INTERNATIONAL GREENHOUSE GAS EMISSION TRADING – WITH SPECIAL REFERENCE TO THE KYOTO PROTOCOL

Peter Bohm, Stockholm University

Forthcoming in "Efficiency and Equity in Climate Change policy", ed. C. Carraro, Kluwer[1]

Contents:

[1] This study was commissioned by the Nordic Council of Ministers (Copenhagen) and was published, in a somewhat larger version, as TemaNord 1999:506 (www.norden.org). The Council has kindly accepted to have the study reprinted here. -- Helpful comments by Björn Carlén, Carsten Helm, and Patrick Säfvenblad are gratefully acknowledged.

Introduction

The purpose of this paper is to identify potential benefits of international greenhouse gas (GHG) emission trading among participating countries committed to emission limits (Annex B countries in the terminology of the Kyoto Protocol) and comment on various design options for this trading. The principal criterion used for evaluating, in principle, the net benefits of different versions of free as well as constrained emission trading is the net costs avoided by the individual country when trade is allowed. The discussion is mainly focused on carbon emissions from the combustion of fossil fuel, the dominating source and that likely to be most, or sufficiently, simple to monitor. Other sources or sinks could be added once their monitoring is given a satisfactory solution, which does not require that such monitoring would have to be the same for all the sources and sinks. Although joint implementation (project-related emission trading among Annex B countries) and the use of the clean development mechanism (project-related emission trading with non-Annex B countries) also represent a form of trading, they are left out of the discussion below, the main reason being that they do not seem to offer any significant benefits in terms of real cost reductions that are anywhere near those of GHG emission quota trading among Annex B countries.[2]

The starting point of the discussion is an overview of the likely potential benefits of a fully global system of emission trading and how the benefits tend to be reduced by a non-global system like that of the Kyoto Protocol (Section 1). This section highlights monitoring issues, carbon leakage and factors promoting flexibility in the design of emission trading. Section 2 addresses the choice of domestic control systems (taxes, tradable permits, etc.) to support the national emission quotas *ex post* international quota trade, as to aspects of this choice that seem to influence the potential benefits of international emission trading to the individual Party.[3] Determinants of the benefits of international emission trading are discussed in Section 3 focusing on the potentialities of certain trading rules, the real implications of trading 'hot air' (non-existing emissions) and the supplementarity requirement in Article 17 of the Kyoto Protocol, calling for some minimum of domestic emission reductions by each Party. The main conclusions are summarized in the final section.

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[2] The reasons are: JI (project-related emission reductions in the new Kyoto Protocol sense of that term) is unlikely to play any significant role for Annex B countries already engaged in full-scale emission trading, which is the topic of this paper. CDM (which is equal to joint implementation in the old sense) refers to project-related emission reductions in non-Annex B countries that are difficult to monitor given that project baselines are unobservable and incentives exist for both buyer and seller parties to exaggerate the emission reductions achieved. Hence, stringent verification requirements will hardly allow international acceptance of a great many such projects. However, in a recent paper (Manne and Richels, 1998), it is assumed that CDM may account for as much as 15 percent of hypothetical full-scale emission trading among Annex B and non-Annex B parties.

[3] The term (national) emission 'quotas' is used for the assigned amounts of national emissions in the Kyoto Protocol. Hence, the term 'tradable emission quotas' that is used here (as in IPCC, 1996) refers to international emission trading, carried out by legal entities or by governments. The term tradable permits is reserved for domestic emission trading, *i.e.*, where a national emission quota has been allocated as permits to legal entities in a country and these entities may or may not be allowed to trade also across national boundaries. For permits traded internationally, they represent a piece of quota trading as well. The primary reason for not using one and the same term for domestic and international emission trading is that tradable quotas and tradable permits as now defined differ in important respects, for which identical terms are likely to cause confusion.

The discussion in what follows is based on literature cited in the reference list. Explicit references to sources will be made only when the argument in question is made solely in one source. The main references for the overview are IPCC, 1996 (Chapter 11); UNCTAD, 1998; two European Commission papers, 1998; Toman and Hourcade, 1998; and Bohm, 1998a,b.[4]

1. The principles of international emission quota trade

The lack of relevant experience

There is little experience of emission trading between nations concerning fully mixed global pollutants. The Montreal Protocol included some provisions for trade of CFC production quotas between (the strictly limited number of) producer countries.[5] The Protocol also allowed CFC consumption quota trade among EU member states, but also in that case trade seems to have been marginal only. Therefore, and especially if future GHG emission trading among nations would be quite extensive both with respect to the number of traders and the volume of trade, it seems fair to say that no significant international precedents exist that could help evaluate the prospects and consequences of GHG emission trading among countries.

Domestic emission trading is well documented by the experience from primarily the US, where this environmental policy instrument was first introduced by the USEPA in 1975 and has been extensively used for controlling local emission problems. There are many success stories from these applications, but also evidence of unexpected implementation problems, many of which relate to market imperfection problems of a thin markets with few traders and, as it seems, unfortunate combinations with concurrent command-and-control policies (Atkinson and Tietenberg, 1991). More recently, emission trading has been introduced for SO_2 emissions covering mainly those from coal-fired electric power plants in the US. This application seems to have offered significant cost savings, but it should be noted that, since the environmental effects of emissions of this pollutant are location dependent (a non-uniformly mixed pollutant), market emission permits here are traded so that less harmful emissions may be replaced by more harmful ones or *vice versa* (*e.g.*, Atkinson and Tietenberg, 1987; UNCTAD, 1998). Hence, the fact that emission trading up to now has been confined to domestic trading and to pollutants that are analytically different from GHGs makes the existing US experience of limited relevance in the present context.

1.1 Fully global emissions trading

It is only with the fully mixed pollutants which delete the ozone layer or risk causing global warming that an 'ideal' case for emission trading has appeared and, in the last-mentioned case, been made possible by the first step taken in Kyoto 1997. Since the global warming

[4] Those interested in the issues of the present paper should probably check UNCTAD, 1998, especially with respect to the detailed account of problems of monitoring, reporting, verification, compliance and enforcement, issues that are not so well covered below. It may also be worthwhile to check the web site www.weathervane.rff.org where the Washington based research institute, Resources for the Future, publishes comments on, as well as analyses of, climate change policies, in particular concerning emission trading in GHGs.

[5] A recent overview of historical precedents of emissions trading can be found in UNCTAD, 1998.

potential of GHGs has been considered to be independent of the location of emissions, efficient policy should treat all emissions in the same way (barring special second-best considerations). Thus, not only should all GHG emissions in a country be subjected to the same deterrents in an efficient climate change policy, this is true also for emissions regardless of national origin. This forms the basis for a straightforward application of GHG emission trading on a worldwide basis.

Since the Parties to international agreements to limit GHG emissions are national governments, international emissions trading will, at least formally, involve trade among governments. We will later return to the case where (some) governments may allocate its emissions quota to firms or other legal entities inside their respective countries. The case for *a fully global tradable emission quota (TQ) system* as a perfectly competitive market for the commodity 'emission reductions' can be simply stated as the case for international trade of any completely homogeneous commodity.[6] In principle, free trade would equalize prices for this new commodity and implement a global least-cost solution to the target of global emissions given by the agreement. Noteworthy is that this trade is 'ideal' or 'perfect' also in the sense that it will not be constrained by transportation costs as is true for trade in goods and many services. Countries can sell commitments to undertake emission reductions at prices that will be the same for buyer countries whatever the distance between sellers and buyers; hence, 'consumers' pay the prices the 'producers' get for individual transactions and these prices tend to be fully equalized for emissions trading on a perfect international market.

