of excedences dropped significantly after the introduction of the ITQ (NRCC, 1999).

Regardless of how well any tradable-permit system is designed, non-compliance can prevent the attainment of its economic, social, and environmental objectives. Non-compliance not only makes it more difficult to reach stated goals, it sometimes makes it more difficult to know whether the goals are being met.[2]

Although it is true that any management regime raises monitoring and enforcement issues, tradable-permit regimes raise some special issues. One of the most desirable aspects of tradable permits for resource users, their ability to raise income levels for participants, is a two-edged sword because it also raises incentives for non-compliance. In the absence of an effective enforcement system, higher profitability could promote illegal activity. Insufficient monitoring and enforcement could also result in failure to keep a tradable-permit system within its environmental limit.[3]

Technology has played an important role in expanding the degree to which monitoring and enforcement needs of a tradable-permits programme can be met at reasonable cost. In the US sulphur-allowance programme (Kruger *et al*., 1999), both the collection and dissemination of the information derived from the continuous emissions monitors is now handled via the web. Special software has been developed to take individual inputs and to generate information both for the public and for Environmental Protection Agency enforcement activities. According to Kruger *et al*., the development of this technology has increased administrative efficiency, lowered transactions costs, and provided greater environmental accountability.

Enforcement costs have also been financed from the enhanced profitability promoted by the tradable-permit system.[4] Sometimes the rent involved in transferable-permit programmes is used to finance superior enforcement systems. In the sulphur-allowance programme, for example, the environmental community demanded (and received) a requirement that continuous emissions-monitoring be installed (and financed) by every covered utility. Coupling this with the rather stringent penalty system has meant 100 per cent compliance. In the Danish system (Pedersen, 2003), which does not rely on continuous emissions-monitoring, the electricity producers pay an administration fee of 0.079 DKK per ton of CO_2 allowance to the Danish Energy Authority to cover the administration costs (verification of CO_2 emissions; control, hearing, and distribution of allowances; operating the registry; monitoring of trading; development of the scheme; etc.).

The rents generated by ITQs have also provided the government with a source of revenue to cover the costs of enforcement and administration. In many of the fisheries in Australia, Canada, Iceland, and New Zealand, industry pays for administration and enforcement with fees levied on quota owners.

A successful enforcement programme also requires a carefully constructed set of sanctions for non-compliance. In the sulphur-allowance programme, generally considered the most successful tradable-permit programme, those found in non-compliance must not only pay a substantial financial

[2] In fisheries, for example, stock assessments sometimes depend on the size and composition of the catch. If the composition of the landed harvest is unrepresentative of the actual harvest owing to illegal discards, this can bias the stock assessment and the total allowable catch that depends upon it. Not only would true mortality rates be much higher than apparent mortality rates, but the age and size distribution of landed catch would be different from the size distribution of the initial harvest (prior to discards). This is known in fisheries as 'data fouling'.

[3] Prior to 1988, the expected positive effects of ITQs did not materialize in the Dutch cutter fisheries owing to inadequate enforcement. Fleet capacity increased further, the race for fish continued, and the quotas had to be supplemented by input controls such as a limit on days at sea (NRCC, 1999, p. 176).

[4] Not only has the recovery of monitoring and enforcement costs become standard practice in some fisheries (New Zealand, for example), but funding at least some monitoring and enforcement activity out of rents generated by the fishery has already been included as a provision in the most recent amendments to the US Magnuson–Stevens Fishery Conservation and Management Act. The sulphur-allowance programme mandates continuous emissions-monitoring financed by the emitting sources.

penalty, they also must forfeit a sufficient number of future allowances to compensate for the overage. It is also possible to allow only those in compliance to transfer permits. Any egregious violations can lead to forfeiture of the right to participate in the programme.

It is not true, however, that the steepest penalties are the best penalties. Penalties should be commensurate with the danger posed by non-compliance. Penalties that are unrealistically high may not be imposed. Unrealistically high penalties are also likely to consume excessive enforcement resources as those served with penalties seek redress through the appeals process.

One quite different and rather unexpected finding that emerges from *ex-post* evaluation of tradable-permit systems is the degree to which the number of errors in pre-existing emission registries are brought to light by the need to create accurate registries for tradable-permit schemes (Montero, 2002; Montero *et al*., 2002; Hartridge, 2003; Pedersen, 2003; Wossink, 2003). Although inadequate inventories plague all quantity-based approaches, tradable permits seem particularly effective at bringing deficiencies to light and providing incentives for the deficiencies to be eliminated.

Direct effects on the resource

Air-pollution programmes have typically had a very positive effect on reducing emissions. The US programmes to phase out lead and to reduce ozone-depleting gases were designed to eliminate, not merely reduce, pollutants. Both the US programme to control sulphur and RECLAIM (the programme designed to control emissions of oxides of nitrogen (NOx) and oxides of sulphur (SOx) in the greater Los Angeles area) involve substantial reductions in emissions over time.

In the fisheries, what have been the effects on biomass? One specific problem in any quota-based fishery is discards caused by highgrading. Highgrading involves discarding low-valued fish to make room in the quota for higher-valued fish. The discarded fish commonly die. Do the protective aspects of the programme outweigh the potential for highgrading?

