Suggestions for the Road to Copenhagen*

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Abstract

We provide a unified discussion of the issues that confront negotiators of the next international climate agreement. We offer a novel proposal that entitles countries to discharge their treaty obligations by paying a "fine". This escape clause provides cost insurance, simplifies the problem of enforcing compliance, and increases incentives to participate in the agreement. We explain why developed country obligations should rely on a cap and trade commitment rather than carbon taxes. A Central Bank maintains stability of carbon prices by defending a price ceiling and floor. An intensity target is not a good alternative to an emissions cap. Modest trade restrictions, consistent with WTO law, will form an important part of the next agreement. Developed and developing countries have differentiated responsibilities. Developing countries do not adopt binding targets at the next round of negotiations, but they accept the principle of binding targets in the subsequent agreement, beginning in the early 2020s. Developed country participation relies on a reformed CDM and sectoral agreements that are financed by the sale of emissions permits.

Keywords: Kyoto protocol, escape clause, emissions trade, taxes versus cap and trade, price stability, carbon leakage, trade restrictions, differentiated responsibility, clean development mechanism, sectoral agreements

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1 Executive Summary

This document provides our suggestions for the design of the international climate agreement that will follow the Kyoto Protocol. The document consists of an introduction and seven self-contained chapters dealing with specific issues.

Section 3 describes a proposal to allow signatories that have accepted mandatory targets to exercise an escape clause, exempting them from some or all obligations under the treaty. Exercise of this escape clause requires that the nation pay a monetary fine to an international fund which is then distributed to all signatories, including the country that exercised the escape clause. This mechanism has two obvious and one subtle benefit. The option to escape puts a ceiling on the cost of signing and thereby provides insurance against unexpectedly high abatement costs. The escape clause transforms an esoteric international obligation – reducing greenhouse gas emissions (GHG) – for which there is no established means of enforcement, into a familiar obligation to pay sovereign debt. The subtle effect is that the reimbursement scheme increases the incentive to become a signatory, because by signing the agreement a country increases the "effective fine" (the nominal fine net of the reimbursement) that other signatories face, and thereby decreases their incentive to exercise the escape clause. We also discuss the possibility of replacing the monetary fine with withdrawal of trade "concessions" negotiated under the WTO.

Section 4 describes the requirements that the treaty imposes on developed country signatories. These countries commit to capping aggregate GHG emissions over the period of the agreement – approximately 10 years. We compare an agreement that sets emissions caps with one that requires a carbon tax. The emissions cap fixes the level of emissions and the tax fixes the level of marginal abatement costs. The tax allows the level of emissions to vary with abatement costs. This arbitrage tends to make taxes more efficient than the emissions cap, especially for a long lasting pollutant when the policy is fixed for a short period of time (e.g. a decade). However, the greater likelihood of actually achieving an agreement that uses an emissions cap rather than a tax militates in favor of the former policy. A common argument in favor of taxes is that they reduce the level of cost variability, relative to the emissions ceiling. We explain why this argument has sometimes been exaggerated.

Each country's aggregate cap during the period of the climate agreement is allocated into subperiod caps, lasting perhaps two years. A country is allowed to bank but not to borrow emissions from future subperiods. This restriction reduces a moral hazard problem and it is also key to our proposal for defending a price floor and ceiling. This floor and ceiling keep cost variability within acceptable bounds. A Central Bank defends the floor and ceiling by making proportional increases or decreases to countries' future sub-period caps, and also by making spot transactions. Signatories finance the Bank by giving it American style put options with a strike price equal to the price floor. This method of financing causes no real financial burden to contributors provided that the agreement remains in force.

Section 5 compares the use of absolute targets, under which a signatory commits to maintaining emissions below a cap, and intensity targets, under which a signatory commits to maintaining emissions per unit of GDP below a ceiling. The two policies are comparable because they lead to the same expected level of emissions. The intensity target is similar to the tax proposal, because it also leads to a kind of arbitrage, under which more abatement occurs when abatement costs are lower. Taxes are likely to be less politically palatable than an emissions cap, and the intensity target may be politically more acceptable than either. The carbon tax is likely to lead to less rent seeking than the cap, but the intensity target it likely to lead to more rent seeking than either. Largely for this reason we prefer an absolute cap to an intensity target. We also consider the economic comparison of the cap and the intensity target. Empirical applications of a partial equilibrium model, in which the parameters of abatement cost are uncorrelated with abatement levels, find that expected abatement costs are likely to be lower under the intensity target than under the emissions ceiling; this finding echoes the comparison of taxes and quotas. We briefly discuss a general equilibrium model that "bypasses" the abatement cost function. In that setting, the intensity target leads to higher expected GDP than the emissions ceiling. However, if the country is even slightly averse to variations in GDP, the emissions ceiling is likely to lead to higher welfare.

Section 6 explains how WTO-consistent trade policy can promote rather than hinder a climate agreement. Differing levels of commitment to emissions reductions, particularly across developing and developed countries, create the danger of carbon leakage and the loss of competiveness in carbon-intensive sectors. The former undermines the environmental objective of the agreement, and both undermine political support for the agreement. Therefore, the ability to use trade restrictions will be a key part of the next climate agreement. WTO law has instruments that enable countries to unilaterally apply trade restrictions in defense of environmental measures, but the usefulness of these instruments is uncertain. The next agreement should allow a signatory that has accepted binding caps and is in compliance, to demand that imports from other signatories surrender carbon permits. This "border tax" applies to a small number of carbon intensive commodities. Imports from signatories that have committed to emissions caps and are in compliance, are exempt. Imports from developing country signatories that do not have binding caps might be given a grace period during which they are exempt, or they might gain exemption by some other means, such as adherence to a sectoral agreement.

Section 7 considers the arguments regarding differentiated responsibility for developing nations. We review the empirical basis for this argument, and then discuss the economic issues.

In our view there is a clear equity-based argument for exempting developing nations from binding caps during the short period of the next climate agreement, approximately a decade. The next agreement should establish the principle that developing countries will make binding commitments under successor agreements, without determining the level of those caps. Acceptance of this principle increases pressure on developing countries to bargain in good faith at the next round of negotiations; it might provide a legal basis for trade restrictions should they fail to do so; and it helps in selling the agreement to voters in developed countries.

Although our proposal does not impose binding caps on developing nations, a successful agreement requires their participation. Section 8 reviews the Clean Development Mechanism (CDM), which allows developed country signatories of the Kyoto Protocol to earn emissions credits by financing emissions reductions in developing countries. The CDM has achieved substantial GHG reductions. Procedural reforms can improve it for the next agreement, but a problem arises from its structure, and likely has no solution within the CDM. Projects must pass a test of "additionality" to insure that they create bonafide emissions reductions. Too weak a test creates bogus credits and undermines the environmental objective of reducing emissions. Too strong a test undermines the economic objective of reducing the cost of controlling GHGs. Many have argued that the additionality test suffers from both of these flaws. In addition, some projects that correctly pass the test of additionality may lead to payments to developing countries that hugely exceed the cost of the emissions reductions. This "overpayment" for a public good might erode support for the mechanism and reduce the amount of emissions reductions that developed countries are willing to finance.

We recommend creating a mechanism that complements rather than replaces the CDM. An independent agency bargains with developing countries in an effort to obtain low cost emissions reductions, for projects that are not eligible for the CDM because of problems arising from the test of additionality. The agency finances its purchases by awarding the developing country emissions permits, which have the same status as those generated by the CDM. The international institution governing the CDM is a referee that attempts to ensure the quality of a commodity that is brought to market. In contrast, the agency that negotiates sectoral agreements is an active bargainer. Its objective is to obtain a large volume of low cost emissions reductions. It does not have development objectives, as is ostensibly the case with the CDM. This agency can bargain to reduce the number of credits allocated to a project either because the developing country's abatement costs are in fact very low, or because of the uncertain additionality of the reductions that the project claims.

This change is likely to greatly increase both the supply and the volatility of supply of new emissions credits. The Central Bank described in Section 4 controls this volatility.

Land use change and forestry offer some of the least expensive opportunities for emissions reductions, but the Kyoto Protocol does not take advantage of these (Section 9). A reformed CDM, using aggregators to create portfolios of “temporary” credits leading to a homogenous product, can achieve some of the low cost reductions. However, the bulk of these will require sectoral agreements, which should be negotiated by an international agency as described above.

2 Introduction

In 2009 the nations of the world have an opportunity to take a major step in creating an international agreement to reduce greenhouse gas (GHG) emissions. This opportunity comes at a time when most developed countries are in recession. The urgency of the economic crisis threatens to overshadow public concern with the potentially much greater danger of climate change; the public finances being marshalled to combat the recession might crowd out investment in green technologies. Those interested in a successful climate agreement should regard the economic crisis as a context that can help achieve an agreement. Most of the public now accepts that a response to the economic crisis requires large scale government involvement. The reflexive distrust shown by many toward government intervention, and their corresponding confidence in markets to self-regulate, has at least been shaken. This shift in world-view can be used to increase public understanding that the problem of climate change is also due to a market failure, and also requires government intervention. The subjective meaning of numbers has also shifted: a couple of hundred billion dollars no longer seems like a crushing burden. What once seemed unimaginably large expenditures now seem rather modest. In addition, some of the fiscal stimulus will find its way to green investment.

History shows that socially progressive reform is more likely in good economic times, while retrogressive measures are more prone to occur in bad times. Proponents of a climate agreement have to make the case that a meaningful agreement can be achieved at a bearable economic cost. The purpose of this paper is to offer suggestions on the form of that agreement.

Some GHGs persist in the atmosphere for many decades. In addition, the inertia of the climate system, and its complicated dynamics with feedback effects and irreversibilities means that effective climate policy will be the work of generations. Nevertheless, nations should attempt to negotiate a short term agreement, lasting perhaps ten years, rather than a long term agreement. There are several reasons for this recommendation. There is tremendous uncertainty about the actual costs of reducing GHGs and about the dangers of failing to do so. We will obtain better information over time. Future policy decisions should be conditioned on that information, not the knowledge we currently have.

Even if knowledge would not progress, it would still make sense to negotiate a short-lived agreement. Policymakers face a "time consistency problem", the desire to choose today actions for the future that subsequent policymakers will want to change; future policymakers face the same temptation. Often this problem takes the form of procrastination, asking future generations to incur costs that our generation would like to avoid. Apart from the issue of intergenerational equity, an agreement based on this kind of policy trajectory is ineffective because it is difficult or impossible to compel future generations to take actions that are chosen today. Therefore, current policymakers should agree to undertake actions for which they can make plausible commitments; this limitation requires a short time frame for the agreement.

In addition, there will be changes in the comparative responsibilities between developed and developing nations. If developing countries imitate the carbon-intensive development trajectory followed by today's rich countries, there is no avoiding dangerous levels of GHG stocks. Because of their greater responsibility for existing stocks and their greater ability to make sacrifices needed to reduce emissions, developed countries must assume primary responsibility in the short run. However, the agreement must establish the principle that developing countries will face binding targets in the future.

Although we support a short agreement, there should be a mechanism to guarantee caps on emissions beyond the period of the agreement. Firms need more than a ten year horizon for some of the investments that will reduce our dependence on carbon. In addition, some policy tools under our proposal use adjustments in future emissions ceilings. Therefore, the agreement should include an automatic extension. For example, if the agreement is set for ten years, then we expect that serious negotiations for its successor would begin after approximately six years. The end of the six year period triggers an automatic two year extension of the existing agreement; there could be more than one such extension, but a new agreement overrides any extension.

The most novel aspect of our proposal is to include an escape clause for those countries that adopt binding commitments (Section 3) The exercise of the escape clause relieves the country of treaty obligations. It requires payment of either a monetary fine or being subject to WTO-consistent trade sanctions. Although this proposal is unorthodox, it has several valuable attributes. Most obviously, it provides signatories with insurance by putting a cap on the cost of fulfilling treaty obligations. It removes one of the reasons that the US gave for staying out of the Kyoto Protocol, the risk of extremely large compliance costs. However, there are other, probably easier ways of providing that insurance. The proposal also eases the problem of enforcing compliance, because it replaces a fairly esoteric obligation, reduction in carbon emissions, by a familiar obligation, payment of a monetary debt or adherence to trade rules (depending on the whether the fine is monetary or involves trade sanctions). There are, admittedly imperfect, international institutions that encourage compliance with these kinds of obligations. The insurance and the compliance aspects of the proposal both make the agreement more attractive, thus encouraging countries to ratify. There is also a more subtle reason that the proposal encourages membership. We structure the fine so that the effective costs to the country that invokes the escape clause is higher, the greater is the membership in the agreement. Therefore, each country knows that its own ratification of the agreement makes it less attractive for any other signatory to invoke the escape clause. Membership thereby gives a country additional leverage on other countries' actions.

Among the several types of requirements that an agreement might impose upon signatories, the two most frequently discussed are binding absolute targets (cap and trade) and carbon taxes. Section 4 reviews the economic and the political economy arguments for these two policies. The tax is likely more efficient, so is favored on economic grounds. However, the visceral public rejection of an additional tax and the possible public acceptance of cap and trade make the latter more likely to lead to a successful agreement, and on that ground we support its use. Quantity targets that are freely distributed make it easier to enlist business support, but also create incentives for rent seeking and corruption. To the extent politically feasible, free distribution of permits should be limited and then phased out. Auctioned permits also reduce one source of trade friction.

The problem of variable cost under the cap and trade system is real, although it perhaps has been exaggerated. International trade in permits should be encouraged, partly to arbitrage emissions across countries with different costs, and also to establish an international price of carbon. The period of the agreement should be divided into subperiods, lasting perhaps two years each, and nations' aggregate emissions ceiling over the entire agreement period should be allocated to these subperiods. A nation is allowed to bank but not to borrow permits across subperiods.

A Central Bank should be constituted whose sole responsibility is to maintain the international price below a ceiling and above a floor. The Bank relies primarily on upward and downward adjustments of emissions ceilings in future subperiods in order to keep the international price within the agreed price bounds. It also can make spot transactions if those adjustments are not sufficient to maintain price stability. The Bank finances emissions purchases by exercising American style put options, at a strike price equal to the price floor. This put option gives the holder the right to sell, and the contracting party the obligation to buy, a unit of the commodity at a price equal to the strike price, at any time during the life of the contract. Developed country signatories capitalize the Bank by providing it with an initial stock of these options. The Bank replenishes its stock of put options by means of market transactions using revenue from the sale of emissions permits that have been undertaken to defend the price ceiling. If this revenue is not sufficient to replenish the stock of options, the Bank imposes additional levies on member countries. The Bank's sales revenue above the amount needed to replenish the stock of put options should be distributed to a different agency that uses the funds to promote emissions reductions in developing country members. The expense of capitalizing this Central Bank will be modest.

Intensity targets allow a country's allowable emissions to depend on their level of GDP; these are sometimes seen as an alternative to caps. Section 5 compares these two policy instruments. Intensity targets have some of the advantages of taxes, without the public relations baggage. A danger of intensity targets is that they become a disguised means of doing very little, or that they are perceived as such. One means of avoiding this danger is to negotiate over absolute targets, and then replace these by intensity targets that lead to the same level of expected emissions. However, the greatest danger of intensity targets is that they seem more likely to lead to rent-seeking activity, and for this reason we prefer the cap and trade.

The limited empirical and theoretical literature suggests that an intensity target leading to the same level of expected emissions results in lower expected abatement costs, or higher expected national income, compared to an absolute target. However, the intensity target may also increase the variance of national income. A country may be better off under an absolute target if it is even slightly risk averse (meaning that the representative agent prefers a fixed level of income to a lottery that yields in expectation that level of income).

The agreement should include trade measures (Section 6). These will help deal with both the real and the perceived problems of loss of competiveness and carbon leakage – the situation where measures taken to reduce emissions in one country cause carbon-intensive production and carbon emissions to shift to countries with weaker regulations. Those problems can occur when nations adopt different carbon limits, and particularly when developing nations are subject to weaker carbon restrictions. The explicit adoption of trade measures will discourage the unilateral application of trade restrictions for the duration of the next agreement, and it will attract political support during the ratification period. Imports into signatories, that originate in signatories, of a small number of carbon intensive commodities should be required to surrender the number of carbon permits used in production. Exporters who are signatories that have adopted binding targets and are in compliance are exempt from this requirement. Thus, this measure primarily affects developing countries, which are not expected to adopt binding targets in this treaty. Developing countries might be exempted from this requirement if they participate in certain kinds of sectoral agreements.

The recognition of differentiated responsibility, between developed and developing countries, is central to the Kyoto Protocol and many other international agreements. Section 7 reviews the basis for the equity argument in a climate agreement and assesses counter-arguments. We support the equity argument for differentiated treatment, with the proviso that developing countries agree in principle to binding caps at the subsequent treaty. This compromise will make it easier to sell the treaty to voters in developed countries.