Furthermore, as we shall see, with certain simple trading rules extensive international emission trading implies that transaction costs per unit of trade will be small. This is another respect in which global GHG emissions would be an ideal case for emission trading and in stark contrast to many cases of local emission trading where transaction costs have constituted a significant drawback (Stavins, 1998).

Market design

To fix ideas for a meaningful discussion of global GHG emission trading, a few characteristics of the commodity traded and how it can be traded should be specified. First, as in the Kyoto Protocol, the commodity is emission reductions or units of national emission quotas that can be used once during a five-year commitment period (or be banked for a subsequent period). Second, it is only at the end of the commitment period that it needs to be checked that the quotas (*ex post* trade) cover the emissions made. It may be helpful to allow Parties some additional time into the next period during which they could purchase additional units from other Parties' first-period excess quota holdings (if borrowing is not permitted) to avoid being in non-compliance, a so-called 'true up' period.

Fully global emissions trading can be carried out, perhaps most easily, on a global exchange similar to a stock exchange. In contrast to present exchanges of this type, an international *emissions exchange* need not close and restart at intervals, since in principle all nations of the world would be operating on this market with, say, three locations of physical exchange branches, one in Eastern Australasia, one in Europe and one in North America with

[6] Note that emission reductions represent a well-defined commodity here since the reductions are counted from the level of the emission quota (or assigned emission amounts) of an Annex B country in the Kyoto Protocol. 'Emission reductions' in the sense of reductions from an uncertain future emission baseline (or business-as-usual level) are not well defined, of course.

overlapping office hours and an around-the-clock electronic market for transactions (see, *e.g*, Sandor *et al.*). Important advantages with this design are that trade can be anonymous (although each agent's sales/purchases are registered, of course) and that current prices are made known to all participants. The problem, who should bear the *responsibility for implementation* of the emission reductions transacted, is then solved by the fact that the seller will be involved in a transaction with a neutral international exchange, the latter of which (or the Protocol secretariat), once the question of sanctions have been settled, holds the seller responsible for its sales of emission reductions.

Thus, the following discussion proceeds under the assumption of an efficient market design (as if perfectly competitive), which explicitly includes 'seller beware' rules. To avoid confusion about the meaning of emission trading in a first commitment period and about the consequences for a Party to be in non-compliance at the end of that period, it is taken for granted here that, well before that period starts, stringent emission quotas for the next period have been negotiated for all countries. We will return to additional aspects of market design later.

Monitoring

While actual delivery of conventional commodities transacted typically can be validated or certified by the buyers in a straightforward fashion, this certification option is absent in the case of emission reductions traded. When governments directly or indirectly trade in this particular commodity, delivery of emission reduction commitments by sellers of quota units can, strictly speaking, be certified on an aggregate national level only and refer to conditions to be ascertained only at the very end of the commitment period, up to some five years later. Against this background, *monitoring of national emission levels* will be crucial for a reliable and well-functioning TQ system. If *combustion of fossil fuel* were the only source of GHG emissions, monitoring (although not likely, in any case, to be one hundred percent accurate) could be comparatively simple to achieve by estimating the country's fossil fuel use. Disregarding carbon removal for the time being, the carbon (or CO_2) emissions from fossil-fuel combustion would be given by the quantities of the use of all kinds of fossil fuel, multiplied by their different levels of carbon content.

Fossil-fuel use equals production *plus* imports *minus* exports (*plus* inventory changes). In a global TQ system, where all countries are committed to emission quotas, it is in the interest of every fossil-fuel exporting country to avoid underestimates of its export volume, and of every importing country to avoid overestimates of its import volume. Thus, the fossil-fuel volumes traded would likely be kept track of by the double-check thus made possible. Fossil-fuel producing countries may be able to hide quantities produced for domestic use. However, if the quantities smuggled out of the statistics can be expected to be small, especially if pre-announced production plans and unannounced inspection arrangements would be part of the international agreement, the accuracy of this approach is likely to be sufficiently high.

One problem with the monitoring of fossil-fuel use, as compared to estimating carbon emissions directly, should that be feasible, is that initial and end-period fossil-fuel inventories would have to be estimated. This particular estimation task is likely to be of the same character as that of monitoring carbon emissions, but may be approached by using some rule of thumb for the changes in inventories, once a reliable estimate of the initial stocks of fossil fuel has been established at the start of the first commitment period.

Another problem is related to *carbon removal* from emissions.[7] Direct monitoring of carbon emissions would have the advantage of eliminating emission sources that would be subjected to carbon removal and hence, also provide incentives for developing and introducing such techniques. Indirect monitoring *via* fossil-fuel use would need a separate approach for carbon removal to be taken into account. This approach could be similar to that of the Montreal protocol (Article 1.5), where it is made acceptable for signatories to subtract CFCs destroyed in the CFC manufacturing process and thus not emitted into the atmosphere, if technologies approved by the signatories are used.

Monitoring obviously belongs to the set of climate-change policy issues that need further elaboration. However, it should be noted that the monitoring problem is nothing specific for the issue of emissions trading. It stems from the demand for international commitments to limit GHG emissions; thus, the problem arises regardless of whether the limits or quotas are tradable or non-tradable. Since both sides of a quota trading market have opposite incentives for deviating from truthful reporting of amounts of fossil fuel traded, the risk for such deviations seems to be small.

1.2 Non-global emissions trading

In one particular sense, the monitoring problem becomes more complicated when we now move to consider the case of *non-global TQ systems*, which is of more immediate concern here. In the Kyoto Protocol, only Annex B countries that have ratified the Protocol can engage in emissions trading. A non-global system implies that one loses the double check on parts of the international fossil-fuel trade; for fossil-fuel imports from (exports to) non-signatory countries one cannot count on any reliable help from the export (import) statistics of these countries. To keep the monitoring of this trade on a high level of accuracy, it may be required to institute measures such as sample unannounced inspections of fossil-fuel transport from non-signatory to signatory countries, given that the rules then also require that the Protocol secretariat is notified of transports when they are contracted.

Without any new additions to the Annex B group, the maximum number of traders would be 36 countries, not counting EU itself and disregarding Lichtenstein and Monaco. The two largest traders have 35% (the US) and 18% (Russia) of the assigned amounts of all GHGs or of CO2 for 2008 to 2012. The EU countries account for 23%. Disregarding the possible influence of market power until later, the expectations are that this market for emission trading will be large enough, and can be given trading rules for it to behave as a perfect market, *e.g.*, according to the exchange design suggested above. However, if trade will be limited in various respects such as in time or that traders meet bilaterally with less room for effective competition among sellers or buyers, the market may not converge to uniform prices and efficiency.[8]

[7] Although there exist technologies for carbon removal from some forms of fossil-fuel combustion, the costs for using such technologies still seem to be prohibitively high or only now getting close to be economically attractive.

[8] The same would be true, if the supplementarity requirement in Article 17 of the Kyoto Protocol led to significant, binding quantitative or qualitative limits on emission trading. (On ‘supplementarity’, see further Section 3.4).