The evidence on the overall effect on the fishery has been mixed. In the Chilean squat lobster fishery the exploitable biomass rebounded from a low of about 15,500 tons (prior to ITQs) to a level in 1998 of between 80,000 and 100,000 tons (Bernal and Aliaga, 1999). The herring fishery in Iceland experienced a similar rebound (Runolfsson, 1999).

On the other hand, one review of 37 ITQ or IQ (individual quota) fisheries, found that 24 experienced at least some temporary declines in stocks after instituting the programmes. These were largely attributed to a combination of inadequate information on which to set conservative TACs and illegal fishing activity resulting from ineffective enforcement. Interestingly, 20 of the 24 fisheries experiencing declines had additional command-and-control regulations such as closed areas, size/selectivity regulations, trip limits, vessel restrictions, etc. (OECD, 1997, p. 82). These additional regulations were apparently also ineffective in protecting the resource; the problems plaguing ITQs plague more traditional approaches as well.

Effects on other resources

The resource controlled by the permit programme is frequently not the only resource affected. In water applications one significant problem has been the protection of non-consumptive uses of water (Young, 2003). In the USA some states only protected private entitlements to water if water was diverted from the stream and consumed. The entitlements for water left in the stream to promote recreational uses could be confiscated by authorities as they did not meet the definition of a beneficial use. Recent changes in policy and some legal determinations have afforded more protections to these environmental uses of water.

According to Shabman (2003) reviews of the wetlands permitting programme have failed to stem the degradation of wetlands. Some reviews have found that the ecological functions, especially for wildlife and habitat, of avoided wetlands and on-site wetlands offsets are compromised by polluted run-off and adverse changes in hydrologic regimes. In some cases ecological failure resulted from poor construction techniques. In other cases, a promised offsetting restoration project may not have been

undertaken at all. In general, the failure to prevent these compromises to the programme can apparently be traced back to limited agency resources available for enforcement.

Leakage provides another possible source of external effects. Leakage occurs when pressure on the regulated resource is diverted to an unregulated, or less regulated, resource, as when fishermen move their boats to another fishery or polluters move their polluting factory to a country with lower environmental standards.

In air-pollution control, several effects transcend the normal boundaries of the programme. In the climate-change programme, for example, it is widely recognized (Ekins, 1996) that the control of greenhouse gases will result in substantial reductions of other air pollutants associated with the combustion of fossil fuels.

In fisheries, two main effects on non-targeted species have been the discard of fish for which no quota is held (bycatch discards) and habitat destruction.

- Bycatch is a problem in many fisheries, regardless of the means of control. The evidence from fisheries on how the introduction of ITQs affects bycatch is apparently mixed. Two reviews found that bycatch may either increase or decrease in ITQ fisheries depending on the fishery (OECD, 1997, p. 83; NRCC, 1999, p. 177).

- Habitat damage occurs when the fishing gear causes damage to the seabed or geological formations that provide habitat for species dwelling on or near the ocean floor. Tradable permits could, in principle, increase or decrease the amount of habitat damage by affecting both the type of gear used and the timing and location of its use. Evidence about this relationship is extremely limited.

(iii) Economic Effects

Ex-post studies that purportedly tackle the question of economic efficiency typically examine some or all of three rather different concepts: Pareto optimality, cost effectiveness, or market effectiveness. Since these are, in fact, quite different concepts, studies relying on them could come to quite different conclusions, even if they are examining the same programme.

Pareto optimality, or its typical operational formulation, maximizing net benefits, examines whether or not the policy derives all the net benefits from the resource use that are possible. Naturally this requires a comparison of the costs of the programme with all the benefits achieved, including the value of reduced pollution or conserved resources. Conducting this kind of evaluation is time- and information-intensive and this review found them to be rare.

A more common evaluation approach relies on cost-effectiveness, particularly for *ex-ante* studies. This approach typically takes a predefined environmental target as given (such as an emissions cap or a TAC) and examines whether the programme minimizes the cost of reaching that target.[5] Another form is to compare the cost of reaching the target with the programme to the cost of reaching the target with the next most likely alternative. This approach, of course, compares the programme not to an optimal benchmark, but rather the most pragmatic benchmark.

While the evidence on environmental consequences is mixed (especially for fisheries), it is clearer for the economic consequences. In the presence of adequate enforcement, tradable permits do appear to increase the value of the resource (in the case of water and fisheries) or lower the cost of compliance (in the case of emissions reduction).

In air-pollution control, considerable savings in meeting the pollution-control targets have been found (Hahn and Hester, 1989; Tietenberg 1990; Ellerman, 2003; Harrison, 2003) For water, it involves the increase in value brought about by transferring the resources from lower valued to higher valued uses (Easter *et al*., 1998; Young, 2003). In fisheries a substantial increase not only results from the higher profitability due to more appropriately scaled capital

[5] The demonstration that the traditional regulatory policy was not value-maximizing has two mirror-image implications. It either implies that the same environmental goals could be achieved at lower cost or that better environmental quality could be achieved at the same cost. In air-pollution control, while the earlier programmes were designed to exploit the first implication, later programmes attempted to produce better air quality and lower cost.

investments (resulting from the reduction in overcapitalization), but also from the fact that ITQs frequently make it possible to sell a more valuable product at higher prices (fresh fish rather than frozen fish; NRCC, 1999). One review of 22 fisheries found that the introduction of ITQs increased wealth in all 22 (OECD, 1997, p. 83).