Success of the agreement requires the meaningful engagement of developing countries (Section 8). Under the Kyoto Protocol, the Clean Development Mechanism (CDM) provides the means of achieving low cost emissions reductions from developing countries. Procedural reforms can improve this mechanism, but are not likely to address its greatest limitation. CDM projects must pass a test of additionality to insure that they contribute genuine emissions. Too weak a test undermines the environmental integrity by admitting bogus credits, and too strong a test undermines the economic objective by excluding low cost reductions. A class of projects, for which the question of additionality cannot satisfactorily be answered, should be excluded from the CDM. A new agency should be created, with the brief of bargaining with developing countries for emissions projects. The agency finances the projects by allocating emissions credits, which have the same status as those generated by the CDM. In the bargain, this agency adjusts the number of credits to take account of the uncertainty of the extent of additionality. The adjustment also accounts for the possibility that the cost of achieving each unit of reduction is much lower than the price of one CDM emissions permit. This agency's sole objective is to obtain a large number of low cost reductions; it is not encumbered by other objectives, such as economic development.

Land use and land use change and forestry offer enormous possibilities for low cost emissions reductions, and a large fraction of these are in developing countries. The CDM can capture some of these opportunities, but the bulk of them will like require sectoral agreements (Section 9).

3 The escape clause

Nations' sovereignty limits the world's ability to design an international agreement that compels participation and compliance. Here we explain how an escape clause can promote participation in and compliance with the agreement (Karp and Zhao 2007). The escape clause also provides insurance against unexpectedly high aggregate costs.

A nation that invokes the escape clause is exempt from fulfilling either all or part of the GHG abatement stipulated by the agreement. As a practical matter, a partial escape, which exempts a signatory from fulfilling only a portion of its agreed abatement, is likely to be more useful than a total escape, which exempts the signatory from all abatement. However, the extent of the escape is a secondary design issue. We want to explain why the escape clause in general provides an important ingredient in the design of the agreement. Therefore, for simplicity only, we explain the policy assuming that it involves a total rather than a partial escape.

In order to have any effect, an international agreement with a (total) escape clause has to include a cost of invoking the clause. Here, for the purpose of illustration, we take this cost to be a monetary fine, which we denote as F. Nations with different characteristics, e.g. wealth, population, carbon intensity, are likely to have different agreed levels of abatement and correspondingly different fines for invoking the escape clause. This heterogeneity complicates the actual negotiation process, but it adds little to understanding the role of the escape clause.

Therefore, here we consider the case where potential signatories are homogenous.

The important conclusions and policy recommendations from this section are:

- The next climate agreement should include an escape clause that entitles a signatory, upon payment of a fine, to be absolved of some or all obligations under the treaty.
- All signatories, including the country that exercises the escape clause, receive a share of fine revenues.
- This mechanism encourages participation because each additional signatory increases the real cost to any other signatory of exercising the escape clause. It eases the problem of compliance because it replaces an esoteric obligation with a familiar obligation.
- The withdrawal of trade concessions is an alternative to the monetary fine.

3.1 The basic proposal

The combination of escape clause and fine provides insurance, as does a safety valve together with emissions trading (Section 4.4). Nations that sign the agreement are assured at the outset that the economic cost of compliance does not exceed the magnitude of the fine. One reason for the US opposition to the Kyoto Protocol was the uncertain and possibly large costs of compliance. There is substantial variation in the estimates of the economic costs of reducing GHG emissions at the regional, national, and international levels (Aldy, Krupnick, Newell, Parry, and Pizer 2008), (Fischer and Morgenstern 2006). Some estimates, particularly those advanced by industry groups, find very high costs. Other estimates assume that win-win policies abound, leading to low abatement costs. The escape clause eliminates, or at least greatly reduces one reason for non-participation. No nation can refuse to participate on the grounds that the costs may be unimaginably large; the costs cannot exceed F. This insurance property is important, but there are other ways of achieving insurance; the chief virtues of the escape clause are that it promotes participation and compliance.

If there are n signatories and if m of these signatories invoke the escape clause, total fine payments equal mF. An essential feature of our proposal is that this revenue be returned to all signatories. In the case under consideration, where signatories are identical, each signatory receives the revenue $\frac{mF}{n}$. Here we ignore transactions costs, such as those arising from the costs of collecting the fine. The receipt of a fraction of revenue from the fine is an inducement to join the agreement. More importantly, this reimbursement decreases with the number of members. The fine net of the reimbursement therefore increases with the number of signatories. For example, if the fine is $F = 100$ (e.g. billion US$) and there are 20 members, a nation that exercises the escape clause is reimbursed 5, so the net fine is 95. If one more country signs the agreement, the reimbursement falls to 4.75 so the actual fine increases to 95.25. This change appears to be modest, but formal analysis of the model shows that the collective effect is substantial, since the additional member increases the effective fine of all 20 preexisting signatories.

The important consequence of this design is that by choosing to participate in the agreement, a nation unilaterally increases the fine, net of reimbursements, that any other signatory must pay in order to invoke the escape clause. Negotiations determine the nominal fine, F, before nations decide whether to ratify the agreement. However, a nation's unilateral ratification decision affects the actual fine, net of reimbursement. Therefore, a nation's unilateral ratification decision affects the actions that signatories take. A larger number of signatories increases the actual fine, making it less attractive to invoke the escape clause, and therefore more attractive to abate.

Nations participate in international agreements primarily to influence other nations' behavior, rarely their own.[1] Abatement of GHGs is a global public good, and each country would like the other countries to abate. The endogeneity of the actual fine gives a potential signatory leverage over other signatories. The desire to exercise this leverage can provide a powerful incentive to participate in the agreement.

The combined escape clause and fine encourage compliance by converting a rather esoteric obligation (GHG abatement) into a familiar one, for which international compliance structures already exist. The Kyoto Protocol requires signatories to not exceed emissions ceilings, but its lack of an effective enforcement mechanism appears to lead to highly imperfect compliance. There is no effective sanction for not achieving a target level of abatement. The Kyoto Protocol's short duration compounds the enforcement problem, because it eliminates the ability to punish current breaches by reducing future emissions allowances. The fine converts the unfamiliar obligation, reduction of GHG emissions, into a familiar obligation: payment of an international debt. The default of sovereign debt shows that the mechanism for enforcing repayment of this debt is not perfect, but perhaps the surprise is that it works as well as it does. For example, it appears likely that Canada will not meet its Kyoto Protocol obligation, and this event does not seem to cause great consternation either within Canada or the rest of the world. Canada is less likely to default on an international debt, and certainly would not do so in a casual manner. The escape clause helps to prevent a signatory from sliding into non-

[1] There are, of course, counterexamples to this claim. By signing an agreement a nation can to some extent tie its own hands regarding its own future behavior. In this case, the treaty serves as a commitment device. Also, some nations may feel a moral obligation to sign the agreement. Those nations, however, do not need to be induced to participate. Our concern is to induce participation by nations who act out of self-interest.

compliance, because it sets out the consequence of a failure to satisfy their agreed emissions constraints. Signatories can voluntarily exercise the escape clause, but if they do not do, their failure to satisfy their emissions constraints automatically triggers the escape. There is no role for discretion here.

An important feature of the combined fine and escape clause is that other signatories actually want to enforce the fine when a partner invokes the escape clause.[2] Thus, although the fine does not completely solve the compliance problem, it greatly reduces that problem. There may be some contingencies under which a nation does want to exercise the escape clause. Therefore, it must be possible to collect the fine.

3.2 Trade sanctions as an alternative to the fine

The monetary fine is probably the simplest way to limit a signatory's incentive to invoke the escape clause, but trade sanctions provide an alternative. Because these sanctions are imposed against a partner who willingly entered into the environmental agreement, the sanctions are consistent with WTO law. For example, the trade sanctions in the Montreal Protocol are WTO-consistent (United Nations Environmental Programme 1999). The WTO dispute resolution mechanism also provides a (nearly) ready-made structure for adjudicating potential disputes. The dispute resolution panels have not previously sat in judgment on exactly this kind of dispute, but they have considered many cases involving environmental restrictions.

Under this alternative, all signatories are entitled to impose trade sanctions, of prescribed magnitude, against a signatory that invokes the escape clause. WTO law and GATT/WTO negotiations refer to a reduction in tariffs or some other trade liberalization as a "concession" that the member country offers other signatories. Violation of WTO law entitles the injured party to withdraw a concession from the offending party, both as a means of punishment and of compensation. The use of the term "concession" and the mindset of many politicians suggest that countries often do view their trade liberalization as imposing a cost upon themselves and conferring a benefit to their trading partner. Some countries are reluctant to take advantage of their right to withdraw concessions, but withdrawal sometimes occurs for an extended period, e.g. in the US-EU beef hormone dispute.

The use of trade sanctions has most of the ingredients of the monetary fine. An increase in the number of signatories increases the cost of invoking the escape clause, because the addition of a signatory increases the number of countries that can legally impose trade sanctions.

[2] A particular signatory might not want to enforce the fine if it anticipates invoking the escape clause and if it believes that its lack of enforecement will weaken the agreement to such an extent that it will in turn not be liable to pay the fine. However, our proposal requires only that no nation can unilaterally undermine the agreement to such an extent that its behavior causes the fine to no longer be collected.

Signatories have an incentive to demand “payment”, in the form of withdrawing concessions. The trade sanctions convert an esoteric obligation, for which there is no obvious penalty for non-compliance, into an obligation with a familiar penalty. There is an existing institutional framework, the WTO dispute resolution mechanism, for adjudicating disputes.

A minor difference is that the monetary fine puts an absolute cap on the cost of joining, equal to the cost of the nominal fine. The actual cost of exercising the escape clause approaches this nominal fine as the number of members increases. The use of trade sanctions, in contrast, puts a flexible ceiling on the dollar cost of exercising the escape clause. If more countries join, and each signatory is allowed to impose a trade sanction of prescribed value on any country that exercises the escape clause, the actual cost of exercising the escape clause can grow large. This difference is minor, however, because the prescribed value of the trade sanctions can be conditioned on the number of members, in order to prevent the total cost of the trade sanctions from exceeding a given limit.

The alternative of using trade sanctions has two real disadvantages relative to the fine. First, regardless of whether nations think that they benefit by withdrawing a concession, in most cases this action harms them. In contrast, receiving a portion of the revenue from fine payments clearly makes the nation better off. Using trade sanctions creates a net welfare loss, whereas the fine is simply a transfer payment. Second, trade sanctions are more complicated than a monetary fine, partly because the monetary value of the trade concession can be questioned. However, the dispute resolution panels are practiced in dealing with this issue.

Two other considerations may offset these disadvantages. First, there is a psychological/political factor. In the event that a nation does want to exercise the escape clause, it might be difficult for voters and politicians to accept that it must pay the monetary fine. Even though the nation had willingly entered into the contract that requires this payment, there may be too much domestic opposition for it to actually occur.[3] Moreover, even if the nation does pay the monetary fine, it might compensate by reducing other contributions to global public goods or to development assistance. Thus, the fine may not involve a real cost to the nation. Trade sanctions carry their own baggage, but perhaps these are psychologically and politically easier to tolerate, compared to a monetary fine.

The second advantage is that the trade alternative is a way of introducing trade policy as a means of promoting environmental objectives. Importantly, it does so in a manner that is legal

[3] There is an important difference in the political difficulty of an agreement that requires payments of fines to signatories in certain contingencies, and the political difficulty arising from making transfers to developing nations to induce them to reduce emissions. The latter transfer is asymmetric – rich countries pay developing countries – and it is a definite obligation at the time of the agreement. In contrast, at the time of the agreement the former transfer is only a possibility rather than a certainty. Moreover, the arrangement is symmetric, because a signatory is as likely to receive fine revenue as it is to pay the fine.

under existing WTO rules. Thus, using the trade alternative during the years that the agreement is in force will help set the stage for a more ambitious and possibly more contentious use of trade policy discussed in Section 6.3.

3.3 Summary

We propose that the next agreement include an escape clause. A signatory that exercises this clause is absolved or some of all – depending on how the agreement is written – of its obligations. Exercise of the option requires that a country either pay a monetary fine or be punished by withdrawal of WTO trade concessions. The structure of the fine means that the effective fine increases with the number of signatories. Thus, a country has an added incentive to join the agreement, because by doing so it makes other signatories more likely to reduce emissions rather than exercise the escape clause.

The fine also eases the problem of enforcement, because it replaces the esoteric obligation of emissions reduction, by a familiar obligation, either monetary payment or a trade sanction. The fine puts a ceiling on the total cost to a country of joining the agreement.

4 Developed country obligations

The next climate agreement should require that *developed countries* adopt mandatory emissions ceilings over the life of the agreement. An internationally agreed price ceiling provides insurance against unexpectedly high abatement cost. An internationally agreed price floor guards against falling permit prices in order to preserve the incentive for investment in low-emission technology. A fall in emissions permit price might be due to an unexpectedly large supply of emissions permits, perhaps emanating from developing countries, or from a drop in demand, perhaps due to recession and falling output in the developed countries. For example, the price of a permit for a tonne of CO2 equivalent (tCO2e) in the European Climate Exchange in London fell from nearly €31 in July 2008 to under €10 in February 2009, due to the contraction in demand caused by the world economic crisis.

A basic question is whether nations should be obliged to impose a tax on carbon emissions or to adopt a quantity target, i.e. to maintain emissions below a ceiling. Comparability of the two policies requires that they both lead to the same expected level of emissions. These two policies can be ranked on economic grounds or on political economy grounds. There appears to be considerable agreement among economists that on economic grounds a tax is better. Most of the disagreement arises in evaluating the political economy arguments. Nordhaus (2007) and Cooper (2008) are among the many economists favoring the use of taxes, and Frankel

(2008) and Stavins (2008) among the many who favor quantity targets. All proponents of the quantity target recognize that a central planner could not possibly distribute emissions permits in a manner that equates marginal abatement costs across firms; all of these proponents therefore see the quantity target as a cap and trade policy.

Assuming that the agreement uses quantity targets, the major negotiation issue is to determine each country's allowable level of emissions over the lifetime of the agreement. Once these levels are agreed, they should be converted to a trajectory of emissions, specifying the allowable amount of subperiod (annual or biannual) emissions. For example, suppose that the agreement consists of five (possibly two-year) periods. If a country i's total allowable MtCO2e emissions during the life of the agreement is X^i, its trajectory of emissions ceiling is $(x_1^i, x_2^i, ...x_5^i)$, with $X^i = x_1^i + x_2^i + ... + x_5^i$. The manner of allocating a country's aggregate allowance over the subperiods should be the same for all countries, possibly with minor variations to account for countries being at different stages of their business cycle at the time of negotiation. Countries are allowed to bank permits from one sub-period to another, but not to borrow against their future emissions. That prohibition eliminates a country's ability to remain in compliance for a period by borrowing permits and then walk away from the agreement. A country that is in deficit at the end of a subperiod must buy permits on the world market to meet its target.

A "Central Bank" should be constituted. The sole responsibility of this bank is to keep the international price of carbon within an agreed ceiling and floor, by means of two policy instruments. First, the bank is allowed to make proportional increases or decreases in countries' future trajectories of permits. Second, to defend the price ceiling the bank is allowed to issue additional permits in the current period, at a price equal to the agreed price ceiling; to defend the price floor it is allowed to buy permits at the price floor. For example, if a particular country i's trajectory of emissions ceilings during the agreement period is $(x_1^i, x_2^i, ...x_5^i)$ and in the second period the international price of permits hits the price ceiling, the Bank's first line of defense is to increase proportionally each country's allowable future emissions, (x_3^i, x_4^i, x_5^i); its second line of defense is to sell permits at the spot market at a price equal to the ceiling

Current negotiations should seek to establish an agreement for a fairly short period of time, e.g. a decade. However, businesses making long term investments would like to have a longer planning horizon. In addition, our proposal for defending the price ceiling and floor uses the manipulation of future emissions ceilings. For these two reasons, it is helpful to have a default plan that extends beyond the nominal life of the agreement. To achieve this, the agreement can have an automatic rolling extension. For example, if the agreement lasts for 10 years, and if each of the subperiods lasts for two years, then at a certain point (perhaps 6 years into the agreement) there should be an automatic two-year extension that serves as a default. This extension might fix country i's ceiling on emissions in the new period at some percentage of

x_5^i, the country's agreed ceiling in the fifth period. A new agreement overrides the extension.

The price ceiling and floor impose boundaries on firms' *marginal* abatement costs. The price ceiling is a safety valve that protects firms against an unexpectedly high emissions price. In contrast, the escape clause described in Section 3 puts a ceiling on a country's *total* abatement cost. Marginal abatement costs might be very high even though total costs are moderate; the converse is also possible. Thus, the escape clause and the price ceiling protect against different kinds of cost uncertainty.