The prospects for having *additional countries joining the Annex B group* and participating in emission trading during 2008-12 can only be speculated about. Additional countries, if any, would belong to the poorer part of the globe and require large enough quota allocations to keep them fully compensated for the first commitment period. However, there may well be several such countries that might be interested in committing themselves to an emission quota and participate in emission trading. In a 1996 study of the acceptability of a global TQ treaty for a sample of countries, where each country was represented by an experienced (Swedish) diplomat (in 24 of 29 cases an ambassador) knowledgeable of the country he/she represented, 9 of 17 non-rich countries were deemed to be willing to join such a treaty (Bohm, 1997b).[9]

Assuming that new trader countries would get at most quotas equal to their BAU emission levels (but still enough to keep them at least fully compensated)[10], the effect of an expansion of the group of trader countries would mean that (1) new low-cost abatement options would be available, hence reducing quota prices and the costs of the emission limits for the original Annex B countries; this, in turn, might make the pre-existing quota importer countries inclined to accept more stringent emission limits for the next commitment period. Furthermore, (2) the new participants would be better off during the first commitment period as compared to not joining the Annex B group this early, since they would now get a new export commodity – emissions reductions – that would increase their export earnings by selling abatement at prices exceeding abatement costs.[11] (3) However, there would also be a group of losers as a result of the addition of new trader countries significantly lowering the quota prices, *viz.* the pre-existing sellers on the quota market. Countries that anticipate their earnings from exporting emission reductions to fall short of what they expected at the time of the initial quota allocation may require larger emission quotas in subsequent periods. Or the may be expected to try to make it difficult for new sellers to enter market – if so, most likely perhaps by requiring that potentially new seller countries get so small quota offers that they would decline to join the Annex B group.

Carbon leakage

A major difference between global and non-global (but still large) TQ systems with respect to the overall efficiency of such systems relates to the fact that non-signatories to the agreement may increase their carbon emissions as a result of the emission reductions by the signatories. Such so-called *carbon leakage* occurs partly because carbon intensive products in signatory countries become more expensive, which causes an increase in imports from, and hence an increase in the carbon emissions of, non-signatory countries. In addition, and specially if certain non-signatories are taken to remain outside international emission-reducing agreements for a period far into the future, firms using carbon emitting technologies in signatory countries now have an incentive to move to non-signatory countries where such emissions cost less.

The Kyoto Protocol does not contain any policies or measures to counteract carbon leakage. One reason is that generally acceptable, *e.g.*, WTO compatible, versions of such measures

[9] Of a total of 29 countries, 17were believed to be in favor of such a treaty; that includes 8 of the 12 rich countries. 'China' and 'India' were not among the non-rich countries saying Yes, as is also in line with what was commonly expected some 18 months before the Kyoto meeting.
[10] See the discussion of 'hot air' allocations below.
[11] This argument disregards the fact that a country may be offered a better quota allocation for a later budget period if they decline a certain 'profitable' quota offer for joining now.

are not easy to come by. But a more relevant reason in the present context for not observing what any such measure might be is that carbon leakage is a problem common to all policies aimed at reducing emissions among a non-global set of countries, *e.g.*, also non-tradable quota systems.

The bottom line concerning non-global emissions trading is that, as long as the number of trader countries is large, there is not likely to be any large difference of the principles in trading arrangements and results between global and non-global trading, with exception for the carbon leakage problem just noted. An important effect of having still more countries joining an agreement like the Kyoto Protocol is that carbon leakage risks will be smaller.

We now turn to address an issue, which is equally relevant for global and non-global carbon emissions trading.

1.4 Flexibility aspects

According to conventional terminology, emission trading provides flexibility to commitments by countries to limit their carbon emissions. Additional flexibility to the TQ system itself can be provided by the choice of the length of the base period and the target period and by allowing banking and borrowing of quota units. As the UNFCCC originally was formulated, the *base period* was set to be one year, the base year 1990, in spite of the fact that a number of 'fairness' problems would have been avoided by choosing a longer period of, say, three or five years. Probably for practical reasons, the Kyoto Protocol kept the same one-year base period. The *target period* of five years, 2008-12, in the Kyoto Protocol avoids some of the problems that are related to the variation over time in fossil-fuel use over the business cycle or as a result of extreme weather conditions (*e.g.*, heating needs and precipitation for hydroelectric output).

The Kyoto Protocol allows *banking* of quota units for use during the next commitment period, presumably for 2013-17 (for which quota negotiations will start no later than 2005, but is assumed here to be finalized well before 2008). Banking means that a country is allowed to keep quota units to sell them later or to cover future emissions. Thus, the implication of banking is (a) that countries are allowed to speculate in quota prices across periods and (b) that countries can make extra emission reductions during the first period that are less costly than the quota prices expected for the next period. Furthermore, (c) banking protects the country from the consequences of abating more than required by mistake. The latter two implications explain why banking is not controversial and thus probably why it is included in the Kyoto Protocol.

What is not accepted in the Kyoto Protocol is *borrowing*, *i.e.*, allowing Parties to borrow from their commitments for the next period, thus exceeding their present quotas. This would provide some leeway for a country that, at the end of the commitment period, is hard pressed to stay within its quota – *ex post* whatever quota trade that has occurred up to that point –and finds additional units at that point in time to be 'too expensive' to purchase.[12] Allowing a strictly limited amount of borrowing, say, by one or two percent of the next

[12] Such problems will essentially remain even if a 'true up' period of a couple of months into the next commitment period is introduced (UNCTAD, 1998) where countries in non-compliance could buy additional units from those who so far have banked quota units from the first period.

five-year commitment period's quota, *i.e.*, 5-10% of the first year's share, could make a significant difference for such a country. Borrowing could be subjected to a cost of a fixed 'rate of interest' or an equilibrium rate at which aggregate borrowing equals aggregate banking (to avoid having emissions exceed the target for the first commitment period). The resulting additional flexibility provided by allowing (limited) borrowing may make some countries more willing to accept stringent (or lower) national quotas and hence, make the aggregate commitments larger than if borrowing is ruled out. Thus, it might be in the interest of efficient climate change policy to allow limited borrowing.

2. Domestic policies to support carbon emissions trading

At the end of a commitment period, trader countries will be accountable for having, *ex post* quota trade, an emissions quota sufficient for covering the carbon emissions made during the entire period (unless amendments to the Kyoto Protocol are made to allow for limited borrowing). An advantage with tradable quotas as an international climate change policy, as compared to policies such as international carbon taxes or harmonized domestic carbon taxes, is that countries can choose individually their domestic policies to be in compliance with their commitments in the Kyoto Protocol. Thus, they could use either a domestic tradable permit (TP) system, domestic carbon taxes (or, which will not be discussed any further here, less appropriate taxes such as energy taxes) or direct regulation of carbon emitting activities. These three options will be discussed in turn.

2.1 Tradable permits

In many discussions of the TQ system, it has been more or less taken for granted that this system will be coupled with domestic TP systems. There are several advantages with this combination. First, the initial national quota can be allocated to domestic units, which in turn may trade on the international market either directly or *via* special trader firms or brokers. This will contribute to an atomization of the market and hence, with special respect to the US, where the preferences seem to be almost unanimously in favor of using a TP system, make those outside the US, who fear a market dominance of that country, more at ease. The government of a country that uses the TP approach is still the Party to the Protocol and only that Party can be held internationally accountable for compliance. Still, by choosing to use a TP system that is integrated into international trade, the government would delegate the everyday quota trade decisions to domestic firms or trading units.

Second, when a TP system is used, the country 'cannot' go wrong in attaining compliance with the Protocol in the sense that rule-abiding domestic units can only use the permits they set out with *plus/minus* permits bought/sold to cover their carbon emissions. This property is clearly absent when taxes or direct regulations are used.[13]

Permit liability placed on emitters or at levels preceding the emitter level

Third, the choice of design of a TP system (and a carbon tax system) is flexible in the sense that there are several options for the level at which permit (tax) liability can be introduced.