In both water and air pollution the transition following the introduction of transferable permits was not from an open-access resource to tradable permits, but rather from a less flexible control regime to a more flexible one. The transition has apparently been accomplished with few adverse employment consequences, though sufficient data to do a comprehensive evaluation on that particular question do not exist (Goodstein, 1996; Berman and Bui, 2001).

The employment consequences for fisheries have been more severe. In fisheries with reasonable enforcement the introduction of ITQs has usually been accompanied by a considerable reduction in the amount of fishing effort. Normally this means not only fewer boats, but also less employment. The evidence also suggests, however, that the workers who remain in the industry work more hours during the year and earn more money (NRCC, 1999, p. 101).

The introduction of ITQs in fisheries has also had implications for crew, processors, and communities. Traditionally, in many fisheries, crew are co-venturers in the fishing enterprise, sharing in both the risk and reward. In some cases the move to ITQs has shifted the risk and ultimately shifted the compensation system from a profit-sharing to a wage system. Though this has not generally lowered incomes, it has changed the culture of fishing (McCay *et al*., 1989; McCay and Creed, 1990).

Secondary industries can be affected by the introduction of tradable permits in a number of ways. Consider, for example, the effects on fish processors. First, the processing sector is typically as overcapitalized as the harvesting sector. Since the introduction of ITQs typically extends the fishing season and spreads out the processing needs of the industry, less processing capacity is needed. In addition, the more leisurely pace of harvesting reduces the bargaining power of processors versus fishers. In some remote areas, such as Alaska, a considerable amount of this processing capital may lose value owing to its immobility (Matulich *et al*., 1996; Matulich and Sever, 1999).

Communities can be, and in some cases have been, adversely affected when quota held by local resource users is transferred to resource users who operate out of other communities. Techniques developed to mitigate these effects, however, seem to have been at least moderately successful (NRCC, 1999. p. 206).

Generally, market power has not been a significant issue in most permit markets, despite some tendencies toward the concentration of quota. In part this is due to accumulation limits that have been placed on quota holders and the fact that these are typically not markets in which accumulation of quota yields significant monopoly-type powers. In fisheries some concern has been expressed (Palsson, 1998) that the introduction of ITQs will mean the demise of the smaller fishers as they are bought out by larger operations. The evidence does not seem support this concern (NRCC, 1999, p. 84).

Although hard evidence on the point is scarce, a substantial amount of anecdotal evidence is emerging about how tradable-permit programmes can change the way environmental risk is treated within firms (Hartridge, 2003; McLean, 2003). This evidence suggests that environmental management used to be relegated to the tail end of the decision-making process. Historically, the environmental risk manager was not involved in the most fundamental decisions about product design, production processes, selection of inputs, etc. Rather s/he was simply confronted with the decisions already made and told to keep the firm out of trouble. This particular organizational assignment of responsibilities inhibits the exploitation of one potentially important avenue of risk reduction—pollution prevention.

Because tradable permits put both a cap and a price on environmental risks, corporate financial people tend to get involved. Furthermore, as the costs of compliance rise in general, environmental costs become worthy of more general scrutiny. Reducing environmental risk can become an important component of the bottom line. Given its anecdotal nature, the evidence on the extent of organizational changes that might be initiated by tradable permits should be

treated more as a hypothesis to be tested than a firm result, but its potential importance is large.

Economic theory treats markets as if they emerge spontaneously and universally as needed. In practice, the applications examined in this review point out that participants frequently require some experience with the programme before they fully understand (and behave effectively) in the market for permits. This finding seems potentially important for the implementation of the Kyoto Protocol's CDM.

III. LESSONS FOR PROGRAMME DESIGN

As new tradable-permit programmes are being defined to meet the obligations of the Kyoto Protocol at both the national and the EU levels, examining the lessons from previous applications might prevent repeating the mistakes of the past or the need to reinvent the wheel. What have these lessons been?

(i) The Baseline Issue

In general, tradable-permit programmes fit into one of two categories: credit programmes or cap-and-trade programmes. Air-pollution control systems and water have examples of both types. Fisheries tradable-permit programmes are all of the cap-and-trade variety.

- Credit trading, the approach taken in the US Emissions Trading Programme (the earliest programme), allows emission reductions above and beyond baseline legal requirements to be certified as tradable credits (Tietenberg, 1985). The baseline for credits in that programme was provided by traditional technology-based standards.

- In a cap-and-trade programme a total resource access limit (the cap) is defined and then allocated among users. Compliance is established by simply comparing actual use with the assigned firm-specific cap as adjusted by any acquired or sold permits.

Establishing the baseline for credit programmes in the absence of an existing permitting system can be very difficult. The basic requirement in the Kyoto Protocol is 'additionality'. In other words, the traded reductions must be surplus to what would have been done otherwise. Deciding whether created entitlements are 'surplus' requires the existence of a baseline against which the reductions can be measured. When emissions are reduced below this baseline, the amount of the reduction that is 'excess' can be certified as surplus.