The important conclusions and policy recommendations from this section are:

- Taxes are likely to involve lower economic costs, compared to a quantity restriction (using cap and trade).
- A quantity restriction offers a greater chance of a successful negotiation, and for that reason we support it rather than the tax.
- Countries are allowed to choose how they allocate permits domestically, but the Agreement includes language encouraging the use of auctioning rather than free distribution of permits.
- Standard economic analyses focus on tax exclusive abatement costs, whereas firms care about tax-inclusive costs; these analyses therefore tend to overstate the advantage of the lower cost variability under taxes compared to quantity restrictions.
- Each country's level of allowable emissions, over the life of the Agreement, is allocated into allowable levels for annual or biannual periods. Countries are allowed to bank but not to borrow across subperiods.
- A Central Bank is constituted with the sole objective of maintaining an international price of permits within a negotiated price ceiling and price floor.
- The Central Bank has two policy tools: the ability to make proportional increases and reductions in allocations for future subperiods, and the ability to buy and sell permits in the current period.

4.1 The economic comparison of taxes and cap and trade

The economic comparison of taxes and cap and trade (i.e., quantity restrictions) asks which of the two policies leads to a lower expected sum of abatement costs and environmental damages. In order for the comparison to be fair, the expected level of abatement – equivalently, the

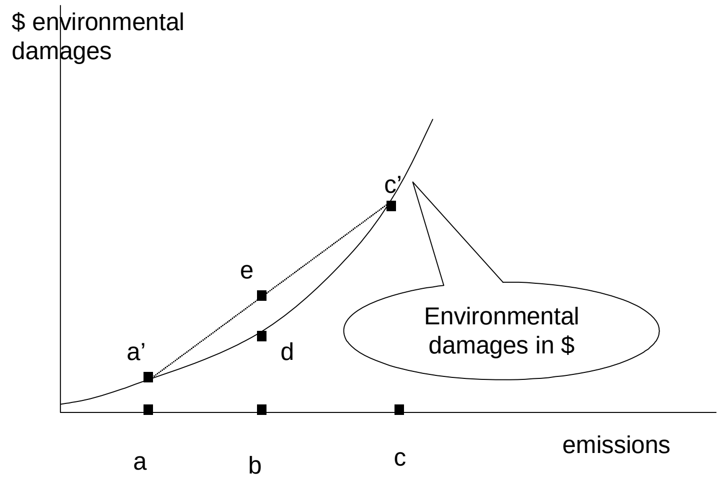


Figure 1: Environmental damages (measured in $) as a function of emissions

expected level of emissions – must be the same under the two policies. If there is no uncertainty (and given competitive markets), the two policies lead to exactly the same results, so the comparison is interesting chiefly if there is uncertainty. This uncertainty is usually assumed to derive from uncertainty about abatement costs.[4]

In the presence of uncertainty about abatement costs, the nature of the comparison is straightforward. Under a binding quantity target, the level of emissions is fixed, but the marginal cost of abatement varies with realizations of the random abatement costs. Under a tax, the level of abatement adjusts so that marginal abatement costs equal the tax. In this case, the constant tax fixes the constant marginal abatement cost, but the level of emissions varies with realizations of the random cost parameter. The question then is "Which would society rather have, constant marginal abatement cost but varying levels of emissions (achieved by the tax) or constant emissions but varying levels of marginal abatement costs (achieved by the quantity target)?" The determinants of the answer to this question are well understood. We first consider the advantage of the quantity restriction, and then the advantage of the tax.

It is reasonable to assume that marginal damages increase with the level of emissions. In this case, the slope of the damage function increases with the level of emissions, as Figure 1

[4]The substantial uncertainty about environmental damages is usually ignored when ranking the policies. The reason is that in static settings where the random variables affecting abatement cost and environmental damage are uncorrelated, uncertainty about environmental damages has no effect on the policy ranking. Karp and Zhang (2006) show that uncertainty about a parameter that affects environmental damage, together with anticipation of learning about that parameter, can make taxes more attractive.

In a second best setting, taxes and quotas are different even without uncertainty. Golembek and Hoel (2006) show that in setting with a technology spillover where countries do not cooperate on technology policy, quotas are better than taxes.

shows. If emissions are constant at level b, environmental damages are constant at level d. Suppose instead that emissions equal level a half the time and level c half the time, so that on average (i.e. in expectations) emissions equal level b. In this scenario, environmental damages equal the levels a' and c' half of the time each. The average level of damages is therefore at the point on the line segment half way between these points, shown as e. Since point e is above point d, expected environmental damages are higher when emissions are random (as under the tax) compared to when emissions are fixed (as under the quantity target). Thus, the quantity restriction leads to lower expected environmental damages, compared to the tax policy. This effect is more pronounced, the larger is the slope of marginal environmental damages.

In contrast, expected abatement costs are lower under the tax. To understand the reason, consider the case where a firm faces high marginal abatement costs half of the time and low marginal abatement costs the other half of the time. The firm is given a choice between emitting at the same level under both cost realizations, or "arbitraging emissions over states of nature". This arbitrage means that the firm is allowed to emit a bit more (abate a bit less) when abatement costs are high, provided that they emit a bit less (abate a bit more) when abatement costs are low. With this rearrangement in emissions, average emissions are unchanged. It is rather obvious that the firm prefers the second alternative, which gives it the opportunity to rearrange its abatement so that more of it occurs in states of nature when abatement costs are low. In fact, the tax achieves the optimal level of arbitrage across states of nature, because under the tax the firm sets marginal abatement costs equal to the constant tax, for every cost realization. The advantage of being able to arbitrage emissions in this fashion increases with the slope of marginal abatement costs.

Under strong assumptions, Weitzman (1974) shows that when a tax and a quantity restriction lead to the same expected level of emissions, the tax leads to lower expected total (abatement plus environmental) costs if and only if the slope of the marginal abatement cost curve is greater than the slope of the marginal environmental damage curve. The assumptions behind this conclusion are that marginal abatement costs and marginal environmental damages are linear and that there is uncertainty about the intercept but not the slope of the marginal abatement cost curve. The magnitude of the gain from using taxes rather than cap and trade is proportional to the variance of the Business as Usual (BAU) level of emissions.

The policy ranking based on a comparison of the slopes of the abatement cost and environmental damage functions holds in a static setting, where the environmental damages result from the flow of pollution. However, climate damages arise from the stock of GHGs, not the flow over the short period that we propose for the next climate agreement. Over a decade, the flow of GHGs will be small relative to the stock, and the difference between the fixed level of emissions under the quantity restriction and the random level under the tax will be very small relative to the stock. Therefore, for a short-lived policy and a long-lived pollutant stock, the environmental difference between the quantity target and the tax is probably small. The difference in abatement costs under the two policies may however be non-negligible. In that case, taxes are likely to be more efficient than a quantity restriction.

Hoel and Karp (2002) generalize the static model in order to compare policies for a stock pollutant. From the range of published literature, they select estimates of the slopes of marginal abatement costs and marginal environmental damages associated with GHGs in a way that favors the use of quantity restrictions. However, even if the parameter choices in this experiment were changed by a factor of 100, the conclusion is that taxes lead to lower expected total costs, compared to a quantity target. The point is that given this model and available parameter estimates, it is difficult to escape the conclusion that taxes are more efficient than quantity restrictions. Subsequent work (Hoel and Karp 2001), (Newell and Pizer 2003), (Karp and Zhang 2006) examines variations of this model, reaching essentially the same conclusion.[5]

The policy conclusion that taxes are more efficient than cap and trade is quite robust to changes in parameter values and minor changes in the model. However, these results are based on strong assumptions about the functional form of abatement costs and environmental damage. The results are not robust to generalizations with respect to functional form, and for that reason they are valuable more as a source of intuition rather than as a basis for categorical advice.

4.2 The political economy comparison of taxes and cap and trade

The disagreement amongst economists concerning the relative merits of taxes and cap and trade turns on political economy considerations, not the efficiency issues described in Section 4.1. In a more perfect world we would recommend an international agreement that requires nations to tax carbon emissions. However, the political realities are such that nations are more likely to succeed in negotiating an international agreement based on quantity targets (with international trade in permits), rather than a tax. For that reason, we support the proposal to use a cap and trade system.

The most important reason to favor the cap and trade alternative is that “tax” has become a dirty word in most Western nations, and certainly in the United States. It is ironic that small-government enthusiasts have contributed to making taxes anathema to the public; these same groups are like to self-identify as pro-market and pro-efficiency and more likely to appreciate the efficiency argument for taxes. The greatest impediment facing taxes is the level of public

[5] Matters change if we take into account that the tax or quota policy affect firms investment decisions for abatement capital. In that case, the use of emissions taxes typically gives rise to a time consistency problem for the policymaker. This problem does not arise with quantity restrictions (Karp and Zhang 2009).

understanding of basic economics. We think that it would be a mistake to base a proposal for an international climate agreement on the ability to raise this public understanding.

The second most significant argument in favor of a cap and trade system unfortunately coincides with the greatest disadvantage of that system. A cap and trade system is more likely than the tax to receive industry support, but it is also more likely to give rise to corruption and wasteful expenditures to capture "rents" (here, equal to the value of the emissions permits). A firm's costs are lower if it is entitled to emit freely a given quantity x of emissions, compared to the case where it is taxed on emissions such that it chooses to emit at level x. It saves the tax payments under freely distributed quotas, although it sacrifices the efficiency gains arising from the ability to arbitrage emissions over states of nature. If the emissions permits are auctioned, the equilibrium permit price equals the tax. Thus, with complete auctioning of permits, the firm pays the same for permits under cap and trade and under the tax. The free distribution of permits reduces political opposition to the policy.

The downside of cap and trade, relative to taxes, is that the mere possibility of free distribution of permits creates opportunities for corruption and rent-seeking. Firms are willing to lobby in order to obtain a higher allocation of free permits. Lobbying not only wastes resources (e.g. the talents of lobbyists) but also creates opportunities to corrupt the political system. The large sums involved suggest that the potential for corruption could be significant. The distribution of free permits is, in itself, merely a transfer, and therefore need not give rise to inefficiencies. The danger arises from the rent-seeking activities engendered by industry's attempt to obtain free permits. An increase in the fraction of permits that are distributed for free increases the potential rent that firms can capture and therefore increases the incentive to engage in rent-seeking.

For this reason, permits should be auctioned rather than allocated freely, to as great an extent as the political process will bear. The EU is in fact planning to phase out the free allocation of permits, at least for major sectors (Ellerman 2008). In considering industry's demand for the free allocation of permits to provide a cushion from higher costs entailed by reduced emissions, regulators need to remember a fundamental economic fact. A regulation that increases firms' costs typically reduces their incentive to supply the good that these firms produce, thereby increasing the market price of that good. The higher market price provides an automatic cushion for firms facing the cost increase.[6] The requirement that firms reduce emissions, together with the free distribution of emissions permits, might increase firms' profits relative to the business as usual (BAU) level. The free receipt of a fraction of permits that a firm uses can fully compensate it for the lost profits due to higher costs caused by regulation.

[6]The model in the previous section does not include this feature. That model implicitly assumes that demand for the good produced by the polluting firms is perfectly price elastic.

The following thought experiment helps to get a sense of how large the fraction of free permits must be, in order to make firms whole. Suppose that there is a fixed relation between output of a product (e.g. electricity) and emissions, so that a tax or a quota on emissions is equivalent to a tax on output of the product. The fraction of emissions permits that an industry needs to be given for free, in order to be made whole, is approximately equal to the "producer incidence" of the implicit tax (with a small correction to account for changes in quantity sold). For example, if the implicit tax on output is €1 and if the imposition of this tax increases consumer price by €0.80 and reduces producer price by €0.20, then the producer incidence is 0.2. With this example, firms are made whole if they receive slightly more than 20% of the emissions credits for free. We can estimate tax incidence; even without estimates, the factors that determine this incidence are well understood. The consumer demand for electricity is quite inelastic (i.e. not sensitive to price), a fact that tends to make the producer incidence of a tax small. Giving all or even most permits to firms might amount to handing them a windfall profit, not providing them with a cushion against cost increases.

The broader point is that, aside from a possible adjustment period, firms are not entitled to any free permits. It is important that the public come to understand that the environment is a scarce resource. Everyone who uses the environment in a manner that diminishes others' welfare, e.g. pollutes, should pay for that use.

An additional reason for auctioning rather than freely allocating emissions permits involves trade concerns (Section 6.2). Free allocation of permits amounts to a subsidy. Particularly in sectors such as steel, where there are frequent trade disputes related to domestic subsidies, it would be helpful to avoid adding another source of contention. We favor a climate agreement that allows individual countries to decide unilaterally how to achieve a given target. However, the agreement may serve as a bully pulpit to encourage countries to auction permits if they choose a cap and trade system.

The ease of negotiating the agreement and ensuring compliance are other practical issues affecting the choice of a tax or a quantity restriction. In some respects, the tax appears easier to both negotiate and to monitor. The efficient tax policy requires that all nations face the same tax, so negotiation of the tax involves a single number. Quantity restrictions require that each country choose a ceiling on emissions, a number that differs across nations.[7] Negotiations over the quantity agreement therefore appear more complex. However, nations have practice and some success in carrying out these negotiations. There are currently systems in place that can

[7]This ceiling is usually expressed as a baseline level of emissions and a reduction from that baseline, two numbers rather than one. However, this distinction seems relatively unimportant. The choice of the baseline, e.g. 1990 emissions or 1999 emissions, affects the framing of the question, but it is obvious that what matters is the ceiling, not whether it is $x\%$ of 1990 emissions or $y\%$ of 1999 emissions.

estimate a nation's emissions; there are also systems that track tax policy. It is not obvious whether it is easier for a nation to disguise its level of emissions, or its tax (e.g. by using offsetting taxes or subsidies for substitutes and complements to carbon).

In negotiating a target level of emissions, it is reasonable to take into account steps that a nation has already taken to reduce emissions. For example, if we were imposing emissions limits on firms in an industry, and some of those firms had already made investments that reduced their emissions, it would not be reasonable to require all firms to make the same emissions reductions from the status quo. A similar issue arises with taxes. Countries currently have different tax levels on fossil fuels. Should adjustments be made for existing taxes, if the climate agreement uses a tax rather than quantity ceilings? The efficiency argument requires an equal carbon tax for all countries, and thus suggests that the adjustments should be make. Doing so would be a negotiating nightmare; it would provide employment for many economists, who would be called upon to measure the effective carbon tax of an existing tax structure. Cooper (2008) offers a simple answer: the negotiated carbon tax, identical for all countries, is to be applied on top of existing taxes; countries are not allowed to adjust other taxes in order to offset the newly imposed carbon tax. That answer would be more attractive to countries that currently have low fossil fuel taxes.

In summary, we support the use of quantity targets rather than taxes primarily because we think that the former offer a better chance of successful negotiations. Quantity targets make it easier to enlist industry support for the policy, but this is a two-edged sword, because distribution of the permits promotes lobbying and corruption. The negotiation and enforcement problems are formidable with both taxes and quantity restrictions, giving neither an obvious advantage as a policy choice.

4.3 Comparison of cost variation

The issue of cost variations involves both economic and political economy considerations. This section explains why the problem of cost variability is sometimes exaggerated. We noted in Section 4.1 that under a tax, levels of emissions adjust so that *marginal* abatement costs are constant in all states of nature; in the linear model, the level of abatement and the tax exclusive abatement costs are also constant in all states of nature. Under a (binding) quantity restriction with cap and trade, the level of emissions is constant, so abatement varies, as does the marginal and the total cost of abatement. Under cap and trade the price of a emissions permit equals firms' marginal cost; business managers care about this variable price.

Firms are likely more concerned about their average than their marginal abatement costs. The fact that the marginal abatement cost is steeper than the average abatement cost (when costs are convex) means that average abatement costs vary less than marginal abatement costs. In the linear model, the marginal abatement cost curve is twice as steep as the average abatement cost, causing the variance of average costs to be one quarter the magnitude of the variance of the marginal cost. The first point, then, is that the focus on the price of emissions permits (equal to marginal, not average costs) can give an exaggerated view of the importance of cost variation.

The ability, under the tax, to arbitrage abatement over states of nature means that expected *tax exclusive* abatement costs are lower under the tax than under the quota; this is the economic advantage of taxes, as discussed above. Economists are typically interested in the tax exclusive investment costs, because the emissions tax revenue is a transfer from tax-paying firms to society; such transfers have no effect on efficiency, and therefore are, for good reason, usually ignored in economic analyses.[8]

Firms, however, care about *tax inclusive* abatement costs; this is the reason that firms prefer a cap and trade policy, with freely distributed permits, rather than a tax policy. Economic discussions that focus on marginal costs (which vary under the quantity target and are constant under the tax) provides a misleading comparison of the cost variability. The focus on marginal costs incorrectly suggests that the cost variation is zero under taxes and high under quantity targets. Business people understand average costs, but may be vague about marginal cost. Using the linear model in Section 4.1, we can show that the variance of average (tax inclusive) abatement costs under the tax policy is four times as large as the variance of average abatement costs under the freely distributed quota. The larger variance is due to the variance of the tax payments, which are non-existent under the freely distributed quota. Of course, to the extent that quota rights are auctioned, the variability of the emissions price will increase the variability of average abatement costs (inclusive of payments for permits).