[13] To be sure, *fraudulent* behavior is possible in all three cases, in that a permit-liable or tax-liable unit or one subjected to regulations can break the law.

There are some strong preferences heard for placing permit-liability as much *downstream* as possible, hence where the combustion of fossil fuel takes place. This would imply, it is argued, that it is the entity, which knows the technology options and the market for its outputs and inputs, that trades in permits to cover its emissions. However, there are several problems with this approach; due to (a) high transaction costs, (b) small end users are likely to be excluded from the TP system, and (c) for this and other reasons, the system does not have the advantages it is claimed to have. Transaction costs for having individual motorists buying and presenting permits to buy gasoline will obviously be very high, and few pro-TP analysts advocate including small users in the TP system, at least not directly.

One way to deal with the problem of a separate treatment of large and small fossil-fuel users is to move permit liability for the group of small emitters *upstream* and place it, by permit-liability regulation, on sellers of gasoline to motorists and heating oil, etc for one-family houses – *e.g.,* on retail sellers, wholesale sellers or importers/producers of gasoline/heating oil etc. This means that the consumer prices of these products will include the current permit (= quota) prices. The remaining question then is whether the individual motorists, house owners or other small-scale fossil-fuel users would make less efficient decisions by adjusting to permit prices *included* in the gasoline etc. price than by adjusting to permit prices that are *excluded* from gasoline price.[14] Since this is unlikely, and equally true for other fossil-fuel users, all fossil-fuel uses can be directly included in the TP system and transaction costs be minimized by placing permit-liability as much upstream as possible, *i.e.,* on producers and importers of fossil fuel.[15] Thus, the initial amount of permits, which equals the country's carbon emission quota, would be distributed to these units. This does not preclude that other units be allowed to hold permits for one reason or another, *e.g.,* as speculators in permit prices changes or as environmentalists who wish to withhold part of the permit volume from emitters (Bohm, 1998a).

An additional advantage of having permit liability placed on the producer (also the exporter) level and the importer level would arise if the country's emissions were monitored simply by its fossil fuel production *minus* exports *plus* imports as mentioned earlier. This presupposes that there is an acceptable solution to the problem of monitoring changes in fossil-fuel inventories. Then, domestic as well as international monitoring would be simplified by having the permit volume distributed to producers and importers of fossil fuel, thus monitoring only the amounts of fossil fuel sold by these entities. Direct monitoring of carbon emissions would not be needed for international or domestic accountability anywhere along the road.

Initial permit allocation gratis (by grandfathering) or by auction

Fourth, the choice of the design of a TP system is flexible also in the sense that the permits can be allocated *for free,* as is the standard procedure in the US, or be *auctioned* off by the

[14] To highlight the permit price part of the consumer price, if that is required, this could be done in the same fashion as is often used to make buyers aware of the share of a consumer price that is a sales tax or a VAT, but now by making mandatory a statement of the absolute amount of the permit price.

[15] As an illustration, a non-fossil-fuel-producing country like Sweden that has some 300-400 registered carbon-tax-liable importers of fossil fuel, would in a TP system simply make these tax-liable units permit-liable instead. (See the account of an experiment proposed to make it possible to compare the effects of the carbon tax system in Sweden with those of a TP system, by replacing the carbon tax system for a representative sample of tax-liable importers by permit liability, STEV 1991.)

government to the permit-liable units and/or those who want to buy permits for other reasons.[16] There are two important differences between these two allocation principles.

(1) Auctioning the whole volume of permits (=equal to the initial quota) provides government revenue that allows a reduction of pre-existing distortionary taxes, a so-called double dividend. The reason is that auction prices on permits (essentially a carbon tax, see below) are not in themselves distortionary (contrary to claims made in parts of the economic literature). Given that the initial permit volume reflects a global environmental concern filtered through a process of international negotiations, the auction price reflects this environmental concern and emerges as corrective rather than distortionary levy just like any other environmental 'tax' reflecting similar concerns would. With *gratis* allocation of permits there would still be permit prices that emerge on the permit market right after the distribution of permits has taken place. These prices would likely be about as high as the auction price, at least in the beginning. These permit prices will not reflect any distortion of the economy, any more than the auction prices (and the permit prices that succeed them) would.

(2) *Gratis* allocation such as grandfathering (allocation guided by some historical emissions/fossil-fuel-use data for individual firms, etc.) means that the wealth (rents) represented by the permits will be given in some proportion to existing legal entities or firms. Strictly speaking the implication is that these firms obtain windfall profits (as compared to not being given the permits *gratis*). This does not mean that it will be less expensive for them to emit carbon. The alternative to emitting a ton of carbon and having permits cover that amount is always to sell or not buy permits. Thus, all agents, with or without a free allocation of permits, will be confronted with the same (opportunity) cost for emitting carbon.

Still, as a result of making some firms richer than others by giving them (a large volume of) permits, the 'favored' firms get 'deeper pockets' which on an imperfect capital market enables them (a) to remain in business for some 'non-economic' reason, (b) to have more funds for risky investments like R&D for which borrowed funds are less likely to be available and (c) to have cheaper access to bank loans and capital markets by simply being richer, making loans less risky for the lenders (Bohm, 1994). Firms that are not favored in this fashion are definitely the new firms that want to enter the market. Since these firms tend to be more efficient than existing firms, giving away permits for free to existing firms can be expected to slow down productivity growth. It follows from what was said in the preceding paragraph that no such favor is given to incumbent firms when the permits are auctioned.[17]

A major issue in the TQ debate has been that a country which uses grandfathering of permits, say the US, would give its firms (in sectors favored by the grandfathering rules used, *e.g.*, carbon-intensive sectors) a competitive edge against countries that uses carbon taxes or auctions permits. However, the two points mentioned above – revenue recycling to

[16] The reason for the US not auctioning permits to any significant extent may be called 'political' and similar to the political resistance to introducing new taxes. A limited amount of auction may exist, such as the 2.8 percent of the SO_2 permit volume. This amount is aimed at facilitating the access of new firms to permit holdings.

[17] This is not to say that there may be *fairness* reasons for transferring some wealth to old firms, which in contrast to new firms have invested in durable equipment guided by relative prices that now are changed by environmental policy.

reduce tax distortions and neutrality towards new firms – imply that auctioning of permits provides other important efficiency benefits to the economy in these countries. In particular, the recycling of auction revenue to reduce distortionary taxes typically provides financial assistance to existing firms as well and could be designed specifically with that purpose in mind (although that would typically reduce magnitude of the double dividend).

Finally, it should be noted that if fossil-fuel producers/importers were made permit liable, these firms rather than the end users would be favored by a free allocation of permits. To avoid such an outcome of unwarranted transfers of wealth, the fossil-fuel producers/importers would have to be taxed and the end users subsidized. When permits are auctioned, and especially when the government wants to use the revenue to reduce taxes, this cumbersome process would not be needed. This is likely to imply that placing permit liability on fossil-fuel producers/importers is attractive mainly for governments that want to auction the permits.

2.2 The equivalence of permits and carbon taxes

For countries that otherwise would use a carbon tax, the revenues of which would be used for tax recycling, an equivalent approach would be to use auctioned tradable permits. Thus, contrary to what is often alleged, tax and TP policies are equivalent as long as political constraints on any of these policy options are disregarded.[18] The price for emissions, the emission volume and the amount of government revenue would be the same if the permits were auctioned by the government or if the tax had been set at a level equal to the resulting auction price for the permits (disregarding the time difference between tax collection (*ex post*) and the permit auction (*ex ante*)).