Defining procedures that assure that the baselines do not allow unjustified credits is no small task. A pilot programme for Activities Implemented Jointly, which was established at the first Conference of the Parties in 1995, is useful for demonstrating the difficulties of assuring 'additionality'. Results under this programme indicate that a greenhouse-gas credit-trading programme that requires a showing of additionality can involve very high transaction costs and introduce considerable *ex-ante* uncertainty about the actual reductions that could be achieved (Rentz, 1996, 1998; Jepma, 2003).

Many credit-based programmes keep a large element of the previous regulatory structure in place. For example, some programmes require regulatory preapproval for all transfers (i.e. wetlands credits and water trading). In addition, other specific design features, such as the opt-in in the sulphur-allowance programme (Ellerman, 2003) and the use of relative targets in the UK Emissions Trading System (Hartridge, 2003), also add administrative complexity.

Theory would lead us to believe that allowance systems would be much more likely to achieve the efficiency and environmental goals and the evidence emerging from *ex-post* evaluations seems to support that conclusion (Shabman *et al*., 2002). This is of considerable potential importance in climate-change policy since only one of the three Kyoto programmes (Emissions Trading) is a cap-and-trade programme.

(ii) The Legal Nature of the Entitlement

Although the popular literature frequently refers to the tradable-permit approach as 'privatizing the resource' (Spulber and Sabbaghi, 1993; Anderson, 1995), in most cases it does not actually do that. Rather, it privatizes the right to access the resource to a pre-specified degree.

Economists have consistently argued that tradable permits should be treated as secure property rights to protect the incentive to invest in the resource. Confiscation of rights or simply insecure rights could undermine the entire process.

The environmental community, on the other hand, has just as consistently argued that the air, water, and fish belong to the people and, as a matter of ethics, they should not become private property (Kelman, 1981). In this view, no end could justify the transfer of a community right into a private one (McCay, 1998).

The practical resolution of this conflict in most US tradable-permit settings has been to attempt to give 'adequate' (as opposed to complete) security to the permit holders, while making it clear that permits are not property rights.[6] For example, according to the Title of the US Clean Air Act dealing with the sulphur-allowance programme: 'An allowance under this title is a limited authorization to emit sulfur dioxide. . . . Such allowance does not constitute a property right' (104 Stat 2591).

In practice, this means that, although administrators are expected to refrain from arbitrarily confiscating rights (as sometimes happened with banked credits in the early US Emissions Trading programme), they do not, however, give up their ability to adopt a more stringent cap as the need arises. In particular, they would not be expected to pay compensation for withdrawing a portion of the authorization to emit, as they would if allowances were accorded full property-right status. It is a somewhat uneasy compromise, but it seems to have worked.

(iii) Adaptive Management

One of the initial fears about tradable-permit systems was that they would be excessively rigid, particularly in the light of the need to provide adequate security to permit holders. Policy rigidity was seen as possibly preventing the system from responding either to changes in the resource base or to better information. And this rigidity could be particularly damaging in biological systems by undermining their resilience. Resilient systems are those that can adapt to changing circumstances (Hollings, 1978).

Existing tradable-permit systems have responded to this challenge in different ways depending on the type of resource being covered. In air-pollution control the need for adaptive management is typically less immediate and the right is typically defined in terms of tons of emissions. In biological systems, such as fisheries, the rights are typically defined as a share of the TAC. In this way the resource managers can change the TAC in response to changing biological conditions without triggering legal recourse by the right holder. Some fisheries and water allocation systems have actually defined two related rights (Young, 1999, 2003). The first conveys the share of the cap, while the second conveys the right to withdraw a specified amount in a particular year. Separating the two rights allows a user to sell the current access right (perhaps due to an illness or malfunctioning equipment) without giving up the right of future access embodied in the share right. Though share rights have not been used in air-pollution control, they have been proposed (Muller, 1994).

Water has a different kind of adaptive management need. Considerable uncertainty among users is created by the fact that the amount of water can vary significantly from year to year, implying that caps are likely to vary from year to year. Since different users have quite different capacities for responding to shortfalls, the system for allocating this water needs to be flexible enough to respond to this variability, or the water could be seriously misallocated.

(iv) Caps and Safety Valves

Even if the apparent 'schedule' of targets is equivalent to those under direct regulation, in the face of 'shocks' the cap is binding in a way that may not be the case for other policies, such as environmental taxation. This has been particularly true in RECLAIM (Harrison, 2003), the Australian water case (Young, 2003), and New Zealand fisheries (Kerr, 2003).

- RECLAIM participants experienced a very large unanticipated demand for power that could only be accommodated by older, more-polluting plants. Permit prices soared in a way that was never anticipated.

[6] One prominent exception is the New Zealand ITQ system. It grants full property rights in perpetuity (NRCC, 1999, p. 97).

- In the New Zealand fisheries case (Kerr, 2003), a lack of understanding of the biology of the orange roughy led to a cap that permitted unsustainable harvests.

- In the Australian water case (Young, 2003), excessive withdrawal would trigger substantial increases in salinity.