Although firms care more about average than marginal costs – because they understand the former better – what they really care about is total (tax inclusive) abatement costs. If, in addition to the assumptions described above, we also assume that the cost shock is normally distributed, then we can obtain a formula for the ratio between the variance of costs under the freely distributed quota, to the variance under the tax. Using this formula with plausible numerical values shows that this ratio is likely to be close to 1, i.e. the two variances have almost the same value.

In summary, using the linear model that provides the intuition behind most of the "tax versus quantity" literature, we find (not surprisingly) that the tax inclusive expected abatement

[8]However, emissions tax revenue or auction revenue can replace tax revenue raised by distortion-inducing taxes (e.g. taxes that increase labor costs). This "double dividend" creates an additional argument for taxes, and for the auctioning of permits under cap and trade.

costs are higher than the expected abatement costs under the quantity target with freely distributed permits, and that the variances of abatement costs are essentially the same under the two policies. Therefore, unless firms are extraordinarily risk averse, they always prefer the freely distributed quota instead of the tax.

This result is important because much of the political economy analysis favoring taxes does so on the basis that these lead to less variable costs. That claim is correct, if we understand “costs” to mean “economic costs”, i.e. costs exclusive of tax payments. But that is *not* how most business people would understand the term. To them, costs include tax costs. Since this argument is often made in the context of a discussion of the political economy of the policies, it probably makes more sense to use the term “costs” as business people understand it. With that usage, the political economy claim that taxes are better than quotas because they lead to greater cost certainty, is overstated.

4.4 Managing cost fluctuations

Despite the qualifications above, the variability of the emissions permit price under cap and trade does create real problems. The permit prices are public information and therefore enter public policy discussion and affect firms’ investment decisions. Fluctuations in permit prices make it more difficult for firms who buy and sell these permits to budget for future costs. Price fluctuations also increase the risk of R&D for new technologies, and decisions whether to install new abatement capital. The fall, during the last half of 2008, in European carbon prices from over €31 to under €10/tonne makes these kinds of investments appear risky. The great virtue of taxes over quantity restrictions is that the former maintain a known implicit price of carbon, reducing the risk of investments in new technology.

Policymakers and businesses have typically been more concerned with high than with low permit prices. There has been more discussion of a price ceiling than a price floor, but both are useful policy tools. The uncertainty about abatement costs and environmental damages makes it difficult to determine the “right” level of emissions or the “right” tax. It is easier to pick “reasonable” levels of emissions and a price ceiling and floor. In order to have a common international price ceiling and floor there must be sufficient international trade in permits to establish a world price of carbon. The price floor and ceiling apply to the price of this internationally traded emissions permit.

Negotiators obtain added flexibility by allowing the price ceiling and floor to change in a predictable way over time; for example, both might be set to increase in order to phase in stricter emissions policies. Alternatively, the ceiling and floor might increase at a rate equal to the expected opportunity cost of investment funds, so that the expected value of holding a permit is roughly constant. Other possibilities include changes in the price floor and ceiling to accommodate changing abatement costs due to technology changes or changing environmental damages; during a ten year period we expect both of those effects to be modest. In the interest of simplicity we consider the case here where the floor and the ceiling are constant, or perhaps increasing at an estimated inflation rate so that the "real" floor and ceiling are constant. These prices should be denominated in a GDP-weighted basket of currencies. There exist financial instruments that enable countries and businesses to manage the exchange rate risk arising from the fluctuations, in terms of domestic currency, in the price floor and ceiling.

Negotiations should establish a Central Bank whose sole objective is to defend the price ceiling and floor.[9] The Bank should attempt to reach this objective while retaining minimal balances. We want the Bank to be a machine for protecting price stability, not a power in itself. The Bank has two policy tools, adjustment of future quantity restrictions, and purchases and sales in the spot market. As in the example given above, an agreement with five periods specifies for each member country i the trajectory of emissions ceilings $(x_1^i, x_2^i, ...x_5^i)$. If we are currently in period 2, adjustment of the future quantity restrictions means a proportional change– the same for each country – in (x_3^i, x_4^i, x_5^i). Countries are allowed to bank permits from one subperiod to the next, but not to borrow against future subperiods.

These policy tools together with intertemporal banking give the Central Bank an ability to influence the current price by adjusting the ceiling in future subperiods. For example, suppose that we are in period 2 and the international price of permits is close to the ceiling. As long as some nations or firms are banking permits, the Central Bank can reduce the spot price by raising the future emissions ceilings (x_3^i, x_4^i, x_5^i) for each country. That increase will lower expected future prices, making it less attractive for countries or firms to bank emissions permits. The release of these permits onto the market puts downward pressure on the current spot price. If instead the spot price is close to the price floor, the Central Bank can defend the floor by decreasing future emissions ceilings (x_3^i, x_4^i, x_5^i). That decrease in future ceilings increases expected future prices, making it more attractive for permit owners to bank rather than use their permits. This diversion of permits into storage puts upward pressure on the current spot price, thereby defending the floor. These adjustments in future ceilings do not require any financial transaction between the Central Bank and the public, thereby achieving the Bank's goal of maintaining a minimal balance.

If no country is banking substantial permits from previous periods – i.e. if there is an approaching stockout – an increase in the future emissions ceilings will not defend the price

[9]Helm, Helpburn, and Mash (2003) discuss various ways to deal with the credibility problem, including the establishement of a Central Bank. Ismer and Neuhoff (2006) discuss the use of put options in a domestic setting, as a means of establishing a price floor.

ceiling. In this case, the Bank can sell permits directly to firms or to countries; the countries can then distribute them in any manner, but preferably by means of auctioning. Any revenue above the minimal amount that the Bank is allowed to hold as balances, should be spent on two activities: first to buy from governments or markets the put options that we describe below; second, to fund a separate agency whose function is to promote developing country abatement. The fact that revenues obtained from sales of these additional permits goes to the international community, via the Central Bank, and not to the domestic treasury, means that at the negotiation stage countries have an incentive to set a “reasonably high” price ceiling. If the price ceiling is low, the Bank will be called upon to defend it frequently, leading to frequent transfers from national treasuries or domestic businesses to the world community.

The ability to reduce future emissions should be adequate to defend the price floor if the Bank retains credibility. It might lose this credibility if the public believes that the floor will not be defended in the future. For example, there is a point below which future emissions ceilings cannot be credibly reduced. If past reductions of these ceilings have brought them close to that point, the promise of further reductions might not be believed. In that case, the announcement of further reductions to future ceilings is not credible, and will not protect the price floor.

In that eventuality, the Bank buys permits on the spot market to protect the floor. For this purpose, the Bank needs finances. In order to keep the Bank operating like a machine and not an agent with discretion, we do not want it to have substantial reserves. For this reason, developed country signatories to the climate agreement should capitalize the Bank by giving it an adequate number of American style put options with a strike price equal to the price floor. Each country’s contribution of these options should be proportional to its share of aggregate developed country emissions during the period of the agreement. Countries with larger shares of total emissions have more responsibility to defend the price floor. Each of these put options allows the Bank to sell to the contracting country, at any time during the life of the contract, a permit to emit one tCO2e at the strike price. Thus, if the Bank finds itself in the position of being unable to defend the price floor by means of adjusting future ceilings, it buys permits on the spot market and pays for these by exercising the equivalent number of put options. It exercises these options with individual countries in proportion to those countries’ original contribution of options.

In this manner, the signatories to the climate agreement indirectly finance the defense of the price floor. One advantage of this method over a direct levy is that it is automatic. Countries agree to the mechanism when they negotiate the climate agreement. The need to defend the price floor might arise in a time of global economic crisis, if for example the fall in permit price is caused by a global recession. That would be no time to try to negotiate government payments to support carbon prices. In addition, the cost of this transaction to the signatories is negligible, providing that the agreement remains in force. If it does remain in force, then the permits that countries receive by honoring the put option will not fall in value below the floor; the country's only cost is the opportunity cost of tieing up the funds. The desire to preserve the value of their asset (the newly purchased permits) reinforces countries' desire to sustain the climate agreement.

If the Bank needs to exercise its original put options at some time during the course of the agreement, it is required to use revenue from future sales of permits, obtained in defending the ceiling, in order to purchase the number of put options needed to replace those it previously surrendered. There should be a market for these options; either governments or firms with sufficient credit should be allowed to sell them. Provided that the climate agreement retains its credibility, there is little risk that the price of permits will fall below the floor, and therefore the price of the put option should be close to 0. A high price of these options is a signal that the market does not trust that the agreement will survive. A high price therefore is a clear indication that signatories need to renew efforts to strengthen the agreement.

Although signatories give the Bank its initial allocation of put options, replenishment of the stock of put options is a market transaction. If the Bank's stock of put options falls below a threshold, and the bank does not have funds obtained in previous defense of the price ceiling, the original contributors are required to make a gift of additional put options on the original terms. This gift maintains the viability of the climate agreement and also protects the value of the countries' stock of permits, obtained through redemptions of the put contracts that the Bank previously exercised.

There are trade-offs in deciding how to allocate the aggregate amount of a country's permits over the subperiods. For any aggregate level, each country would like to have all of its allocation in the first period, because it has the option of banking but not borrowing permits across periods. That kind of front-loading creates the moral hazard problem that we want to avoid, by spreading the allocation over periods. It would also make our proposal ineffective, since the proposal requires the adjustment of future limits, and that requires that the future limits be non-negligible. However, banking has to occur in order for it to be possible to defend the price ceiling by means of adjusting future targets. A generous percentage allocation in the first period increases the chance of this banking. A reasonable rule of thumb allocates per-period shares of the total allocation approximately equal to estimated BAU emissions shares over those periods, with slightly more generous shares in the first period, and correspondingly lower shares in subsequent periods.

An important feature of this proposal is that the price ceiling and floor correspond to the international price of carbon. If the international market for carbon works well, the domestic and international prices should be approximately the same. There already exists a reasonably successful international market for carbon, but there is no single price carbon price (Section 8.2). For example, the price of a "guaranteed" Certified Emissions Reduction unit obtained from the Clean Development Mechanism is lower than the price of a European Union Allowance on the Emissions Trading Scheme. In a properly functioning market, these two prices should be equal.

Individual countries can insure that their domestic price of carbon is close to the international price simply by avoiding trade restrictions in the permit market. Countries are entitled to manage a domestic price ceiling and/or floor different than the international levels set by the agreement. However, we discourage that action. The decision by a large country or several small countries to set a domestic ceiling or floor different than the internationally agreed levels would undermine the international market for permits. Our proposal requires a well functioning international permit market, because it uses the international permit price to make policy adjustments during the life of the agreement. Any country that decides to maintain a domestic price floor or ceiling different than the internationally agreed levels is still required to fulfill its international obligations. In particular, the country must meet the subperiod targets set by the agreement, and perhaps modified by the Central Bank. Countries are not allowed to issue themselves more permits, or to borrow against their future allocations.

4.5 Summary

Our proposal requires developed countries to agree to an aggregate ceiling on emissions for the life of the climate agreement. This aggregate level is divided into levels for subperiods of the agreement. Countries are allowed to bank, but not to borrow permits across subperiods. At the end of each subperiod, all countries must purchase sufficient permits to eliminate any deficit.

International trade in permits makes it possible to take advantage of low cost abatement opportunities in other developed countries, and also makes it possible for countries to satisfy their per-period ceilings. A Central Bank maintains a price floor and a price ceiling. Lowering or raising future per-period ceilings provides the primary defense of the floor and ceiling. If this method fails in defense of the price ceiling, the Bank sells enough permits to keep the market price from exceeding the ceiling. If the method fails in defense of the price floor, the Bank exercises put options.

The developed country signatories finance the Bank by contributing American style put options at a strike price equal to the price floor. Each country's share of options equals its share of aggregate allowable emissions during the agreement period. After the Bank has exercised put options, in defense of the price floor, it is required to use revenue from subsequent sale of permits to buy enough put options to replenish its original stock. If its stock of put options falls below a minimum level when the Bank does not have sufficient capital to replenish the stock, the developed countries contribute proportionally to bring the Banks' stock of options to that minimum.

5 Absolute versus intensity targets

Replacing an absolute emissions target with an intensity target has been proposed as a means of limiting the danger that emissions constraints inhibit growth. The intensity target links allowable carbon emissions to GDP. The simplest intensity target requires that a country's ratio of GHG emissions per unit of GDP not exceed a ceiling. More complicated proposals choose a formula that determines the emissions ceiling as a function of GDP. This section discusses the relative merits of absolute and intensity targets. In order for the two policies to be comparable, the expected level of emissions under the intensity target must equal the level of emissions under the absolute target.

The principal policy implications are:

- Absolute targets, compared to intensity targets, are likely to lead to slightly better environmental outcomes, but the difference may be small.

- The limited empirical and theoretical evidence suggests that at least for a number of developing countries, intensity targets may reduce expected abatement costs. A simple general equilibrium model provides another kind of evidence that expected GDP may to be higher under an intensity target, compared to the absolute target.

- However, if countries are even slightly risk averse, in the sense that they are willing to sacrifice a small level of expected income in order to reduce the variance in income, they may be better off under an absolute target.

- Political economy arguments also cut in both directions. Intensity targets may be an easier sell to the public and policy-makers, but they may also lead to greater rent-seeking.

- Our assessment of these arguments leads us to recommend absolute over intensity targets

5.1 General considerations of absolute and intensity targets

We consider only the simple, constant intensity target, rather than a target based on a more general formula. As in most circumstances, the greater flexibility achieved by a more complicated rule leads – at least in principle – to higher welfare than under the constant target. There are three reasons to restrict attention to the constant intensity target. First, this restriction enables us to explain the economic issues in the simplest manner. Second, the constant absolute target involves a single policy parameter. In order to provide a fair comparison between the intensity and the absolute targets, it makes sense to restrict the intensity policy to a single number also. Third, given a general intensity target rule (a function relating the intensity target to observables), we can always duplicate the outcome using an absolute target rule. Thus, at a high enough level of generality, the two policies are always equivalent. The comparison between the two policies is interesting only if we require that each be simple, e.g. when each involves a single parameter.

Under certainty and with competitive markets, a constant absolute target and a constant intensity target lead to the same results, provided that the levels are chosen correctly. Thus, an important reason for being interested in comparing the absolute and the intensity policies is because GDP and the economic cost of abatement are uncertain. In a world without uncertainty, we might propose different intensity targets for rich and poor countries, simply because of their different stages of development. In this case, the difference in targets has nothing to do with uncertainty, which by assumption is absent, and everything to do with the stages of development. However, in this case we can also use different absolute targets to accommodate the different stages of development. Similarly, in a world without uncertainty we might propose for a particular country an intensity target that decreases over time, to reflect higher stages of development in the future. An equivalent absolute target policy can achieve the same goal. Our point is that the comparison of the absolute and intensity target is motivated by uncertain growth and uncertain abatement costs, not by differences in stages of development.

Both developed and developing countries have proposed replacing an absolute target with an intensity target. Argentina made this suggestion at the Conference of Parties in 1999, and others endorsed it. President GW Bush proposed using an intensity target for the US, although that suggestion was widely seen as a subterfuge for avoiding genuine reductions. In the interest of clarity, it is better that all nations that accept binding targets choose the same form, either an absolute or an intensity target. If the decision is to use the intensity target, the implied absolute target should be made explicit. The relation between the two requires the use of forecasting models.

Provided that the absolute target is binding in all states of nature – a mild assumption – emissions under the absolute target are fixed. In contrast, even when the intensity target is binding in all states of nature, the level of emissions fluctuates with the level of GDP. Thus, the major environmental difference between the two policies is that the former fixes the actual level of emissions, whereas the latter fixes only the expected level of emissions. In this respect, the comparison between absolute and intensity targets is similar to the comparison between quantity restrictions and taxes, discussed in Section 4.1. In a special case discussed below, the intensity target is equivalent to a tax.

Whenever the marginal damage increases with pollution, the expected environmental benefits are greater under an absolute target than under an intensity target (or a tax) that yields the same expected level of emissions (Dudek and Golum 2003), (Fischer 2003). This consideration is one reason that environmentalists may oppose intensity targets. The basis for this result is identical to the reasoning that we discussed in the context of Figure 1, where we compared taxes and quantity restrictions.

Environmentalists have two other reasons for disliking the intensity target. First, as in the case of the Bush plan, they may regard it as a public relations maneuver that avoids real reductions. However, the possibility of using a weak emissions target does not mean that the policy is ineffective. Given any level of abatement achieved by an absolute target, the same level can be achieved in expectation by an intensity target. Second, environmentalists may be concerned about a nation's willingness to make absolute reductions when required by an intensity target. A target that puts a ceiling on the ratio of emissions to GDP allows emissions to rise with GDP, but requires that emissions fall when GDP falls. Environmentalists may worry that a nation would not make the stricter reductions required when GDP is low. This objection is not persuasive. A nation also has an incentive to renege on commitments undertaken with an absolute target. There is no reason to suppose that this incentive is greater under one policy than another. Moreover, there is no particular reason for thinking that, under an intensity target, the incentive to renege is larger when GDP falls. Even though this contingency requires a lower level of emissions, the cost of achieving that level might be either greater or smaller than when a high GDP leads to higher allowable emissions.