If the permits instead were distributed for free in certain proportions to certain firms, the TP option would be the same as a tax that would generate the same emission volume and where the resulting tax revenue, equal to the wealth value of the 'grandfathered' permits, were redistributed to the same firms in the same proportions as in the case of grandfathered permits. In other words, not only price and quantity but also the distributive outcome can, in principle, be made the same in the two cases of TPs and carbon taxes.

Political reasons may explain why the US does not seem to have access to the same set of options as other countries that do not 'have to' give away the permits for free or 'cannot' use taxes. Thus, for example, a Nordic country that could use carbon taxes and recycle the tax revenue could also accomplish the same thing by auctioning permits, since the tax policy and the permit policy are environmentally – or emission- wise – equivalent in the present context. For reasons given at the end of the preceding subsection, a country like the US may not have any other option than grandfathering permits to emitters, *i.e.*, ruling out the use of carbon taxes as well as the cumbersome tax/subsidy scheme, where producers/importers of fossil fuel are made permit liable, as politically unpalatable. This means that the US might be politically 'forced' to use an approach, which harms new firms, hence, productivity growth, and misses a chance to reform its tax system through revenue

[18] This is correct, strictly speaking, under full information. Under uncertainty, it may not be practically feasible to implement this equivalence, since the permit approach implies a control of quantities and the tax approach a control of prices.

recycling.[19] By contrast, some other countries such as the Nordic countries may use either taxes or permits and have permit liability placed where otherwise tax liability would be placed, *e.g.*, on producers/importers of fossil fuel.

2.3 Carbon taxes and regulations

In Section 2.1, one principal argument was given that may support the claim that TPs will be more efficient to use than other options for domestic policies. It was stated that a TP system would lead automatically to fulfillment of a quota commitment, when TPs were issued in the amount of the initial national emission quota and permit-liable entities (and others who wish to hold permits) trade directly or indirectly to increase or decrease the quota that the country is given. By contrast, options such as direct regulation and carbon taxes would have to be adjusted over time if the target is to meet the government's *ex-post*-quota-trade quota; such adjustments may be more difficult to predict and hence more costly for all those affected by these taxes or regulations than having these entities adjust to changes in market-determined permit prices.[20] Or a government would have to adjust its quota trade to meet the outcome of whatever tax levels or regulations that initially had been decided; this would be costly for the country in that its marginal emission abatement costs would end up deviating from the 'international market quota price', thus forcing the government to abate too much at home or to buy quota units at prices that exceed abatement costs at home.[21] For the case of regulations, there is, of course, also the well-known argument that regulations are unlikely to be as cost-effective as the market-based instruments, carbon TPs and carbon taxes.

Still, individual countries may not like, or may not find it technically feasible, to use a TP system at all or one that implies that individual permit holders trade on the international quota market. For a government that wishes to use TPs for domestic trading only, prices on the domestic permit market that exceed the international quota price would encourage the government to buy additional quota units and feed them in terms of permits into the domestic market. Or, in the opposite case when the quota price is higher than the domestic permit price, the government could buy permits on the domestic market and sell them as quota units on the international market.

In the last-mentioned case as well as when carbon taxes or regulations are used, the government will be the trader on the quota market. An argument commonly voiced is that this would be inefficient for the reason that governments are not known to be efficient traders (although they may very well hire professionals to do the job for them)[22] or that they

[19] However, things may be changing now, at least as evidenced by the June 1998 working paper by two US economists, entitled "Tradable Carbon Permit Auctions: How and Why to Auction, Not Grandfather " (Cramton and Kerr, 1998).

[20] It would seem possible that a country would end up having, possibly as a political compromise, both (low) carbon taxes – say, keeping an already existing such tax – and a TP system, to which also international emission trading now had been delegated. However, confusion may arise especially if the tax would exceed the international quota price level, hence implying that the domestic permit prices should be negative. Such combinations are not considered anywhere in the text here.

[21] In both these two forms of adjustment – through changes in the levels of domestic taxes/regulations or the *ex-post*-quota-trade quotas – the cost of deviations from the efficient levels would be reduced if the Parties had access not only to banking but also to (limited) borrowing.

[22] It may be noted that the emission trading experiment with 'government traders' from Denmark, Finland, Norway and Sweden (Bohm, 1997a) performed very close to the theoretical efficiency level of a perfect market.

would not be as well informed about the relevant marginal abatement costs as the permit holders would be. However, as discussed in Bohm, 1998a, given that governments will keep negotiating emission quotas for new commitment periods, there are strong incentives for them to be well informed about their countries' marginal abatement costs. Only then can they evaluate the costs of proposed quota allocations and how internationally fair such proposals are.[23] By contrast, there are many possibly permit-liable firms, which may not be so well informed about their position on their future commodity markets, e.g., those in strong competition with other firms. Given the arguments stated above for having part or all of the permit liability placed upstream, at least some permit-liable firms in such a system would not have any direct information about the relevant market conditions and the carbon substitution technologies downstream. They may even be less well informed than a government, whose perspective for international quota trade is the relevant aggregate marginal abatement costs for the country as a whole. Thus, even countries that won't use an integrated TQ/TP system may not be much less efficient than others in trading on the international quota market.

Further work is, of course, needed to identify which of the domestic market-based policy options and their various versions that would be best suited to meet the policy targets of an individual country. But given the efficiency arguments presented above, a likely candidate at this point in time would be TPs auctioned to fossil-fuel producers and importers.

3. Determinants of the benefits of international emission trading

If emission trading would arise among countries that act in their own self interest, the resulting trade is proof enough that the benefits of international emission trading are large enough. Still, the likely size of these benefits is naturally of great interest to ascertain for countries that need to determine the extent to which they would like to participate and the trade design they would prefer. As a general remark, aggregate trade benefits would be larger (and carbon leakage problems smaller) the larger the number of participating countries and the more the quota allocation among a given set of trader countries deviates from the cost-effective distribution of emissions among them. Individual country gains from trade would be larger the more distant their initial quotas are from their internationally cost-effective emissions volume, although each country, of course, loses from having a smaller initial quota, other thing equal. Furthermore, aggregate as well as individual country gains from trade would be larger the larger the span between buyers' and sellers' reservation prices (*i.e.*, the span between high and low marginal abatement cost curves) around a given equilibrium quota price.

A more specific indication of what benefits may arise from international carbon emission trading is given by the Nordic quota trade experiment referred to earlier. Using marginal abatement cost data derived in a fashion that made them unlikely to differ much from what could be expected to be realistic, it turned out that even for these, in many respects, quite similar countries, abatement costs differed a great deal and gave rise to considerable trade gains. The estimated aggregate cost for Denmark, Finland, Norway and Sweden to stay on their 1990 carbon emission levels by the year 2000 (a Rio 'target') amounted to USD 713 million in the absence of trade, but was reduced to USD 368 million as a result of

[23] Also for a government that uses carbon taxes or auctioned permits and needs to predict government revenues, it would need information about the aggregate marginal abatement costs in the country.