The experience with the price shocks in the RECLAIM case shows how to handle unexpected, and sometimes rather large, changes in circumstances that can cause the cost of achieving the cap to skyrocket. The general prescription is to allow a 'safety valve' in the form of a predefined penalty that can be imposed on all emissions over the cap in lieu of meeting the cap. This penalty can be different from the normal sanction imposed for non-compliance during more normal situations. In effect this penalty would set a maximum price that would have to be incurred in pursuit of environmental goals (Roberts and Spence, 1976; Pizer, 1999; Harrison, 2003). RECLAIM rules specified that if permit prices went over some threshold the programme would be suspended until they figured out what to do. An alternative (substantial) fee per ton was imposed in the interim with the revenue used to secure additional emission reductions (Harrison, 2003).

(v) Initial Allocation Method

The initial allocation of entitlements is perhaps the most controversial aspect of a tradable-permits system. Four possible methods for allocating initial entitlements are:

- random access (lotteries);
- first come, first served;
- administrative rules based upon eligibility criteria; and
- auctions.

All four of these have been used in one context or another. Both lotteries and auctions are frequently used in allocating hunting permits for big game. Lotteries are more common in allocating permits among residents, while auctions are more common for allocating permits to non-residents. First come, first served was historically common for water, especially when it was abundant. The most common method, however, for the applications discussed here, is allocating access rights based upon historic use.

Though an infinite number of possible distribution rules exist, 'grandfathered' rules tend to predominate.[7] Grandfathering refers to an approach that bases the initial allocation on historic use. Under grandfathering, existing sources get free allocations of rights. They only have to purchase any additional permits they may need over and above the initial allocation (as opposed to purchasing *all* permits in an auction market).

Grandfathering has its advantages and disadvantages. Recent work examining how the presence of pre-existing distortions in the tax system affects the efficiency of the chosen instrument suggests that the ability to recycle the revenue (rather than give it to users) can enhance the cost-effectiveness of the system by a large amount. That work, of course, supports the use of taxes or auctioned permits rather than 'grandfathered' permits (Goulder *et al*., 1999).

How revenues are distributed, however, also affects the attractiveness of alternative approaches to environmental protection from the point of view of the various stakeholders. To the extent that stakeholders can influence policy choice, 'grandfathering' may have increased the feasibility of implementation of transferable permit systems (Svendsen, 1999). Interestingly, the empirical evidence suggests that the amount of the revenue needed to hold users harmless during the change is only a fraction of the total revenue available from auctioning, not the whole amount (Bovenberg and Goulder, 2001). Allocating all permits free of charge is therefore not inevitable in principle, even if political feasibility considerations affect the design.

A second consideration involves the treatment of new firms. Although reserving some free permits for new firms is possible, this option is rarely exercised in practice. As a result, under the free distribution scheme new firms typically have to purchase

[7] In the EU carbon-trading programme the rules allow 5 per cent of the allowances to be auctioned off by 2005 and up to 10 per cent after 2008.

all permits, while existing firms get an initial allocation free. Thus the free distribution system imposes a bias against new users in the sense that their financial burden is greater than that of an otherwise identical existing user. In air-pollution control this 'new user' bias has retarded the introduction of new facilities and new technologies by reducing the cost advantage of building new facilities that embody the latest innovations[8] (Maloney and Brady, 1988; Nelson *et al*., 1993).

A third consideration involves how a grandfathered process may promote inefficient strategic behaviour. When the initial allocation is based upon historic use and users are aware of this aspect in advance, an incentive to inflate historic use (to qualify for a larger initial allocation) is created (Berland *et al*., 2001). This strategic behaviour can intensify the degradation of the resource before the control mechanism is set in place.

Some tendency to over-allocate quota in the initial years has been evident, presumably in many cases to enhance the political feasibility of programme adoption.

- The evaluation of the Dutch phosphate quota programme, for example, shows that initial quota was over-allocated 10–25 per cent (Wossink, 2003).

- Initial allocations were also high in the initial years of the RECLAIM programme (Harrison, 2003).

In the climate-change case, a primary concern has been about 'hot air'. (Hot air is the part of an Annex I country's assigned amount that is likely to be surplus to its needs without any additional efforts to reduce emissions.) Hot air resulted from the initial allocation because assigned amounts are defined in terms of 1990 emission levels and for some countries (most notably Russia and the Ukraine), economic contraction has resulted in substantially lower emissions levels. Hence, these countries would have surplus permits to sell, resulting in the need for less emissions reduction from new sources.

Other initial allocation issues involve determining both the eligibility to receive permits and the governance process for deciding the proper allocation. In fisheries the decision to allocate permits to boat owners has triggered harsh reactions among both crew and processors.

Finally, some systems allow agents other than those included in the initial allocation to participate through an 'opt-in' procedure. This is a prominent feature of the sulphur-allowance programme, but it can be plagued by adverse-selection problems (Montero, 1999, 2000).

Traditional theory suggests that tradable permits offer a costless trade-off between efficiency and equity, since, regardless of the initial allocation, the ability to trade assures that permits flow to their highest-valued uses. This implies that the initial allocation can be used to pursue fairness goals without lowering the value of the resource.

In practice, implementation considerations almost always allocate permits to historic users, whether or not that is the most equitable allocation. This failure to use the initial allocation to protect equity concerns has caused other means to be introduced to protect equity considerations (such as restrictions of transfers). These additional restrictions tend to raise transactions costs and to limit the cost-effectiveness of the programme. In practice, therefore, tradable-permits systems have not avoided the trade-off between efficiency and equity so common elsewhere in policy circles.