Economists have been sceptical of intensity targets for domestic regulation, partly out of concern that these distort firms' choices (Helfand 1991). For example, if regulation caps firms' ratio of pollution to energy, firms might have the incentive to increase energy use to help satisfy the cap. The variable of interest here is the numerator, pollution, but firms might reduce the ratio by increasing the denominator (energy use in this example) rather than reducing the numerator. This concern is not relevant for an economy-wide intensity cap, because firms cannot strategically manipulate GDP.

The economic rationale for an intensity target is sometimes vague or confused in policy discussions. As an example of confusion, consider the following justification (mentioned in a UN document) for an intensity rather than an absolute target. A country's GDP might grow by less than expected but BAU emissions do not fall proportionally; in other words, BAU income and intensity are negatively correlated. In that circumstance, under an absolute target, even when GDP is lower than expected the country has to keep emissions below the same ceiling, but it has to make this effort when it is poorer. In this case, the county is hit by two forces, the low GDP and the cost of abatement. This argument against absolute targets gets it exactly wrong: the intensity target *reinforces* the regressive effect, because the intensity target requires lower emissions when GDP is lower.

The most common economic rationale for the intensity target is that it lessens the concern that the absolute cap constrains growth. The intensity target allows higher emissions in high-growth states of nature, and in this respect it appears to be more friendly to growth. However, both types of policies constrain emissions and therefore constrain economic output. The relevant question is: "Under which states of nature – high growth or low growth states – are the extra emissions most valuable to the economy?"

Pizer (2005) provides two arguments against using intensity targets as a means of dealing with uncertainty. First, he claims that (for a group of six developed countries) an intensity target would not significantly reduce uncertainty, relative to an absolute target. Second, he points out that for the same sample, year to year fluctuations in intensity and GDP are negatively correlated. Therefore, a country faced with an intensity target is likely to have to make a larger reduction in intensity, relative to its BAU level, in a year when its income is lower. In this respect, the intensity target appears regressive, as we noted above. Pizer supports the use of intensity targets on the grounds that they provide a politically more palatable way to frame the goal of emissions reductions. An absolute targets connotes a limit on growth, whereas the intensity target suggests a performance standard, which to some people sounds appealing.

A different political economy argument cuts in the opposite direction. If a country faces an intensity target, industry groups have a strong incentive to lobby over intensity targets for their sector. These groups also have an incentive to lobby under an absolute target, but in that case auctioning permits provides a simple means of obtaining an efficient use of permits. It would be possible to use an intensity target merely to allocate emissions rights, and allow permit trading to achieve efficiency, but that outcome seems unlikely. Moreover, under a national intensity target, a natural outcome – i.e. one that might be perceived as fair – is for all sectors to face the same intensity target. From there it is a short step to have all firms face the same intensity target. Whenever firms' emissions restriction takes the form of an intensity target – regardless of whether the target is the same for all firms – there arises the perverse incentives that cause economists to resist intensity targets: firms have an incentive to increase output in order to increase their allocation of permit rights.

In summary, although the environmental arguments against the use of intensity targets rather than absolute targets are essentially correct, they are probably not especially important. The economic tradeoff is not completely clear, but the evidence suggests that abatement costs are likely to be lower, or national income higher, under intensity targets. Intensity targets may also increase the variance of national income, so if the country dislikes this type of risk, it might prefer an absolute target. There are also two sides to the political economy argument. The intensity target may be an easier sell to the public and to policy-makers, but it is also likely to lead to a greater rent seeking.

5.2 Comparison of policies using formal models

The informal economic arguments described in the previous section emphasize a possible advantage of a policy in one situation without balancing it against the possible disadvantages in another situation. The growth argument suggests that unexpectedly high growth and correspondingly high GDP should justify higher emissions, thereby favoring the use of an intensity target rather than an absolute target. However, those higher emissions must be compensated by having lower emissions when GDP is lower, in order that the expected (or average) level of emissions not exceed the target. The economic cost of abatement is the opportunity cost of the factors of production that must be used to reduce pollution rather than to generate output. The opportunity cost of abatement might be either higher or lower in the high growth scenario than in the low growth scenario.

Even if the opportunity cost of abatement is higher in the high growth scenario, the value to society of the additional consumption (obtained from using factors of production to produce goods rather than to reduce emissions) may be lower in that circumstances. An additional unit of consumption may be worth less to a country that has grown faster than expected and is therefore richer than expected, compared to a country that has grown more slowly than expected. This consideration is the basis for requiring that richer countries meet stricter standards. The same logic that recommends stricter intensity standards for rich countries than for poor countries can be used as a basis for recommending that a country be given a higher intensity target (a weaker standard) when its growth has been low, and a lower intensity target (a stricter standard) when its growth has been high. But that argument favors an absolute rather than an intensity target.

This sections considers these arguments more carefully. We first discuss a partial equilibrium model based on the idea that countries want to reduce the variance of abatement. The criterion of abatement variability leads to a simple formula that can be taken to data, to determine which policy is likely to be better for particular countries. The empirical results support the use of an intensity target, especially for developing countries. This partial equilibrium setting contains an implicit assumption that the parameters of the abatement cost function are not correlated with the level of abatement.

The abatement cost function is likely to depend on technology and on factor prices. The parameters of the abatement cost function are therefore likely to be random and correlated with BAU GDP and emissions intensity. The correlation between a parameter of the abatement cost function and the level of abatement affects the ranking of policies. Under strong assumptions, a model with random cost parameters leads to the same criterion for ranking policies as does the simpler model (in which the abatement cost function is certain and only the level of abatement is random). Absent those strong assumptions, it is difficult to rank the two policies using available data.

We then describe a general equilibrium model in which random events that affect GDP and emissions also affect the opportunity cost of abatement (the "abatement cost function"). Instead of asking which policy leads to a lower variance of abatement or lower expected abatement costs, our general equilibrium approach asks which policy leads to higher expected income, or higher expected welfare. These variables, rather than abatement cost *per se* are the variables of interest. Higher income leads to higher welfare (by assumption), but the relation need not be linear. An additional unit of income may contribute little to the welfare of a rich country, but a great deal to the welfare of a poor country. In this case, marginal ("incremental") utility decreases with income; this situation is formally identical to risk aversion. A country (or person) is risk averse if they prefer a certain level of income rather than a lottery that pays, on average, that level.

The particular model that we describe produces sharp results. First, if the criteria is expected income (i.e. if the country is risk neutral, so that each additional unit of income provides the same incremental increase in welfare), then the intensity target is always better. The reason for this result is that the intensity target allows emissions to fluctuate with random events. In particular, this policy allows emissions to be higher in precisely the circumstances where they provide the greatest benefit to production. However, the intensity target also leads to greater fluctuations in income. If the representative agent in the economy is even moderately risk averse, the agent always prefers the absolute target. The absolute target gives a lower expected ("average") level of income, but it also leads to less uncertainty.

The next two subsections present details of these arguments. These sections can be skipped without loss of continuity.

5.2.1 Partial equilibrium models

Here we summarize and evaluate a comparison of the two policies based on Sue Wing, Ellerman, and Song (forthcoming); Jotzo and Pezzy (2007) describe a similar model. The idea is that required abatement is a random variable under either an absolute or an intensity target, and a reduction in the variation of abatement reduces expected abatement costs. Therefore the policy that leads to a smaller variance in abatement leads to lower expected abatement costs and higher expected welfare. There are two steps to the argument: first showing that a smaller variation in abatement leads to lower expected abatement costs, and second comparing the variance in abatement corresponding to the two policies. Demonstration of the first part uses essentially the same argument as in Section 4.1, so we do not repeat it here.

To compare the variance of abatement levels under the absolute and the intensity targets, let Q^{BAU} be BAU emissions, a random variable. If we pick an absolute target level of emissions (a fixed number) Q^{target}, required abatement is the difference between emissions under BAU and the target level of emissions:

$$A^{\text{absolute}} = Q^{\text{BAU}} - Q^{\text{target}}. \tag{1}$$

Under a fixed intensity target that leads to the same expected level of emissions, the required abatement level is

$$A^{\text{intensity}} = Q^{\text{BAU}} - \frac{Q^{\text{target}}}{EY}Y. \tag{2}$$

where Y is the random level of income and EY is the expected level of income.

These two equations illustrate an important point. Under the absolute target, the level of abatement varies only with the BAU level of emissions. In contrast, under the intensity target, the level of abatement increases with BAU emissions and it decreases with the level of national income. A higher correlation between BAU emissions and income reduces the variance of abatement under the intensity target. However, whenever BAU emissions and income are not perfectly correlated, abatement under the intensity target is affected by an additional source of noise, thus increasing the variance.

A simple calculation leads to a formula for the difference in the variance of abatement under the two policies. This formula can be taken to the data to determine which policy is likely to be better for particular countries, depending on the stringency of the emissions reduction. Sue Wing, Ellerman, and Song (forthcoming) make this comparison in two different ways. Using the approach that has broader applicability, they find that most countries, including all six developing countries in their sample, prefer the intensity target. Newell and Pizer (2008) use the same criterion to rank policies. Among developing countries in their sample, they find that Brazil, China and Mexico would clearly prefer the intensity target, while India and Indonesia would likely prefer the absolute target.

The limitation of this approach is that it begins with the premise that the abatement cost function is exogenous. In fact, parameters in this function are likely to be endogenous, and to vary with both BAU emissions and GDP. A generalization allows the abatement cost function to depend on a parameter that is correlated with the level of abatement. The correlation arises because some of the same factors that affect the required level of abatement also affect the cost of abatement. For example, under the absolute target, abatement is the difference between BAU and target emissions. BAU emissions depend on the realizations of many random variables, including those that affect technology and terms of trade. Some of these random variables also affect the cost of achieving a given level of abatement. Under a intensity target, required abatement depends on both BAU emissions and BAU GDP. The random events that affect these variables are likely to also affect the cost of achieving a given level of abatement.

In order to examine the effect of this possible correlation, we can evaluate a second order approximation of the difference in expected abatement costs under the two policies. This calculation shows that the policy ranking depends on two types of considerations. First, the difference in the variance of abatement is still important, and can be calculated in the same manner as above. This difference can be estimated with available data. However, a second term involves the difference between the covariances (under the two policies) between abatement and the random cost parameter. Unfortunately it is not possible to estimate this second term because the absence of historical GHG restrictions means that we do not have data on abatement costs.

The unsatisfactory conclusion is that the ranking based only on the variance in abatement misses key economic factors. However, we have little insight into how we should adjust the criterion to rank the policies. Therefore the next section discusses a general equilibrium model that avoids the need to obtain an explicit expression for abatement cost. This model can compare expected income and expected welfare directly, without taking a detour to construct the abatement cost function. Income and welfare (rather than abatement costs), after all, are the variables of interest.

5.2.2 General equilibrium with endogenous abatement costs

Karp (2009) compares absolute and intensity targets in a general equilibrium setting, using an extension of Copeland and Taylor (2003) that includes random output and random intensity. This setting treats output and emissions as joint products, produced using the economy's factors of production. Under BAU, output is the random variable Y. The random variable Q denotes emissions. The economy can reduce emissions by using some of its BAU ("potential") output for abatement. Of course, what the economy actually does in this case is to divert some of the factors of production into abatement activities, but it is "as if" the country converts potential GDP into abatement services. The fraction of BAU output that it actually uses to reduce emissions is θ. The fraction $1 - \theta$ of BAU output remains for consumption and investment. Under BAU the economy uses none of its (potential) output to reduce emissions, so $\theta = 0$.

In this model, under a fixed intensity target that has the expected level of emissions equal to the absolute target, the actual emissions are higher in precisely the circumstance where the incremental emissions provides a greater contribution to productivity. In this sense, the intensity target makes it possible for emissions to be "arbitraged across states of nature". That is, the intensity target causes the emissions to occur in the circumstance where they are most useful to the economy. For this reason, expected income is always higher under an intensity target compared to an absolute target, given that both lead to the same level of emissions in expectation.[10]

In this model, a constant emissions tax reproduces the outcome under a constant emissions intensity. This result arises from special functional forms, and is not general. However, in general the emissions tax and the intensity ceiling share the property that both allow the economy to adjust the level of emissions, leading to arbitrage of emissions over states of nature.

If agents dislike income risk, then welfare depends on the distribution (over states of nature) of income, not merely the expected level of income. If welfare equals the natural log of income, which implies a small to moderate level of risk aversion, and if in addition BAU income and intensity are independently log normally distributed, then society always prefers the absolute target rather than the intensity target. Although the intensity target leads to higher level of expected income, it also leads to more uncertainty about income. With even a moderately risk averse society, the higher expected income is not worth the greater uncertainty.

5.3 Summary

We reviewed the environmental and economic arguments regarding the choice between an absolute and an intensity target on GHG emission. The environmental arguments slightly favor the use of an absolute target, simply because it is better for the environment that emissions be fixed rather than a random variable. However, the environmental improvement in moving from random to fixed emissions is likely to be small in the case of a long lasting stock pollutant, where the policy is fixed for a short period of time, such as a decade. The environmental criterion is therefore not decisive.

There appears to be a widespread belief that economic considerations favor the use of an intensity target. We reviewed a model that ranks the two policies on the basis of variability of abatement. In this case, the empirical evidence supports the view that the intensity target is likely to be better for developing countries, and also for some developed countries. The variability of abatement is a reasonable criterion for ranking policies if the abatement cost function is deterministic, or if it contains stochastic parameters that are uncorrelated with the level of abatement.

However, the abatement cost function likely depends on technology and on factor prices, which are correlated with BAU GDP and emissions intensity. The resulting endogeneity of the

[10] This result assumes that BAU intensity and BAU income are independently distributed. A negative covariance between these two, which is consistent with empirical evidence, would strengthen this conclusion.

abatement cost function calls into question the relevance of using the variability of abatement to compare the different policies. We considered a general equilibrium formulation which takes into account the endogeneity of the abatement cost function. The important advantage of the intensity target (like the tax) is that it permits emissions to be arbitraged over states of nature. In the simple model that we discussed, this consideration always causes the intensity target to lead to a higher level of expected income. Even in that case, however, when the representative agent in the economy is only slightly risk averse, expected welfare (as distinct from income) is higher with the absolute rather than the intensity target.

Altering the functional forms or the assumptions about the random variables could overturn both of these results. Despite this caveat, the results identify economic forces that are important in quite general circumstances. It appears likely that replacing an absolute target with an intensity target leads to higher expected income and more variable income. Given this trade-off, the ranking of the policies is not at all clear.

The political economy arguments are also double-sided. Intensity targets may be more attractive to policy-makers and the public, compared to an absolute target, when the two lead to the same expected level of emissions. However, intensity targets likely provide greater scope for more damaging rent-seeking activities. On balance, we favor the use of absolute targets.

6 The role of trade policy

Environmentalists and trade economists have debated for years whether trade policy should be used to attempt to solve transboundary environmental problems. Until recently at least, trade economists have been broadly united in opposing that option. Ensuring that environmentally motivated trade policy is consistent with WTO rules requires either that the trade policy be carefully tailored or that the WTO be modified. The second outcome requires consensus from WTO members and is unlikely given the opposition of many countries. Even if such a consensus could be obtained, a common view amongst economists has been that the gains from further trade liberalization are large and that the current trade rules are vulnerable to erosion. Moreover, many have thought that the dangers associated with climate change are modest, whereas the risks to the global trading system are substantial. These views lead naturally to attempts quarantine environmental objectives from trade policy. An alternate view is that globalization of world markets is on a sound footing and that there are major risks of climate change. Under this view, it might make sense to use trade policy to achieve environmental goals.

Three powerful ideas bear on the trade and environment debate. The first, the Theory of Comparative Advantage, provides a basis for understanding how trade increases global economic output. The second, the Theory of the Second Best, provides a rationale for using trade restrictions or other policies that interfere with the free working of markets, in the presence of a pollution externality or some other market failure. The third idea, the Principle of Targeting, explains that even though a trade restriction might be a means of improving welfare, it is rarely the optimal remedy for a market failure. The combination of these three ideas makes economists wary of using trade policy to deal with the climate change problem.

The global economic crisis that the world is currently experiencing encourages some politicians to blame "unfair" trade rules. In view of the experience of beggar-thy-neighbor trade policies during the depression of the 1930s, and the anti-trade rhetoric that crops up periodically, it is easy to imagine how the world trading system could be undermined.