(hypothetical) emissions trading, *i.e.*, by almost 50 percent (for details see Table 1 and Bohm, 1997a).[24]

Table 1 Carbon emission trading among four countries(the fully efficient trade in parentheses)

Country	**Unilateral**		**Trade**	**Ex post emission trading:**		
	Em. red. (Mton)	Cost (MUSD)	Exp./Imp. (-) (Mton)	Em. red. (Mton)	Cost (MUSD)	Net gain (MUSD)
Denmark	1.7	61	0.5 (1.19)	2.2 (2.9)	83 (116)	6.7 (5.1)
Finland	6.0	94	5 (5.76)	11 (11.8)	216 (251)	136 (132.2)
Norway	5.4	456	-3.5 (-4.4)	1.9 (1.0)	91 (40)	178 (194.5)
Sweden	1.6	102	-2 (-2.55)	-0.4 (-1.0)	-22 (-51)	24.4 (25.1)
Total	**14.7**	**713**	**±5.5 (±6.95)**	**14.7**	**368 (356)**	**345 (357)**

The outcome of this experiment illustrates another important aspect of the benefits of international emission trading. The efficient trade volume in the year 2000, *i.e.*, the volume exhausting all potential aggregate gains from trade for these countries, amounted to 6.95 million metric tons of CO2, while negotiated trade actually amounted to only 5.5 million tons, *i.e.*, 80 percent of efficient trade. However, trade achieved 97 percent of the fully efficient trade gains (gains as if under perfect competition). This outcome reflects the fact that, when all potentially valuable transactions are not carried out, it is only the least valuable trade, where buyers' and sellers' reservation prices are very close, that does not materialize.

The design of the experiment also reflected the likely extent of certain aspects of *uncertainty* in real-world trading and some of their implications for the gains from emission quota trade. As already pointed out, countries negotiating quota allocations need to know as much as possible about the cost implications of alternative such allocations for themselves but also about the extent to which different proposed allocations can be regarded as internationally fair; hence, countries will have strong incentives to estimate the marginal abatement costs of their own country as well as those of others. To the extent that the marginal abatement costs are likely to guide emission trading among Annex B Parties, this information will also allow estimates of quota prices for the upcoming commitment period and thus, the order of magnitude of their expected trade gains. Investigations into the marginal costs have been going on for some time in both international organizations and individual countries and can be expected to make the international community approach a state of near-full common knowledge of what the cost differences are. In the Nordic experiment, the participating countries had been exchanging information for some time about their respective marginal abatement costs as far as the *technical* abatement options were concerned. However, the trade-relevant *social* marginal abatement costs, *i.e.*, after the

[24] If trade gains to an individual country are considerable, income effects are likely to play a role. General equilibrium models, of which there are now many in use to estimate the net costs of climate change policy, need to take such effects into account.

trader countries have taken income distribution, employment and other 'political' costs into account, which may introduce small or large information asymmetries, will emerge as essentially unknown deviations from the technical costs. The experiment was designed to reflect these information conditions, which can be expected to hold also for the trade among the Annex B countries, although the trade rules may be quite different when the number of countries will be much larger than four.

3.1 The 'hot air' issue

Estimating business-as-usual (BAU) emissions ten years from now is obviously difficult. However, it is widely expected that they would fall short of the "assigned amounts" or quotas in the Kyoto Protocol for some of the Annex B countries, notably Russia and the Ukraine. If so, the outcome is that part of the emission reductions eventually bought will be 'hot air' only. But the claim that this is a failure of the Protocol may be based on a misunderstanding of what was possible to achieve in the Kyoto negotiations. The resulting Protocol would certainly be a failure if the relevant comparison for the Protocol were that the negotiations could have ended in no country being given a quota with 'hot air', other things equal. But it may well be that other things would not have been equal.

First, Russia and the Ukraine may not have accepted a reduction of their quotas to equal their most likely BAU levels, especially not given the time-pressed conclusion of the Kyoto negotiations. Instead, the risk would seem to have been significant that, confronted by such a quota offer, one or both of these countries would have dropped out of the agreement. Recall that BAU estimates are uncertain, perhaps especially so for countries like Russia and the Ukraine. These countries may also be more optimistic about their GDPs around 2010 than other countries are and predict that their BAU emissions would grow considerably even after an expected increase in their energy efficiency.

Second, if Russia and the Ukraine would have dropped out if offered quotas without any 'hot air' according to some given estimate, other Annex B countries would realize that their commitments then would have become more costly and therefore may have negotiated larger quotas to themselves. Take the case where these countries taken together now would have added the assumed known 'hot air' amount to their quotas, thus keeping aggregate emission reductions on the level of the Kyoto Protocol. Their costs would then be reduced by the fact that they no longer would have to pay for the 'hot air' bought from Russia and the Ukraine. But they would then also have to replace the amount of real emission reductions that these two countries otherwise
would have made at the estimated above-zero quota price. If the approximate marginal abatement cost relationships up to 2012 were known, it would have been possible to estimate the likely quota trade and quota price already now and hence, whether the net costs for the remaining Annex B countries would be smaller or larger as compared to the present Protocol. Since this was not known in December 1997, it can only be said that there is a risk that their costs would be larger for the unchanged aggregate emission reductions and that they may have wanted to increase their quotas by more than the 'hot air' amount as so far assumed.

In addition, it should be observed that, as a result of Russia and the Ukraine having dropped out, there would be an increased risk for carbon leakage from the remaining Annex B countries and hence, a risk that global emission reductions then would be smaller than what

would follow from the present Protocol. This would add to the risk that the remaining Annex B Parties would have liked to increase their quotas by more than the 'hot air' amount, thus increasing the aggregate emission level above the level implied by the present Protocol. If so, it follows that the Kyoto Protocol may be the 'best' that could have been achieved under the given circumstances.

More specifically, this means that the 'hot air' component of the Kyoto Protocol could be seen as part of a successful agreement, *i.e.*, as one with possibly larger aggregate emission reductions than a feasible alternative outcome of the negotiations without 'hot air'. In this alternative case, the argument that now is heard that 'hot air' calls for deviations from free emission trading – to ensure that the expected quota buyer countries would abate more at home – would not have been made. Then, it hardly makes sense to argue that such deviations are called for in the Protocol that may accomplish larger aggregate emission reductions than in the alternative unobservable case. (See further the subsection on 'supplementarity' below).

It should be noted that the introduction of emission trading may increase the attempts by seller Parties to obtain large quotas, possibly including 'hot air' (which the Russian and Ukrainian behavior may be an illustration of), as compared to the case of non-tradable quotas, other things equal. The reason is that making quotas tradable implies that the value of an additional quota unit to a seller country, *i.e.*, a Party with low marginal abatement costs, is increased from the marginal abatement cost (zero if already in the 'hot air' region) to the expected quota price (see Bohm, 1992). Also, if seller countries (countries in transition to market economies and, later on, presumably also developing countries) are countries with expectations to grow at rates above the Annex B average in later periods, they may press for larger quotas already in a first commitment period, given that larger quotas 'today' will help to get larger quotas 'tomorrow' accepted.

The conclusion of this subsection – that the presumed 'hot air' component of the Kyoto Protocol, in fact, may be part of a successful agreement – may be incomplete in one possibly important respect. In Toman and Hourcade, 1998, it is argued that "Trading in 'hot air' is seen as a bad precedent in terms of future entry by other countries into Annex B of the Protocol". However, the 'hot air' in the Kyoto Protocol is now a 'fact of life'. The concern that it would work as an effective precedent can only be addressed by Parties being better prepared for future negotiations than they were in Kyoto. In addition, it could be declared up front that the expected 'hot air' component of the Kyoto Protocol should not be regarded as a precedent but as a specific characteristic of this the first round of emission quota negotiations, where the quota negotiations close to the time limit and a desire to get 'at least something' out of these negotiations called for significant concessions to a set of poorer countries.