(vi) Transferability Rules

While the largest source of controversy about tradable permits seems to attach to the manner in which the permits are initially allocated, another significant source of controversy is attached to the rules that govern transferability. According to supporters, transferability not only serves to assure that rights flow to their highest-valued use, but it also provides a user-financed form of compensation for those who voluntarily decide to use the resource no longer. Therefore, restrictions on transferability only serve to reduce the efficiency of the system. According to critics, allowing the rights to be transferable produces a number of socially unacceptable outcomes, including the concentration of rights, the destruction

[8] The 'new source bias' is, of course, not unique to tradable-permit systems. It applies to any system of regulation that imposes more stringent requirements on new sources than existing ones.

of community interests, and the degrading of the environment.

Making the rights transferable does allow the opportunity for some groups to accumulate permits. The concentration of permits in the hands of a few could either reduce the efficiency of the tradable-permits system (Hahn, 1984; Anderson, 1991; Van Egteren and Weber, 1996), or it could be used as leverage to gain economic power in other markets (Misiolek and Elder, 1989; Sartzetakis, 1997). Although it has not played much of a role in air-pollution control, concentration has been a factor in fisheries (Palsson, 1998).

Typically, the problem in fisheries is *not* that the concentration is so high that it triggers antitrust concerns (Adelaja *et al*., 1998), but rather that it allows small fishing enterprises to be bought out by larger fishing enterprises. Smaller fishing enterprises are seen by some observers as having a special value to society that should be protected (Palsson, 1998).

Protections against 'unreasonable' concentration of quota are now common. One typical strategy involves putting a limit on the amount of quota that can be accumulated by any one holder. In New Zealand fisheries, for example, these range from 20 to 35 per cent, depending upon the species (NRCC, 1999, pp. 90–1), while in Iceland the limits are 10 per cent for cod and 20 per cent for other species (NRCC, 1999, p. 102).

Another coping strategy involves trying to mitigate the potential anticompetitive effects of hoarding. The US sulphur-allowance programme does this in two main ways. First, it sets aside a supply of allowances that could be sold at a predetermined (high) price if hoarders refused to sell to new entrants.[9] Second, it introduced a zero-revenue auction that, among its other features, requires permit holders to put approximately 3 per cent of their allowances up for sale in a public auction once a year. The revenue is returned to the sellers rather than retained by the government. Hence, the name 'zero-revenue auction' (Svendsen and Christensen, 1999).

Another approach involves directly restricting transfers that are perceived to violate the public interest. In the Alaskan halibut and sablefish ITQ programme, for example, several size categories of vessels were defined. The initial allocation was based upon the catch record within each vessel class and transfer of quota between catcher vessel classes was prohibited (NRCC, 1999, p. 310). Further restrictions required the owner of the quota to be on board when the catch was landed. This represented an attempt to prevent the transfer of ownership of the rights to 'absentee landlords'.

A second concern relates to the potentially adverse economic impacts of permit transfers on some communities. Those holders who transfer permits will not necessarily protect the interests of communities that have depended on their commerce in the past. For example, in fisheries a transfer from one quota holder to another might well cause the fish to be landed in another community. In air-pollution control, owners of a factory might shut down its operation in one community and rebuild in another community, taking their permits with them.

One common response to this problem in fisheries involves allocating quota directly to communities. The 1992 Bering Sea Community Development Quota Program, which was designed to benefit remote villages containing significant native populations in Alaska, allocated 7.5 per cent of the walleye pollock quota to these communities (Ginter 1995). In New Zealand the Treaty of Waitangi (Fisheries Claims) Settlement Act of 1992 effectively transferred ownership of almost 40 per cent of the New Zealand ITQ to the Maori people (Annala, 1996). For these allocations the community retains control over the transfers and this control gives it the power to protect community interests. In Iceland this kind of control is gained through a provision that if quota is to be leased or sold to a vessel operating in a different place, the assent of the municipal government and the local fishermen's union must be obtained (NRCC, 1999, p. 83).

A final concern with transferability relates to possible external effects of the transfer. The theory

[9] This set-aside has not been used because sufficient allowances have been available through normal channels. That does not necessarily mean the set-aside was not useful, however, because it may have alleviated concerns that could have otherwise blocked the implementation of the programme.

presumes that the commodity being traded is homogeneous. With homogeneity, transfers increase net benefits by allowing permits to flow to their highest-valued use. In practice, without homogeneity, that is not necessarily so if the transfers confer external benefits or costs on third parties.

When the location of the resource use matters, spatial issues can arise because the transfer could alter the location of use. Spatial issues can be dealt with within the tradable-permit scheme, but those choices typically make transfers more difficult. Both the RECLAIM programme (Harrison, 2003) and the Nutrient Quota System in the Netherlands (Wossink, 2003) place restrictions on the spatial area within which the permits may be traded. The US Wetlands Program requires regulatory pre-approval of trades. In the sulphur-allowance programme (Ellerman, 2003), no regulatory restrictions are placed on permit trades, but permit users do have to assure that any permit use does not result in a violation of the National Ambient Air Quality Standards.

(vii) The Temporal Dimension

Standard cost-effectiveness theory suggests that a cost-minimizing tradable-permit system must have full temporal fungibility, implying that allowances can be both borrowed and banked (Rubin, 1996). Banking allows a user to store its permits for future use. Borrowing allows a permit holder to use permits earlier than their stipulated date.