Our view is that trade policy should be used to promote an international environmental agreement, and that this can be done without endangering the world trade order. Approximately half of the recent climate policy proposals considered by the US Congress involve some form of trade restriction (Frankel 2008). The challenge is to devise an agreement that respects and perhaps even enhances the WTO. Including trade policy in an environmental agreement can make the agreement work better and encourage participation. Trade policy enhances the agreement by reducing the problem of carbon leakage. It also provides policymakers with the tools that make it easier to resist post-ratification demands from industry or labor to renegotiate or to simply walk away from the agreement. Trade policy can promote the participation objective in three obvious ways: (i) Rational decision makers should be more willing to join an enterprise that has a higher likelihood of success. (ii) At the time of signing and ratification, the inclusion of trade policy enables politicians to assure their constituencies that they will not be victims of "unfair trade". (iii) Countries that are tempted to stay out of the agreement will anticipate higher costs and lower benefits of rejecting the treaty.

We assume that the next climate agreement will involve all major developed countries, including the US. Therefore, we do not consider the possibility of one group of developed countries using climate-related trade restrictions as punishment for another developed country's refusal to ratify the agreement. Climate-related trade sanctions apply only to signatories: developed country signatories that are not in compliance, and possibly to developing country signatories that do not accept binding caps. A subsequent agreement may use trade policy more aggressively.

The next section discusses the problems of loss of competitiveness and carbon leakage, the reasons that an international climate agreement requires trade policy. The following sections discuss possible uses of WTO-consistent trade policy in a climate agreement.

The policy implications/recommendations for this Section are:

- A climate agreement cannot ignore the possibility that trade might undermine climate policy, either due to carbon leakage or to a perceived loss of competitiveness.

- WTO rules offer options for unilateral trade measures in support of environmental objects, but the applicability of these measure is uncertain and their aggressive use might violate the spirit if not the letter of the world trade order.
- The climate agreement should specify permitted trade restrictions, used only against signatories to the agreement, and applied only to a small number of named carbon-intensive commodities.
- The preferred trade measure requires that signatories without binding carbon targets, and all signatories not in compliance with the agreement, surrender carbon permits equal to the amount of carbon used to produce the product they export.
- Signatories that meet their agreed carbon limits are deemed to be in compliance, and therefore not subject to the border measure, regardless of the manner in which they meet their domestic target.
- Developing country signatories are granted a phase-in period, longer than that given to developed country signatories. However, the former may be subject to additional interim measures, such as required accession to a sectoral agreement.

6.1 Carbon leakage and loss of competitiveness

Carbon leakage is the process by which stricter emissions standards in one place encourage higher emissions elsewhere, as production of dirty goods moves to places with weaker environmental standards. In 2007 some EU politicians proposed a "Kyoto tax", aimed primarily at the US, as a response to carbon leakage and loss of competitiveness. This tax would offset the estimated cost advantage that the US enjoys because of its decision to withdraw from the Kyoto Protocol. World Bank simulations show that the tax would have caused a substantial reduction in US exports to the EU (World Bank 2008). Many people believe that carbon leakage and loss of competitiveness currently exist and would become more severe under a stronger climate agreement.

The magnitude of carbon leakage is uncertain; Intergovernmental Panel on Climate Change (2001) provides estimates ranging from 5 – 20%. McKibbin and Wilcoxen (2008) give much smaller estimates for most traded goods. In extreme cases, a carbon restriction in one country could lead to an absolute increase in emissions (leakage in excess of 100%), if production shifts to countries that use more carbon-intensive methods. An OECD study (cited in Pauwelyn (2007)) estimates that a price of €15/tonne of CO2e would reduce European cement production by 7.5% in 2010, causing this production to move to unregulated markets, increasing carbon emissions there and reducing cement production in Europe.

Carbon leakage is an example of the "pollution haven effect" for which the empirical evidence is mixed but generally quite weak (Copeland and Taylor 2003), (Copeland and Taylor 2004). Perhaps this evidence is weak because the magnitude of the historical change in environmental policy has not been great enough to have an appreciable effect on the location of industry. The quality of the evidence may also be a consequence of statistical and measurement problems.

Trade policy can be used to persuade policymakers in signatory countries that they can achieve substantial reductions in GHG emissions without significant leakage and the accompanying job loss (Stiglitz 2006). This reorientation of trade policy carries with it the well-recognized risk of protectionist policies disguised as environmental policies ("environmental protectionism"), for which there is no simple inoculation.

6.2 Unilateral trade policy to strengthen environmental policy

Before describing how an international climate agreement should include trade policy, it is worth considering how trade policy can be used in the absence of such an agreement. There is substantial latitude for unilateral climate-related trade intervention under the WTO. However, some apparently plausible avenues are not open. For example, although people often speak of "environmental dumping" as a rationale for trade restrictions, the WTO has a strict interpretation of the term dumping. People who speak of environmental dumping typically mean that a country does not require their producers to pay the full production cost, including the environmental cost. However, under trade law a country is guilty of dumping if it exports at a price lower than its domestic price, or its domestic production cost. Because the market cost instead of the cost under ideal policies is relevant, environmental dumping is not a basis for trade intervention. There are two likely foundations under WTO law for unilateral climate-related trade intervention, a border tax adjustment and an Article XX environmental exemption.

Border tax adjustments (BTA) offer the simplest approach, but their efficacy may be limited by the form of domestic policy. WTO law allows countries to provide export subsidies or impose import tariffs that offset certain kinds of domestic taxes. "Indirect" (or "product") taxes, which include taxes on inputs, can be adjusted at the border, whereas "direct" (or "process") taxes, such as a payroll or a profits tax cannot be adjusted. The status of a carbon tax is uncertain. Pauwelyn (2007) writes

> ...would such domestic carbon tax be regarded as an adjustable product tax that can be imposed also on imports for carbon produced abroad? Or would the WTO classify it as a producer (or direct) tax which cannot be adjusted at the border for imports? This is a long-standing debate and no definite answer can be given.

The fact that many countries will control carbon emissions using either cap and trade or a command and control policy (i.e. production standards), instead of a carbon tax, adds to the difficulty of using BTAs as an environmental mechanism. If the country uses a cap and trade system, the amount of tax eligible for adjustment might depend on whether permits are auctioned or given to producers. If all permits are auctioned, the result is the same as a tax, so the total cost of the permits could be "adjusted". Matters are more complicated if some permits are given to firms. The value of the free permits could be construed as a subsidy, even though the firm incurs an opportunity cost in using them rather than selling them. Freely distributed permits could raise firms' profits, relative to the no-policy BAU level (Section 4.2), in which case the net effect of the policy is a producer subsidy, not a tax. The amount of border tax adjustment would likely equal the actual cost to firms of the policy, rather than the opportunity cost of the permits that they use. The actual cost could be negligible, in which case the BTA does little to protect against carbon leakage or loss of competitiveness. If the actual cost to firms is negative, the distribution of permits might run afoul of the WTO's limits on producer subsidies.

Although limiting the BTA to firms' actual costs might seem fair, it undermines the environmental objective. Regardless of whether permits are auctioned or given to firms, the opportunity cost of a tonne of emissions equals the price of a permit. Therefore, if firms behave rationally, and absent special circumstances,[11] the emissions decisions should not depend on the manner in which the permits are distributed. However, if the amount of border tax adjustment does depend on the manner of distribution of permits, then the effect of the border tax adjustment on foreign firms' incentive to abate, and therefore its ability to limit carbon leakage or loss in competitiveness, could be negligible.

Matters appear even more complicated if the domestic regulation uses standards rather than a market based policy such as cap and trade. The (unadopted) GATT rulings on the Tuna – Dolphin dispute distinguished between product and process restrictions, rejecting those that are based on the processes used to produce a good. A standard imposed on domestic producers appears to be a process-related rather than a product-related attribute, and might therefore be considered ineligible for BTA. A GATT panel in the US – Superfund dispute allowed the US to tax imports that used chemicals that were taxed or restricted in US domestic production. The panel did not require that the chemicals be physically present in the imported goods. The

[11] A free gift of permits is a lump sum transfer. A firm facing a credit constraint might be forced out of business in the absence of this transfer. The manner of distribution of the permits – free or auctioned – determines the magnitude of the lump sum transfer and can affect firms' decisions whether to exit the industry. The number of firms in the industry might affect total emissions. Although this scenario is possible, we question its practical importance.

US also applied a domestic tax to ozone-depleting chemicals, and levied this tax on imports whose production process used those chemicals; this tax has not been challenged under the WTO (Pauwelyn 2007). Both of these taxes appear to be process rather than product taxes.

The second means of imposing a unilateral climate-related trade restriction uses the environmental exemption under Article XX of GATT. Such a restriction must meet a two-part test. First, the trade restriction must satisfy the article g exemption, which requires that it "relat[es] to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production and consumption." A climate change policy that reduces domestic emissions seems to easily pass this test. The second part of the test, stated in the preface to Article XX, is that the restriction does not create "arbitrary or unjustifiable discrimination between countries.... or a disguised protection on international trade".

All environmental restrictions that have been rejected under Article XX.g have failed this second test. In the Shrimp-Turtle dispute, made famous by protestors at the 1998 Seattle WTO meeting, the dispute panel recognized that the US was entitled to impose trade policies in order to protect turtles that were being caught in shrimping nets. Since the manner in which the shrimp were caught had no physical effect on the imported shrimp, this finding was a clear rejection of the process-product distinction underlying the earlier Tuna-Dolphin decisions. However, the US restrictions were deemed illegal because they failed the preamble test. The US had made accommodations with Caribbean shrimpers without extending the same opportunities to Southeast Asian shrimpers, providing clear evidence of arbitrary or unjustifiable discrimination between countries.

Despite the Seattle protests, the ruling was a victory for environmentalists, because it recognizes that a country is entitled to use trade measures to protect transboundary resources. It was also a victory for the international trade regime, because it respected the core WTO principle of non-discrimination. Some trade economists were concerned that this decision would lead to environmental protectionism against developing countries (Bhagwati 2004), but we know of no evidence of this occurring. The evidence of the past 14 years of the WTO's existence shows it capable of taking a nuanced view of the relation between trade and environmental protection (Neumeyer 2005).

If neither the BTA nor the Article XX exemption sustain the use of trade restrictions applied to support domestic climate policy, the country losing the WTO dispute can ignore the WTO decision. The WTO cannot force a country to do anything. The WTO allows the prevailing party in the dispute to "withdraw concessions", i.e. to raise trade restrictions on the losing party that refuses to implement the WTO decision. For example, the EU lost in their dispute with US over restrictions on hormone-fed beef, but has maintained these restrictions. The US has responded by imposing WTO-sanctioned tariffs on a variety of EU products.

If an important country or group of countries were to respond to a similarly important country or group in this manner, over a matter as significant as climate-related trade restrictions, it would put real strain on the world trading system. However, if all major developed countries are in broad agreement on climate change policy, they might be willing to impose WT0-*inconsistent* trade restrictions against one or more large developing countries that refuse to cooperate in a climate agreement. It would be very expensive for the developing country to "withdraw concessions" against a united front of developed countries. This outcome would violate the spirit of the WTO and it would erode international cooperation. It seems unlikely that such a situation would arise, but it provides a last resort, least-good option for using trade policy to support climate policy.

6.3 Trade policy as part of a climate agreement

Rather than expecting countries to use existing WTO rules to justify unilateral trade policy in support of climate protection, it is better to have the trade policies written into the climate agreement. According to United Nations Environmental Programme (1999), signing an international climate agreement (IEA) after accession to the WTO changes a country's status with respect to WTO rules. An IEA-approved trade restriction levied against a signatory to the IEA does not violate WTO rules, even if that same trade restriction would contravene the rules if imposed against a non-signatory to the IEA. Although this interpretation has not been tested in international courts, it is the basis for trade sanctions in the Montreal Protocol, and it makes sense. By signing the IEA, a country willingly gives up some (potential) rights under the WTO.

This approach requires a clear statement of the IEA-endorsed trading rules. There appears to be broad agreement that the trade rules should apply to the narrow range of sectors most vulnerable to carbon leakage (Frankel 2007). The usual list includes aluminum, cement, steel, and possibly paper and glass. Goods that use these products as inputs, e.g. cars using steel, should not be eligible for trade relief.

A more difficult issue concerns the form of this trade relief. The two most obvious alternatives are that imports on this list of carbon-intensive products be subject to a border tax adjustment, or the requirement to surrender carbon permits (as under the Bingaman-Specter "Low Carbon Economy Act" of 2007). We support the second alternative. The BTA option is complicated and subject to dispute. In addition to keeping track of the taxes in the different countries, it requires dealing with some of the issues discussed in Section 6.2. For example, it becomes necessary to determine whether the value of permits that are given to the sector is included in the implicit domestic tax. As we noted above, the right economic answer is to include this value, but the answer that will seem commonsense to many is to exclude it. The difference in opinion arises because economists think of opportunity costs, and many others do not.

It seems simpler to require that imports surrender permits equal to their carbon content. Here it is important to avoid double counting. A country that accepts and abides by a limit on carbon emissions either implicitly or explicitly taxes its carbon-intensive producers, and exports from that country should not be subject to additional border measures.

For example, suppose that the EU and the US agree to carbon limits and India rejects such limits. Suppose also that the EU auctions all permits and the US distributes for free some permits to its domestic steel producers. Steel trade between the US and EU should not be subject to any border measures, provided that both countries are in compliance with the climate agreement. EU exporters face the explicit cost of purchasing carbon permits. US steel exporters face the implicit (opportunity) cost of using their free permits rather than selling them. It is true that in this scenario US steel producers receive an implicit subsidy. However, this subsidy is capped by the cost of the permits. Moreover, EU policymakers have the option of giving their steel producers the same subsidy. Trade in steel has been the subject of repeated disputes, largely arising from domestic subsidies. Our proposal does not make it any easier to solve these disputes, but it avoids introducing new complications by explicitly taking the issue of carbon subsidies off the table.

Section 4.2 considers the issue of how carbon permits should be distributed in countries that adopt a cap and trade scheme. We recommend auctioning all permits, or at least reducing over time the fraction of permits that are distributed for free. In the example here, the US's free distribution makes it politically more difficult for the EU to oppose demands for equal treatment from its domestic steel producers; but the EU auctioning makes it easier for the US to keep its free distribution within limits. Of course, in the unlikely event that nations impose a carbon tax rather than using a cap and trade scheme, this arena for contention does not exist.

To continue the example, the simplest proposal requires that exports from India into the US or EU be accompanied by carbon permits. The number of permits per tonne of steel equals to the average carbon intensity of steel production in the exporting country. This requirement can be phased in, a manner consistent with the differentiated responsibilities of developed and developing nations. One alternative is that countries that do not adopt global carbon limits must face this trade requirement after a period of time, e.g. ten years. By accepting this delay, the developing country explicitly accepts the principle that it will have to make mandatory emissions reductions in the future, or face a trade penalty. A somewhat stricter alternative requires in addition that the developing country adopt interim measures. A possibility is that the country sign the kind of agreement discussed in Section 8.4, for example a "sector no-lose target". The baseline against which the emissions credits are calculated can be chosen conservatively, thus reducing the number of credits the country obtains from the agreement. This reduction is a *quid pro quo* for temporary relief from the trade measure.

The requirement that non-compliant exporters surrender carbon permits rather than pay a border tax eliminates any tax revenue incentive for the border measure. The exporting country must purchase permits from the global carbon market. We noted above that this market is not currently fully developed. For example, although "guaranteed" permits generated under the Clean Development Mechanism should be equivalent to permits sold on the European Trading Scheme, the latter command a significant price premium (Section 8.2). If market segmentation persists, it becomes necessary to decide which type of permit must be surrendered by imports. One possibility is that the permits should be purchased in the importer's domestic market, giving the importer an added incentive to make sure that the permits are not bogus. This question should become moot as the carbon market develops.

Disputes among countries regarding trade-related climate measures may still arise. These disagreements should be adjudicated by the WTO's dispute resolution process. In these cases, the WTO panel (or the Appellate Board) must determine whether the trade measures are being used in a manner consistent with the international environmental agreement, which the disputing parties have previously signed. The rationale for involving the WTO is that it is the major forum governing international trade. If the country being required to surrender emissions permits objects to the measure, the WTO must determine whether that measure is being applied in a manner consistent with the exemption from WTO rules that the country explicitly accepted in signing the climate agreement.

6.4 Summary

The proposal outlined above uses carefully circumscribed trade measures. The border adjustment (surrender of permits) applies to products from a limited range of commodities. It exempts even these commodities when they are exported from countries that have accepted and are complying with carbon limits. It recognizes the differentiated responsibilities of developed and developing countries. It respects WTO rules and uses the WTO dispute mechanism to resolve disagreements. The limit that the proposal imposes on trade measures means that these are not likely to involve large transfers – which is as it should be. The objective is not to use trade policy to solve environmental problems (a clear violation of the Principle of Targeting), but to ensure that trade does not impede the solution of environmental problems.

7 Equity

Although developing countries' emissions have overtaken those of OECD nations, and China has become the single largest emitter of GHGs, wealthy countries have contributed disproportionately to the stock of GHGs. OECD countries therefore bear greater responsibility for causing the problem of climate change, and they are better able to make the economic sacrifices needed to solve the problem. For these reasons, rich countries should subsidize poor countries' emissions reductions.