3.2 Trading rules and trade gains

A possible version of *efficient, free international emission trading* is, as mentioned earlier, that of an exchange where Annex B countries and, for some of them, private entities, to which a national quota has been distributed, enter bids and asks (offers) in terms of quota units and prices. Such bids or asks made on a market that is worldwide and constantly open would be accepted or rejected in the same way as on an ordinary stock exchange. At the end of the first commitment period, a series of trade/price combinations will have been

observed, including possible resales or repurchases as a result of changes in underlying factors determining quota demand and supply and changes in expectations of new trade opportunities that evolve over time. The gains from these trades will be the result of (a) supply and demand as revealed by the asks and bids and accepted bids and asks made and (b) the dates when these bids and asks will have been made. The latter determinant of the gains made may be referred to as revealing the skill (or 'luck') of individual traders. However, since all participants in this trade are likely to have access to similar trading skills, it would seem that the second determinant of the differing gains by the traders is essentially due to stochastic elements. Although all countries are familiar with, and have experienced, the influence of stochastic elements on trade gains, *e.g.*, when negotiating long-term contracts for fossil-fuel trade, it would seem that the trade rules now suggested may be acceptable to the Parties (see also the subsequent discussion of 'market power').

If trade would take place directly between two parties, outside an exchange or in the absence of an exchange, a strong feeling may arise that some of these *bilateral transactions* are unfair to other traders. The role of such transactions would have to be analyzed in detail. However, as a minimum condition for acceptable bilateral transactions, it would seem to be necessary to make all transactions subject to a transparency requirement, where they and their prices are made commonly known to all traders (*e.g.*, *via* a Protocol secretariat), though not necessarily who trades with whom. For this transparency requirement to be meaningful, it would also seem necessary to require that Parties consent to abide by a rule of no 'side-payments' of any kind, although enforcement of such a rule, of course, would be difficult.

Implementing multilateral transaction systems, as on an exchange market, would make it possible to keep traders anonymous to one another (but not to the market administrator, the Protocol secretariat). If non-anonymous, certain mutually beneficial transactions may not come about for reasons of diplomatic controversy or, when firms trade, for reasons that established firms do not want to sell permits to new competitors. Anonymity would thus seem to make market transactions more efficient.

3.3 Market Power

Much attention has been paid to the risks that one or two large trader countries could influence market prices to their own advantage. As a case in point, it has been feared that the US might act as a monopsony and keep prices down, although this would be less likely if the US government delegates its international quota trading to independent firms. The trading rules finally adopted will certainly have been scrutinized from the perspective of market power. However, it is worth noting that the quota exchange discussed above is likely to make market power inoperative. The primary reason is that one buyer cannot succeed in reducing prices by reducing its demand, when all other traders can keep making transactions as long as there are sellers that can accept prices offered by buyers and *vice versa*. This means that the aggregate trade volume cannot be made smaller than the perfectly competitive volume and that prices for final trades must approach the competitive price level.

Still, it may be possible for a dominant trader to make early transactions at prices that are favorable to this trader. If so, part of the conventional market power argument would remain valid. However, since the trader countries, as already pointed out, would have strong

incentives to collect information about not only their own but also their trade partners' marginal abatement costs, they would be able to predict fairly well what the competitive price level would be on the international quota market. Then, it becomes less likely that sellers (buyers) would accept prices much below (above) that level, hence reducing this form of market power in early transactions as well (Bohm, 1998; Carlén, 1998).

3.4 Supplementarity: Caps on Quota Imports or the Use of Flexibility Mechanisms

Article 17 of the Kyoto Protocol calls for emission trading to be only "supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under Article 3". The principal reason seems to be that it would be unsatisfactory if a Party could meet its commitments only (mainly) by buying emission reductions from other Parties and thus avoid doing any (significant) reductions at home. It has been suggested that quantitative constraints on imports of emission reductions be introduced, possibly including not only emission trading but also JI and CDM activities. Or the constraints may be of a qualitative character implying, *e.g.*, harmonization of policies and measures across countries. Such constraints might increase marginal costs or shadow prices of emission reductions in the importing countries and be, as has been argued, a more effective stimulus to "technical innovation needed to make future targets more affordable" (Toman and Hourcade, 1998).[25]

Only constraints on emission trading will be discussed in what follows. The reason is the assumption that, if CDM operations are properly checked for possible distortions of the projects' nation-wide baselines and hence their *de facto* emission reductions, both strictly speaking unobservable (see e.g. Bohm, 1997a), this flexibility mechanism will most likely play a modest role only.[26] JI among committed countries, also on a project-by-project basis with its demanding estimation problems, can hardly be expected to attract much attention since the simpler and more potent emission trading mechanism exists for these countries.

Furthermore, no distinction will be made between quantitative and qualitative constraints here. The latter type of constraints may be: changes in average quota prices, levels of subsidies on carbon intensive activities, road pricing, norms and standards for energy efficiency, etc. (UNCTAD, 1998). The reason for discussing only binding quantitative constraints is that the resulting reduction in efficient emission trading is the crucial point and that the purpose of qualitative constraints in this context is to force countries to do more abatement at home than they otherwise would like to do.

First of all, it should be noted that the opening up of emission trading implies that a new tradable commodity is introduced in the world economy. As with all other tradable commodities, a case can be made for free trade, which would benefit all trader countries. If

[25] This argument is strange for several reasons (as Toman and Hourcade, no doubt, would agree). First, the argument, as it stands, says that making abatement (artificially) more costly now will make it less expensive later; the first effect is certain whereas the second is not. Second, it may be noted that caps on trade may not always make imported abatement as expensive as domestic abatement. If trading institutions are such that market power can arise, market power on the importer side would tend to reduce prices on quota units traded below the free-trade competitive price. The opposite would be true if market power were placed on the seller side of the international market. (For an exercise along these lines, see Manne and Richels, 1998).

[26] However, it may be noted that "limits on Annex B trading could drive more trading to the CDM, which is more difficult to establish and monitor" (Toman and Hourcade, 1998).

all countries eventually would agree to observe negotiated emission quotas and thus become Annex B countries, global free emission trading would minimize global costs for a given global emission target and benefit all countries that participate, especially if we can assume that significant economic distortions do not exist to the extent of making unregulated trade detrimental to some or all countries participating.

Regardless of emission trading being global or non-global, all participating countries acting in their self interest would make at least part of their emission reductions at home, given quota prices non-trivially exceeding zero. The basic reason for this outcome is that the lowest costs for a country to reduce any of its emissions from its BAU level will barely exceed zero, especially when forewarned several years in advance. This presupposes, of course, that there are no absolute political constraints on actions at home, which if they did exist would mean that the country is punishing itself by accepting costly constraints on trade. What this means is that the country would pay more by not undertaking low-cost actions at home – by not producing, as it were, a commodity to the extent the country has a comparative advantage to do so.[27] Moreover, if the country is large, its extra demand for imports of emission reductions will tend to increase quota prices, thus punishing it even more.

If an individual country expects quota prices in 2008-12 to be much lower than those expected for the subsequent commitment period, it might seem to pay the country to do less – and in an extreme case, nothing – at home now and save, if meaningful, domestic emission reduction options for the next period. In principle, this may go on for several periods, thus implying that domestic emission reductions are postponed for quite some time. It is unlikely, however, that this would go on forever, so eventually also such domestic emission reductions would come about. But the significance of such delays is likely to be small for the following two reasons. First, postponement would not come out in this fashion if many countries tried to act in the same way, thus reducing quota prices in early periods. Second and more important, banking is there to make it possible for countries to do what is worth doing at home now, still import more quota units than needed now, thus banking excess quota units for tomorrow.