Tradable-permit schemes differ considerably in how they treat banking and/or the role of forward markets. No existing system that I am aware of is fully temporally fungible. Older pollution-control programmes have had a more limited approach. The emissions-trading programme allowed banking, but not borrowing. The lead phase-out programme originally allowed neither, but part way through the programme it allowed banking. The sulphur-allowance programme has banking, but not borrowing, and RECLAIM has very limited banking and borrowing owing to the use of an overlapping time frame for compliance.

How important is temporal flexibility? The message that emerges from this review is that this temporal flexibility can be quite important. Ellerman (2003) discusses the considerable role that both banking and forward markets have played in the US sulphur-allowance programme. Harrison (2003) reports that, during the tremendous pressure placed on the market by the power problems in California, even the limited temporal flexibility in RECLAIM allowed the excess emissions to be reduced by more than a factor of three—from about 19 per cent to 6 per cent. Pedersen (2003) also notes the importance of temporal flexibility for investment in the Danish greenhouse-gas programme.

Interestingly, what will happen after the initial commitment period in the Kyoto Protocol is up in 2012 has not been defined. This means that those who are investing in greenhouse-gas-emissions reductions face a great deal of uncertainty about the value of those reductions after 2012 and that presumably has an adverse incentive on making those investments.

IV. THE LESSONS FOR CLIMATE CHANGE

What can be gleaned from this necessarily brief survey of the theory and implementation experience with tradable permits that might be useful in thinking about their application to climate change?

What does the historical implementation evidence suggest? Though this review has uncovered several success stories for the application of tradable permits, it has also uncovered some failures. Though tradable-permit systems can be, and often are, cost-effective, they are not always so. In some cases they may even be more expensive than traditional policy instruments, if the preconditions for the successful operation of this system are not present.

What lessons seem to emerge for the climate-change case?

- The climate-change permit programme will inevitably move tradable-permits programmes on to new ground. The number and types of participants will necessarily be much larger than ever before experienced. The Kyoto Protocol envisions controlling six greenhouse gases under the rubric of a single programme. Experience with multi-pollutant programmes is rare. The implication is that while past experience

is no doubt helpful, it is unlikely to be definitive.

- Cap-and-trade programmes have in general proved superior to credit-trading systems in terms of both economic and environmental results. Reasons for this have to do with the lack of commodity nature of credit trades, their higher transaction costs, and regulatory barriers to their creation.

- Some previous programmatic failures have been due to inadequate monitoring and enforcement. Although it is probably true that monitoring carbon emissions indirectly via fuel use is relatively effective, other monitoring issues could still be important in the climate-change case. Not only do some countries have substantially less capability for reliable monitoring, but also some sources of greenhouse gases (land-use changes and carbon sequestration, for example) are inherently less easy to monitor reliably. Furthermore, the European Union trading scheme excludes non-CO_2 greenhouse gases on grounds of inadequate monitoring (despite protests by several members states that monitoring protocols are adequate). Reliable monitoring in the climate-change case is by no means a foregone conclusion.

- Enforcement at the international level relies heavily on the effectiveness of national enforcement. National enforcement capabilities vary widely across countries. Weak national enforcement systems would provide a significant opportunity for non-compliance in those countries, jeopardizing the achievement of the climate-change goals. Although these weaknesses in international enforcement apply to other means of controlling greenhouse gases as well as to permits, a tradable-permit system could intensify the problem through trading. Countries with poor enforcement systems could end up selling permits to those with good enforcement systems, in effect substituting ineffectively for effectively enforced permits.

- The spatial externalities that plague fisheries and water allocation seem less important for the climate-change effects of CO_2 since the emission location of CO_2 does not matter. However CO_2 is only one of the greenhouse gases and the other gases could impose spatial externalities. In addition, the leakage problem, where production facilities move to avoid the regulations, does seem a potentially serious problem. Leakage problems could arise either within countries (if certain sized plants or certain sectors are exempt) or between signatory and non-signatory countries, particularly if greenhouse-gas controls result in considerably higher energy costs in signatory countries.

- The evidence suggests that setting the cap is a crucial step in the process. Given the level of scientific uncertainty associated with some dimensions of the climate-change problem, the appropriate level of the cap for commitment periods that follow the first is by no means a foregone conclusion. Lack of consensus about the appropriate level of the cap can undermine the determination to reach it.

- A tradable-permits system depends upon the ability of emitters to recognize and to seize cost-effective opportunities to reduce carbon. While some emitters, particularly large emitters in the industrialized countries, could probably live up to that expectation, it is not at all clear that all emitters in developing countries have the requisite knowledge of the spectrum of emission-reducing choices. To some extent, the CDM mechanism diminishes the disadvantage of this asymmetry by allowing industrialized nations to identify and propose promising projects in developing countries.

- The evidence suggests that while the security of a full property right is not essential for the promotion of investments in greenhouse-gas reduction, some adequate level of security is. In terms of the Kyoto protocol, the lack of any definition of what obligations and responsibilities will accrue to nations and companies after 2012 could become a major impediment to the smooth transition to a new greenhouse-gas regime.