Equity considerations will play a role in international negotiations. These considerations may be one more subject of dispute, giving all sides an excuse for failure and jeopardizing an agreement. Or they may be a matter upon which countries can reach consensus, and then use to help sell the eventual climate agreement to domestic stakeholders. Therefore, it is worth reviewing the factual basis for the equity argument and the kinds of objections raised against it.

Our policy conclusions in this section are:

- OECD countries should accept the equity argument for differentiated responsibility between developed and developing countries.
- Developing countries are not required to accept binding emissions caps during the next agreement. However, the agreement should establish the principle that in the successor agreement, beginning in the early 2020's, developing countries will face binding caps. The level of those caps cannot be specified during the current negotiations.
- The equity argument is an important part of selling the agreement to voters in the OECD countries and to decision makers in the developing countries.

7.1 Responsibility for GHG stocks

Figure 2 summarizes Müller, Höhne, and Ellermann (2007)'s estimation of shares of responsibility for emissions (including those from land use change and forestry) of CO_2, CH_4 and N_20 from 1890 to the present. They use three criteria for allocating these shares across countries. "Causal contribution" measures the aggregate shares over the period; by this measure, the US is responsible for over 25% of emissions, and China for approximately 12%. The Annex I countries have jointly contributed 54.5%.

The other two measures, strict and limited responsibility, introduce a moral dimension into the calculation. To calculate strict responsibility, the authors use the difference between a country's actual emissions and a "basic allowance" equal to the country's population-weighted share of 7 Gt C02e/year. The amount 7 Gt C02e is taken to be harmless, because it approximately

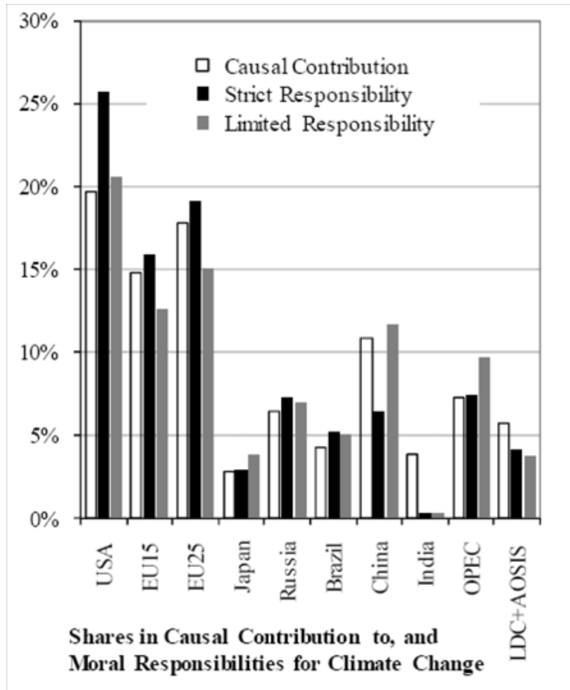


Figure 2: Müller et al's (2007) estimate of differentiated responsibility for GHG stocks

equals the level absorbed by ocean sinks. To calculate limited responsibility, the authors include only post-1990 emissions. They take this to be the year after which leaders of a country cannot claim that they were ignorant of the risks posed by GHGs. The move from causal contribution to either strict or limited responsibility nearly eliminates India's share of responsibility. The change from causal to strict responsibility greatly increases the US share and reduces China's, due to the difference in population size in the two countries. The movement from causal to limited responsibility has little effect on the two countries' shares.

Kahrl and Roland-Holst (2008) use Lorenz curves of past (Figure 3) and forecast (Figure 4) energy-related C02 emissions to measure different levels of responsibility.[12] This measure relates the responsibility for emissions to income groups rather than to nations. The horizontal axis in these graphs shows the cumulative percent population, ranked from the poorest to the richest using Purchasing Power Parity;[13] the vertical axis shows the cumulative percent emissions. Under perfect equality of responsibility, $x(100)\%$ of the population will account for

[12]The authors note that the exclusion of land use change and forestry, and the lower quality of data for non-OECD countries both cause their meaures of the inequality of responsibility to be overstated. The calculations in Müller, Höhne, and Ellermann (2007), in contrast, do include land use changes and forestry, leading to a a somewhat lower allocation of responsibility to rich populations.

[13]Purchasing power parity (PPP) exchange rates, unlike official exchange rates, make adjustments to account for the difference in cost of living in different countries. Income levels based on PPP attempt to measure differences in real rather than nominal income.

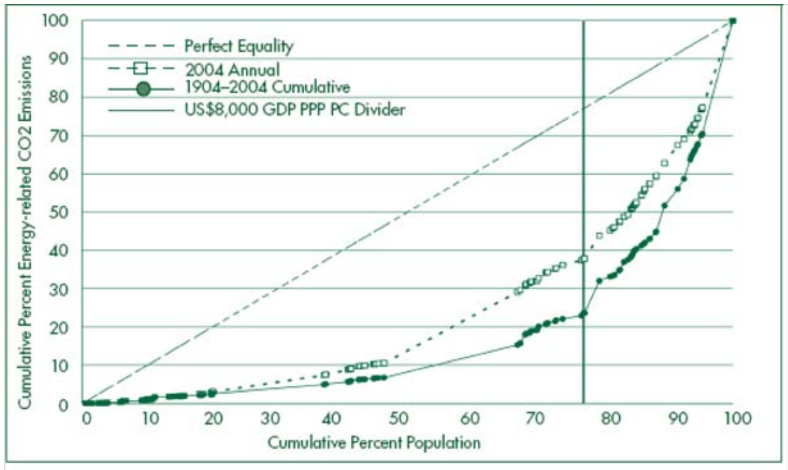


Figure 3: Lorenz curves of past emissions, from Karhl and Roland-Holst, 2008

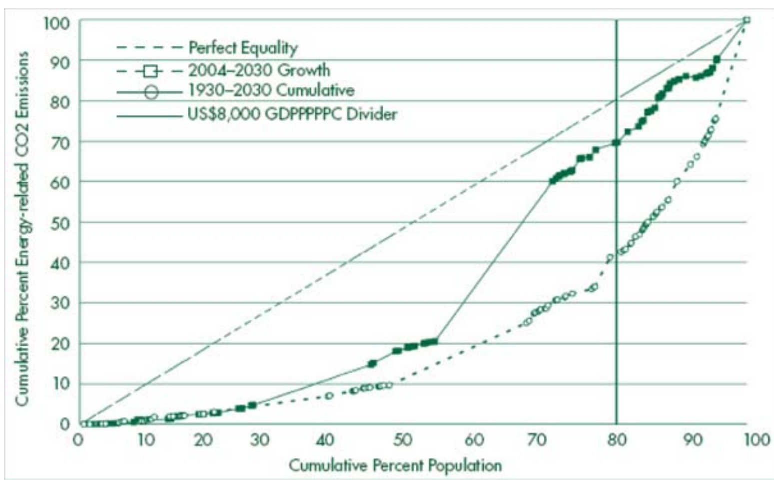


Figure 4: Lorenz curves of forecast emissions, from Karlh and Roland-Holst 2008

$x(100)\%$ of emissions, for any $0 \leq x \leq 1$. In that case, the Lorenz curve is a straight line on the 45^o diagonal. The Gini coefficient equals 2 times the area between the perfect equality line and the Lorenz curve. This index ranges from 0 (under perfect equality of responsibility) to 1 (the most extreme form of inequality, when the richest 1% of the population is responsible for 100% of emissions).

The Lorenz curves provide a means of visualizing inequality of responsibility. The Gini coefficient is an index of inequality, which can be compared over time or for different factors that affect wellbeing (e.g. income or GHG stocks). Comparison of the two Lorenz curves in Figure 3 shows that inequality of historical cumulative emissions exceeds the inequality of emissions during 2004. Because the damages associated with GHGs depend on the stock rather than the flow, historical cumulative emissions provide a better measure of responsibility.

The Gini coefficient corresponding to cumulative emissions is similar in magnitude to the Gini coefficients for income in some of the countries with the highest level of income inequality. In 2004 the richest 23% percent of the world's population accounted for 62% of global energy-related CO2 emissions.

Figure 4 uses projected emissions until 2030 to examine the effect of likely increases in non-OECD shares of emissions. The Gini coefficient corresponding to 1930 - 2030 cumulative emissions is 0.6, only slightly lower than the Gini coefficient corresponding to 1904-2004 cumulative emissions (0.64). Thus, the increasing share of emissions from poorer countries is likely to have little effect on the allocation of responsibility for GHG stocks over the next 20 years. The Gini coefficient for 2004-2030 growth in stocks is much lower, at 0.33. During this period, the richest 20% of the world's population is expected to account for about 30% of the growth in stocks.

7.2 Assessing the equity argument

Many people who raise the issue of equity accept that it provides a basis for requiring transfers from rich to poor countries, to persuade the poor countries to reduce emissions. Cooper (2008), in contrast, finds that the "concept of equity is highly dubious" and concludes that

> ...the only equity argument with enduring merit is that everyone who emits greenhouse gases from now on should be discouraged from doing so, insofar as practicable, in proportion to their emissions. The rich will and of course should pay more because they emit more per head.

His proposal for an international climate agreement excludes transfers. We summarize and evaluate the practical, moral, and economic reasons he gives for thinking that equity considerations have no role in a climate agreement.

As a practical matter, Cooper is concerned that arguments over equity would distract from progress in negotiations. ("To focus on alleged retrospective wrongs of the remote past is to assure inaction.") Although the precise allocation of responsibility for current stocks is neither possible nor important, the evidence summarized in Section 7.1 shows that the richest countries have contributed disproportionately to those stocks. The developing countries are not likely to forget this point. For the rich countries to tell them, in the context of climate negotiations, that the point is irrelevant is hardly likely to advance the negotiations. Many international agreements, ranging from the Montreal Protocol to the GATT/WTO, recognize the principle of differentiated responsibility due to differing income levels. Historical emissions provide one more good reason to invoke this principle.

As a moral issue, Cooper points out that the people who started the coal-based industrial revolution were unaware of the climate change problem, and therefore it is unfair to penalize their descendants. This observation is one rationale for the distinction between strict and limited responsibility in Müller, Höhne, and Ellermann (2007). However, it is not possible to separate the good and the bad consequences of an action. To the extent that the descendants of the early emitters benefit from those emissions, i.e. to the extent that they are currently richer than average because of accidents of birth, they should also bear more of the costs of remedying the bad consequences. Of course, the descendants incur no moral blame for the actions of their ancestors. As noted above, for some important emitters including the US and China, Müller, Höhne, and Ellermann (2007) find little difference in the degree of causal and "strict" responsibility, when the period of responsibility is taken to begin in 1990. Even if one were to accept (as we do not) that strict responsibility is a better criterion than causal contribution, the starting date for responsibility is important. Under Cooper's proposal, this date begins at the time of the next agreement.

As an economic argument, Cooper invokes the principle of ignoring sunk costs: "Economists teach that optimal decisions generally require bygones to be ignored: in this as in many areas we should look forward rather than backward and provide adequate incentives for desired behavior." The advice of ignoring sunk costs means in this context that the optimal trajectory of abatement does not depend on which nations created existing GHG stocks. The advice does not mean that allocating the cost of abatement should be independent of which nations created the stocks. The quote conflates two sound principles (ignoring sunk costs and providing incentives for desired behavior) and thereby suggests that looking into the source of the stocks is somehow an impediment to providing the incentives. In our view, rich countries' recognition of their responsibility is more likely to promote than to retard an agreement that makes possible the provision of adequate incentives for desired behavior.

Finally, Cooper mentions the principle that financing a public project requires contributions both from those who benefit most from it, and from those most able to pay for it. To the extent that developing countries are most at risk from climate change, they are prime beneficiaries of a climate agreement, and therefore should be willing to make corresponding contributions. The uncertainties regarding the danger of both climate change and abatement costs, and the differences across nations of competing demands for scarce resources, are such that we cannot hope to rank (with any precision) the benefit-cost ratios for different countries. We know that climate change is a global problem, likely to harm most if not all countries, and that the rich countries can most easily afford the sacrifices needed to reduce risks.

7.3 Summary

Deciding whether rich countries should shoulder most of the cost of GHG emissions reduction is an important part of reaching a climate agreement. Rich countries have contributed disproportionately to existing stocks of GHGs. Even though aggregate emissions by developing countries have already overtaken those of OECD countries, the latter will continue to bear major responsibility for GHG stocks at least for the next several decades.

To some commentators, the answer to the ethical question is too obvious to merit discussion. However, the review in Section 7.2 shows that the question is unsettled. The precise degree of responsibility of current stocks is a matter of debate, the answer depending on the sources of emissions (e.g. with or without land use change and forestry) and the time period. All answers, however, show that rich have greater responsibility, particularly on a per capita basis.

As a practical matter, if for no other reason, we recommend that rich countries embrace the conclusion that they have disproportionate responsibility for creating the problem of climate change. Because of this responsibility and because of their greater wealth, they must bear the largest cost of solving the problem, at least in the short term. The recognition of this point is important not only in order to avoid wasting time during negotiations, but also as a means of selling the eventual agreement to voters within the rich countries. The explicit recognition of the responsibility will also make it easier for negotiators from developing countries to convince their stakeholders that the agreement incorporates equity considerations.

Our proposal exempts developing countries from binding caps during the short life of the agreement. However, it is important that the agreement also establish the principle that developing countries will accept binding caps at the next agreement. We cannot determine the level of those caps at this round of negotiation. By accepting this principle during the current round, developing countries put themselves under an obligation to bargain in good faith at the next round. The principle may also help in selling the agreement to voters in developed countries, and it might help to establish a legal basis for trade sanctions in the event that developing countries fail to establish caps at the next round of negotiations.

8 Developing country participation

A successful climate agreement requires the participation of non-OECD countries. These countries' share of annual fossil fuels emissions increased from 46% to 51% between 1990 and 2005; the US Department of Energy estimates that this share will rise above 63% by 2030 (Figure 5). The expected growth in non-OECD emissions between 2005 and 2030 nearly

World Carbon Dioxide Emissions[a]
(billion metric tons)

	1990	2005	2010	2020	2030
World	21.2	28.1	31.1	37.0	42.3
North America	5.8	7.0	7.1	7.6	8.3
USA	5.0	6.0	6.0	6.4	6.9
OECD Europe	4.1	4.4	4.5	4.8	4.8
OECD Asia	1.5	2.2	2.2	2.3	2.4
Japan	1.0	1.2	1.2	1.2	1.2
Total OECD	11.4	13.6	13.8	14.7	15.5
Total Non-OECD	9.8	14.5	17.3	22.3	26.8
Russia	2.4	1.7	1.8	2.0	2.1
China	2.2	5.3	6.9	9.5	12.0
India	0.6	1.2	1.3	1.8	2.2
Brazil	0.2	0.4	0.5	0.5	0.6
Other	4.4	5.9	6.8	8.5	9.8

[a] From fossil fuels

Source: EIA. International Energy Outlook, 2008, Table A10

Figure 5: World CO2 emissions (billion metric tons). From Cooper, 2007

equals OECD emissions in 2005.[14] It will not be possible to achieve the reductions needed to control climate change without the participation of developing countries.

Many of the low-cost opportunities to reduce emissions are in developing countries. The IPCC estimates that 13.5 GtCO2e of emissions reductions can be achieved by 2030 at a cost of less than $20 per tCO2e, and that an additional 6.5 GtCO2e can be achieved at a cost of less than $50 per tCO2e; half of these possible reductions are in developing countries (Capoor and Ambrosi 2008). US Environmental Protection Agency (2008) estimates that by 2015 internationally traded emissions offsets would reduce the US price of carbon under the Warner-Liebermann bill by nearly 50%.

The next climate agreement should establish the principle that developing countries will face binding limits on GHG emissions in the subsequent agreement, beginning in the early 2020s. However, the successor to the Kyoto Protocol should rely primarily on voluntary means of obtaining reductions in developing countries. Here we discuss ways to engage these countries.

The conclusions and policy recommendations of this section are:

- Obtaining voluntary emissions reductions in developing countries raises three fundamental problems: measuring the emissions reductions associated with a particular action or investment, determining the compensation for that action, and financing that compensation.

[14] In 2004 total global anthropogenic emissions reached 49 GTCO2e, an increase in 25% compared to the early 90's. By 2050 emissions could triple the 2004 levels, in the absence of climate change policies (Intergovernmental Panel on Climate Change 2007).

- The Clean Development Mechanism (CDM) uses the market to solve the second two problems, but the first problem remains.

- Despite this limitation, the CDM has achieved a substantial volume of low cost reductions.

- Procedural reforms of the CDM would improve its functioning. We oppose the removal or softening of the requirement of additionality, seen as a means of enabling the CDM to scale up its activities.

- Sectoral agreements with developing countries will be a useful complement to the CDM, providing a means of scaling up emissions reduction. These agreements should be negotiated by the developing country host and an international agency whose sole goal is to obtain a large number of low cost emissions reductions (and not, for example, to promote development, as is an ostensible goal of the CDM).