It follows from this discussion that regulating quota trade for <u>all</u> countries to fall below the level of free trade would not be in the interest of any country (although, as always, it may be to the benefit of some groups inside a country). Forcing countries to produce more of the emission reduction commodity at home than it wants to is like forcing cold Nordic countries to grow some minimum share of bananas before it is allowed to import bananas from countries that have a comparative advantage in banana production. It would increase the costs of banana consumption in the regulated countries and reduce demand for imports and hence prices to the exporting countries.

Regulating quota imports for <u>some</u> but not all countries would, of course, tend to reduce quota prices and hence benefit those importers not affected by the regulations. Likewise, varying the extent to which regulations would limit trade for different countries means that they would be treated differently. This would add to the complexity of ever negotiating the

[27] This argument presupposes that a country cannot successfully hide its low marginal abatement costs by increasing its quota imports (or reducing its exports), hence augmenting its fossil-fuel use, in order to gain international acceptance for being given a much larger quota allocation for the next commitment period, sufficiently much larger to cover the extra costs of not using the less costly abatement options at home.

details of a stringent Article 17, a safe prediction for any future ambition to make this article anything else than a paper tiger, it would seem.

Confronted with the argument for putting a cap on emission trading – to avoid that rich industrialized countries 'get away with' covering 'too much' of their emission reduction commitments by importing cheap emission reductions from other countries – we have noted that not only these, but typically all, Parties lose. This has two further important implications. First, by making emission reductions globally more costly in this way, also emission reduction commitments in subsequent periods will be made more expensive and therefore less likely to be significant. Second, since trade regulations would reduce the gains from trade for poorer countries, such as Russia and the Ukraine now, it will also reduce the prospects for trade gains for potential entrants from the developing countries in the future. Thus, supplementarity will not only make present Annex B countries less likely to accept more stringent future commitments, it will also make it harder to get new countries to join the set of Annex B countries.

Finally, in the more immediate time frame, the success of the Kyoto Protocol stands and falls with the US ratifying it. It is well known that the likelihood that they would depends to a large extent on emission trading being unregulated. This, if nothing else, would seem to call for meeting the supplementarity requirement in Article 17 in the least stringent way possible or by replacing this requirement as much as possible by having the rich countries make stringent commitments for the period after 2012 as early as possible.

4. Main conclusions

1. Although precedents to international emissions trading are almost non-existent, it seems clear that there are enough options available for efficient carbon emission trading benefiting all participating Annex B countries and assisting them to make more stringent emission reductions possible in the future. The aggregate benefits are likely to be large given the expected large international differences in the marginal costs of emission abatement.

2. The entry of new Annex B countries, all likely to be sellers at least initially, improves the aggregate trade gains and tends to reduce carbon leakage. Constraints on trade to meet a stringent supplementarity requirement would reduce the willingness of new countries to enter.

3. The Kyoto Protocol does not allow countries to borrow additional emission quota units from their quotas in the subsequent commitment period. Strictly limited borrowing, say, up to as little as one or two percent of emission quota for a subsequent commitment period would still add important flexibility with small drawbacks, if any. Old and new Parties would most likely be more willing to commit themselves to stringent emission reduction commitments in the future if also this flexibility were available. Thus, it seems worthwhile to have the Protocol amended to allow limited borrowing.

4. Reliable monitoring of greenhouse gas emissions may be seen as particularly important when international emission trading is introduced requiring verification that net emission reductions sold to other countries are actually made. Monitoring would seem more effective the less it relies on direct monitoring of carbon emissions or varying monitoring techniques

for different sectors of the economies. Although indirect monitoring *via* the carbon content of the fossil-fuel use of each country is not without problems – primarily concerning the monitoring of fossil-fuel inventories – it seems to offer the simplest and overall most reliable approach. Checking domestic compliance to a system of tradable permits seems relatively easy to administer if producers and importers of fossil fuel have been made the only permit-liable entities in a country.

5. Several options exist for the institutional design of international emission trading. A stock-exchange kind of institution has been in focus here as an example of a design that is likely to be efficient and avoid any significant influence of market power. Bilateral trading is unlikely to be equally internationally efficient and fair.

6. Among the feasible domestic policies to support international emission quota trade, a system of tradable permits is likely to be the most efficient, although perhaps not much more than carbon taxes. A tradable-permit system is compatible with either a government in charge of international quota trade or, if the individual country so prefers, by delegating also international trade to the permit-liable firms or their brokers. Given the existing incentives, governments cannot offhand be taken to be less efficient as international traders than firms, contrary to what is often alleged.

7. Auctioning of permits (= the initial emission quota volume) is more efficient than *gratis* distribution of permits (grandfathering) and need not be harmful to existing firms, especially not if part of the revenue is used for compensation when required. Auctioning produces a 'double dividend' in that the (remaining) revenue can be used to reduce pre-existing distortionary taxes. Furthermore, auctioning does not slow down the entry of new and presumably more efficient firms, at least not to the extent grandfathering would.

8. Tradable carbon permit systems and carbon taxes are equivalent in the sense that the permit prices/taxes, government revenue and firm wealth could be made the same (under certainty), (a) when permits are auctioned or emissions are taxed and the revenue in both cases is kept for revenue recycling by the government, and (b) when permits are distributed *gratis* to a set of firms or the revenue of the alternative tax is redistributed to these firms in the same proportion as the permits were grandfathered.

9. Making only fossil-fuel producers and importers permit liable is the most comprehensive and transaction-cost effective design of a system of tradable carbon emission permits.

10. The introduction of 'hot air' in some of the emission quotas of the Kyoto Protocol has been interpreted as a drawback jeopardizing the Protocol's effect on the overall emission reductions. However, this argument may stem from a misrepresentation of what the alternative to the present Protocol actually would have been. It was shown here that the aggregate emission reductions may well have turned out to be smaller, if 'hot air' had been removed from the countries concerned and they therefore would have chosen to drop out. If so, other Parties may have significantly reduced their emission reduction commitments. If the relevant 'no-hot-air' alternative would have implied aggregate emission reductions smaller than in the present Protocol, the reason for even raising a demand for a supplementarity requirement can be questioned.

11. It is most unlikely to be in the interest of any Annex B Party to avoid making domestic emission abatement to any significant extent, if quota prices would exceed zero, *i.e.*, if the Protocol's aggregate emission reductions were non-trivial.

12. All quota exporting countries stand to lose from the enforcement of a stringent supplementarity requirement, as do all those importing countries that are effectively restrained from reaching the desired import volume. Since this is likely to imply that no importer country will be protected from binding constraints (which otherwise would have changed the cost distribution of the Kyoto Protocol as it stands now), it seems likely that all countries will lose from any binding supplementarity requirement. Hence, benefits of emission trading would be maximized for all countries if the least possible were done to limit the trading. Particularly important to note is that regulating trade and thus reducing the trade gains is likely to reduce the willingness of existing Annex B countries to commit themselves to lower emission quotas in the future. This would reduce also the willingness of new countries to join the Protocol and enter into emission trading, which would have provided them with a new 'export industry'.

13. Rather, it would seem better to meet the concerns of those who advocate supplementarity by having Parties make strong commitments for the period after 2012 and leave emission trading as free as possible. Avoiding to introduce any (binding) trade constraints would also help to have the US Senate ratify the Kyoto Protocol. Without US participation there may be no significant emission reductions at all for quite some time.

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