- It is common for tradable programmes to evolve considerably over their lifetime. Generally, the

evolution moves from a more to a less restrictive environment as participants (both public and private) become more familiar with the system. We have also seen, however, in both the US wetlands and Dutch nutrient programmes, that it is possible to add so many restrictions to the initial system that it prevents the evolution. A balance must be struck.

- Banking of allowances allows sources significant additional flexibility in compliance investment and decision-making. Heavy use of banking in both the US sulphur-allowance and lead credit-trading programmes have led to early reductions and substantially lower overall costs of compliance. Banking is especially significant for industries in which major capital expenditures must be made, as it allows individual sources flexibility in the timing of such major investments.

- In existing programmes the private market has supplied an adequate to high number of allowances or credits, so that market-power issues have not been a problem. Several mechanisms can be and have been implemented in past programmes to address concerns about market power, should they arise.

We have also derived some specific lessons for programme design.

- One enforcement principle that has become firmly established in fisheries could be usefully established for climate change as well—the presumption that the administrative cost associated with monitoring, enforcing, and administering the system will be borne by permit holders rather than by general taxpayers. These costs could be financed with a fee levied on each permit.

- Monitoring in the Kyoto Protocol will inevitably involve some degree of self-reporting. Systems of self-reporting do offer many risks of deception, although analysts may overstate the extent to which purposefully deceptive self-reporting occurs. Creating layers of veracity checks should strengthen the integrity of the allowance- and emissions-monitoring systems. At the initial stages of the permit system veracity checks of government self-reporting will be needed, but as the system matures more extensive checks on emission sources at the domestic level will be needed. National governments could provide many (or most) of the domestic checks, provided that those checks are themselves reviewed occasionally at the international level. It remains to be seen how intrusive the international monitoring system for greenhouse gases will be, but this review suggests it is an essential element.

- Enforcement could be enhanced by allowing trading only among eligible parties and by defining 'eligibility' to include only those countries that have approved domestic enforcement systems and were in compliance in the previous commitment period.

- Transparency can be an important aspect of both monitoring and enforcement and the smooth functioning of the market.

  Transparency of prices can facilitate the smooth working of the market. Providing price information is important to reduce the uncertainty of trading and create public confidence in the trading programme. Price information could be required to be revealed in reporting requirements for emissions trades, or through alternative systems such as holding regular public auctions.

  Transparency of compliance behaviour should be promoted through wide public availability of collected data. Quality assurance is easier if data are widely available; veracity-checking is facilitated by the availability of multiple sources of information; and the involvement of private monitors is frequently heavily dependent upon the existence of a rich database. There will be reluctance to reveal some information because of privacy and industrial secrets, but free flow of information should be the norm. One model for tracking trading activity is provided by the US Allowance Tracking System used in the Acid Rain Program. This publicly open allowance registry system helps to create a transparent and self-enforcing compliance system, and

has contributed to high compliance records in the programmes.

- The mischief caused by not having defined the reduction obligations for at least one future commitment period (after 2012) could be considerable.

  Knowing future ground rules would reduce uncertainty about the value of emission-reduction investments.

  Once the future assigned amount is specified, assigned-amount adjustments could provide a reasonable means of protecting the goals of the climate-change convention while encouraging compliance. This approach, which has been applied in the US sulphur-allowance programme, subtracts any overages (and possibly a penalty) from the assigned amounts in the next commitment period.

- Permit systems can be (and should be) designed to deal with the price-spike problem. Safety-valve mechanisms involving a maximum price on permits (perhaps coupled with the requirement to offset overages in any year with reductions in future allocations) could eliminate the severe economic damage that could result from a dramatic, if temporary, change in circumstances such as occurred in the California electricity deregulation case. The California case also points out the importance of having some temporal flexibility built into the programme as a hedge against temporary price spikes.

- Credit programmes, such as the CDM and joint implementation, must face the need to define a reliable 'additionality' baseline that does not pose a significant barrier to the creation and certification of tradable credits. History suggests that this is no small task.

Two important expectations flowing from the economic theory have proved to be an inaccurate characterization of reality.

The first example comes from the theoretical expectation that transferable-permit programmes do not effect conservation of the resource because the cap handles that and setting the cap is considered to be outside the system. Hence, it is believed, the main purpose of the system is to protect the economic value of the resource, not the resource itself. In fact, the stringency of the cap as well as the level of compliance with the cap may both be affected by the policy instrument choice.

The second theoretical expectation that falls in the light of implementation experience involves the trade-off between efficiency and equity in a tradable-permits system. Traditional theory suggests that tradable permits offer a costless trade-off between efficiency and equity, since, regardless of the initial allocation, the ability to trade assures that permits flow to their highest-valued uses. This implies that the initial allocation could be used to pursue equity goals without lowering the value of the resource. In practice, implementation considerations almost always allocate permits to historic uses, whether or not that is the most equitable allocation. This failure to use the initial allocation to protect equity concerns has caused other means to be introduced to protect equity considerations (such as restrictions of transfers). The additional restrictions generally do lower the value of the resource. In practice, therefore, tradable-permits systems have not avoided the trade-off between efficiency and equity so common elsewhere in policy circles.

This evidence seems to suggest that tradable permits are no panacea, but they do have their niche. Climate change may well turn out to be the most important niche.

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