- The emissions reductions should be financed by issuing emissions permits that can be sold on the international market. Our proposal for a price floor (Section 4.4) guards against the price uncertainty arising from a possible glut of permits.

- The next agreement is likely to continue to limit the extent to which developed country signatories can satisfy their obligations by purchasing emissions credits from developing countries. This limit should be generous.

- The differentiation in responsibility between developed and developing countries will persist throughout the next agreement. We doubt that it will be useful to place the richer developing countries in a special category that allows them to use a mechanism similar to the current Joint Implementation.

8.1 Basics of the Clean Development Mechanism

Under the Kyoto Protocol, the Clean Development Mechanism (CDM) is the primary means of obtaining developing country participation in emissions reductions. The CDM allows an investor in an Annex I country to subsidize a developing country project that leads to a reduction in GHG emissions, and to obtain credits for the reduction. These credits, known as Certified Emissions Reductions (CERs), can be sold on a secondary market or used to satisfy the investor's Kyoto-mandated emissions limit. The price of these credits in the primary transaction, times their number, minus transactions costs, equals the subsidy that the developing country receives for the project. The investor and the developing country negotiate the price. The CDM's Executive Board (EB) decides the number and date of issuance of credits.

The CDM's two primary stated objectives are to provide Annex I countries with a source of low-cost emissions reductions, and to provide host countries with development opportunities. CDM projects are also supposedly evaluated on their environmental impact, their contribution to technology transfer, and the equity of their geographical distribution (Maosheng 2008). Neither these secondary criteria nor the objective of development are central to the CDM. Authorization of a CDM project requires the approval of the host country, the party in the best position to determine whether the project is consistent with development objectives. There may be little additional value in stating that the project should contribute to these objectives, and it might be counterproductive if it introduces extraneous considerations into the endeavor to reduce emissions. Economic development, environmental protection, and technology transfer are intrinsically important, but the CDM's role is to achieve low cost emissions reductions. If it is worth including these other goals at all, the reason would be to try to avoid having the CDM harm any one of them. For example, we want to avoid unintended negative environmental impacts of a CDM project.[15]

However, the CDM does have one additional implicit goal whose importance is widely understood: to give the developing countries a financial stake in the global project of controlling GHG emissions. Because developing countries enter into the projects voluntarily, and because each individual project has negligible effect on global emissions, the presumption is that the host country benefits directly from each transaction. The price that the host receives for the emissions credits is in general strictly more than the amount needed to make the host indifferent between accepting and rejecting the project. Host countries therefore have a financial interest in the continuance and extension of the CDM and thus in the success of current climate negotiations.

Recognizing this, the European Commission has proposed that the number of CERs that can be used in the EU after 2012 will depend on cooperation from developing countries in the current negotiations. This conditionality is reasonable, but the Commission should have exempted CERs issued before 2012 from this limit, in order not to diminish the value of those credits and thereby reduce the efficacy of the CDM.

There are differing opinions on the success of the CDM, but widespread agreement that in

[15]Haya (2007) describes some unintended consequences associated with hydro projects. The analogy with the WTO is instructive here. The preamble to the Marrackech Agreement, which established the WTO, states that a goal is "…the optimal use of the world's resources in accordance with the objective of sustainable development." The WTO's central goal is to promote an open trading system, not sustainable development. Nevertheless, the preamble has been significant. For example, it was invoked by the 1998 Appellate Body ruling in the shrimp-turtle dispute, mentioned in section 6.2. Possibly the language promoting economic development and environmental goals in the CDM will be used to exclude projects that reduce GHG emissions but which harm the environment or economic development.

its current form the mechanism is not likely to achieve the degree of engagement needed from developing countries.

8.2 The performance of the Clean Development Mechanism

Figure 6 shows the size of the world carbon market and the relative importance of its components. The principal submarkets are the EU Emissions Trading Scheme (ETS), the primary and secondary markets for Certified Emissions Reductions (CERs) under the CDM, and the market for Emissions Reductions Units (ERUs) under Joint Implementation (JI).

The volume of primary CDM transactions was roughly constant over 2006 - 2007, although the value increased by over 27% following the rise in carbon prices in the ETS. The value of primary sales over the two year period exceeded $13 billion. A secondary market, in which aggregators sell slices of carbon portfolios as guaranteed CERS (gCERs), increased by a factor of 10. The volume of primary CDMs exceeded 25% of the size of ETS market. The 2007 average price of tCO2e in the ETS market was approximately 80% higher than the average price in the primary CDM market, and about 7% higher than the price in the secondary CDM market. These price differences reflect different levels of risk. The EU Commission's proposal to condition the post-Kyoto ceiling of CERs on developing country participation in a post-Kyoto climate agreement increased uncertainty about the future value of existing CERs, likely reducing their current price.

In 2007, China accounted for 73% of the volume of CERs. India and Brazil were the next largest providers, with much smaller shares (Figure 7). China acted as a market leader by setting a price floor on projects (Capoor and Ambrosi 2008). The CDM is intended to operate as a market, bringing together many buyers and sellers who are each too small to affect the price of CERs. However, individual transactions involve bargaining over compensation, not simply anonymous exchanges by price-taking agents. There appears to be potential for the exercise of market power in the CDM. The use of a price floor by a large seller might be evidence of market-distorting power that reduces efficiency. Alternatively, if China is facing monopsonistic buyers, then a price floor diminishes or eliminates those buyers' market power, increasing efficiency. That is, a binding price floor could either distort the market or make it more efficient. We cannot determine which is more likely, given available evidence.

To date, industrial gas projects (primarily HFC and N20) have constituted the largest source of both issued and contracted CERs (Figure 8). These projects are also the most contentious, due to questions about whether they satisfy the requirement of additionality (Section 8.3.2). However, most of the potential HFC projects have already been contracted. Consequently, the portfolio of CDM projects is likely to change significantly over the next several years, and will

	2006		2007	
	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)
		Allowances		
EU ETS	1,104	24,436	2,061	50,097
New South Wales	20	225	25	224
Chicago Climate Exchange	10	38	23	72
UK ETS	na	na		
Sub total	**1,134**	**24,699**	**2,109**	**50,394**
		Project-based transactions		
Primary CDM*	537	5,804	551	7,426
Secondary CDM	25	445	240	5,451
JI†	16	141	41	499
Other Compliance & Voluntary Transactions	33	146	42	265
Sub total	**611**	**6,536**	**874**	**13,641**
TOTAL	**1,745**	**31,235**	**2,983**	**64,035**

*: Clean Development Mechanism; †: Joint Implementation
M: million.

Figure 6: The size of the carbon market (Capoor and Ambrosi 2008)

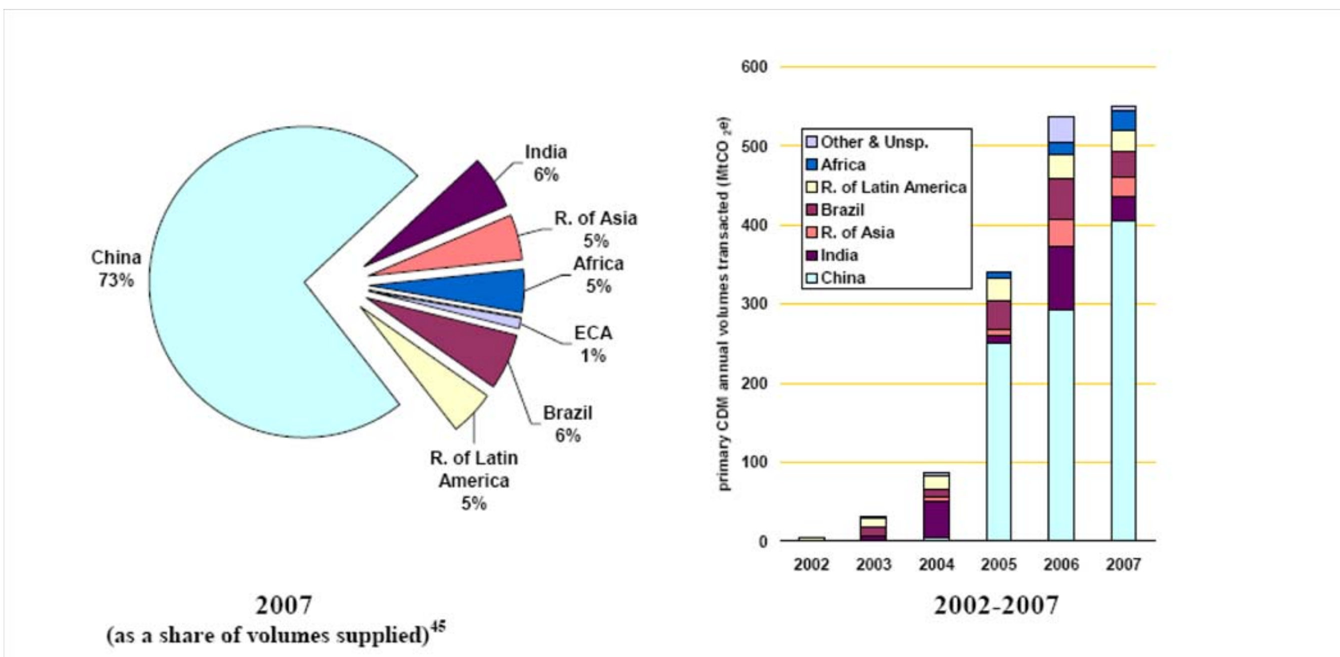
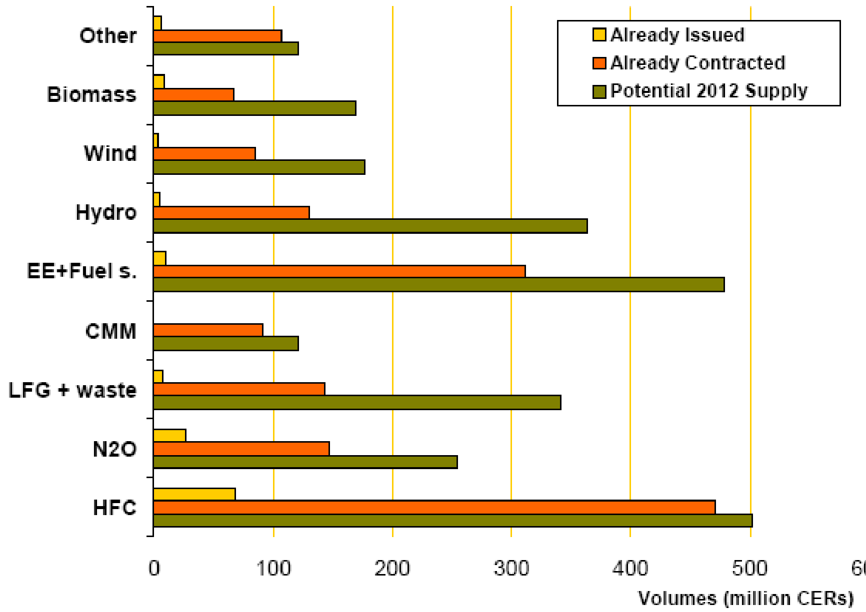


Figure 7: Sources of CDM projects (Capoor and Ambrosi 2008)



Source: J. Fenhann *et al.* UNEP Risoe CDM/JI Pipeline Analysis and Database, April 1st 2008 & World Bank.

Figure 8: Typesof CDM (Capoor and Ambrosi 2008)

rely less on HFC projects. If the problems with the CDM arose due to features peculiar to industrial gas projects, we could then expect those problems to diminish over time. However, if the problems are inherent in the structure of the CDM, there is no reason to think that time will solve them.

Capoor and Ambrosi (2008) estimate a potential 2008 – 2012 demand for carbon permits from industrialized countries of 2,485 MtC02e, with a potential supply of CDM permits ranging from 1,400 – 2,200 Mtc02e (and a point estimate of 1,600 MtC02e). These estimates suggest that the CDM is likely to be a large source of low cost emissions reductions during the Kyoto period. These authors also estimate that in 2007 the CDM leveraged $33 billion in additional investment for clean energy.

8.3 Reforming the CDM

Even the most enthusiastic supporters of the CDM recognize the need for reform. The CDM is a recent policy tool, one requiring complicated and unfamiliar decisions. It has been necessary to create the bureaucracy that administers the CDM, starting from nothing. In reviewing recent policy discussions of the CDM, several types of suggestion appear repeatedly. We mention some of the most important of these in the subsection on procedural reform. The role of additionality is a fundamental issue that we take up in the next subsection.

8.3.1 Procedural reforms

Every CDM project requires approval by both the host country and the Annex I country purchasing the permits. (Annex I countries have accepted emissions caps under the Kyoto Protocol.) The Executive Board (EB) must approve the methodology used to calculate baselines and monitor emissions reductions. Some of these methodologies have been criticized as unclear and overly complex and some have not been employed. An environmental auditor known as a Designated Operational Entity (DOE) validates the project. The EB decides whether to approve the project, after which a different DOE is responsible for verifying the emissions reductions. The EB then issues CERs to the purchaser's accounts, held in a registry. Many have noted the need for procedural reforms in the CDM (Capoor and Ambrosi 2008), (Maosheng 2008), (Streck and Lin 2008), (Wara and Victor 2008).

Commentators note the lack of transparency and predictability of EB decisions. Many board meetings are held behind closed doors, sometimes making it difficult for participants in CDM projects to understand the basis for a decision. The EB appeals process is less developed than appeals processes in many domestic regulatory settings. If dissatisfied parties begin to take their complaints to domestic courts, the result would be increased complexity and lack of uniformity across nations. The policy recommendations here include improving procedural rules to promote transparency and due process, including an appeals mechanism.

DOEs both validate CDM projects and also verify emissions reductions; the seller selects the (different) DOE for each activity. A DOE has an incentive to establish a reputation for audits that lead to successful projects, i.e. those producing a large number of CERs. This incentive creates moral hazard. Increasingly, the EB has re-examined DOE verification decisions because of questions about their legitimacy. The verification activity should be removed from DOEs and handled by an agency answering to the EB and funded by a tax on CER receipts.

The EB's lack of institutional memory may contribute to the unpredictability of EB decisions. In addition, members are sometimes overwhelmed by technical detail that exceeds their competence. Some EB board members also serve as their country's UNFCC negotiator or as managers of government CDM purchasing programs, a fact that might jeopardize their independence. Decisions are sometimes influenced by political trading rather than determined by technical criteria. All of these problems indicate the need to professionalize the EB, and to provide it with a stronger and more efficient secretariat.

Some decisions are made very slowly. For example, it takes between six months and two years to obtain approval for a new methodology to establish baselines. There are approximately 2000 projects in the pipeline and over 1000 have reached the stage of verification and certification. Only approximately 20 organizations have been designated as DOEs, and these have difficulty meeting the demand for their services. Many of the staff in these DOEs are inexperienced and lack the technical training needed for their work. An increase in the number and complexity of CDM projects threatens to swamp the capacity of both the DOEs and the EB.

In summary, the process of validation needs to be simplified and made more efficient; the EB needs to be professionalized and insofar as possible removed from political influence; and the verification process should be overseen by the EB, not by auditors hired by the project developers.

8.3.2 Additionality and the price of CERs

The nub of the disagreement about the CDM involves the issue of additionality, and the related issue of the price that developed countries pay for CERs. "Additionality" requires that a project produce fewer emissions (more abatement) than would have occurred under business as usual. In the absence of a test of additionality, the CDM would simply exchange real emissions reductions in Annex I countries for bogus reductions in developing countries. The cost to developing countries of producing bogus reductions would be close to zero, so the price of CERs would be negligible. Firms in Annex I countries facing emissions ceilings would want to buy as many CERs as allowed.

As with most "yes/no" decision problems, two types of errors arise in applying the test of additionality. Projects might be incorrectly accepted even though they do not provide additional reductions ("type I error") or they might be incorrectly rejected even though they do provide additional emissions reductions ("type II error").[16] Reducing the probability of committing one of these types of errors is likely to increase the probability of committing the other type. The design problem is that it is difficult to reduce the probability of committing both types of errors, so usually one has to make a tradeoff. Would we rather risk accepting bogus projects, thus undermining the integrity of the program, or risk rejecting bonafide projects, thus undermining the ability of the program to deliver low cost reductions? People strike different balances in answering this question, and these differences lead to fundamentally different policy recommendations. Those who think that it is most important to avoid type I errors believe that the test of additionality should be made so strict as to reduce the CDM to a niche market. Those most concerned with avoiding type II errors favor a relaxation in the test of additionality, to increase the scope of the CDM.

It is difficult to design a reliable test of additionality because it is often hard to estimate the baseline, i.e. the level of emissions if CDM credits are withheld. The logic of the financial

[16] The null hyothesis here is "The project reduces emissions".

test of additionality assumes that firms would undertake any profitable activity. A project passes this test only if the project is not profitable in the absence of CDM payments. This test is equivalent to requiring that the project entails positive abatement cost, since a profit maximizing firm does not incur unnecessary costs. The profitability of a project in the absence of CER sales therefore constitutes a *prima facie* case against additionality.

We first discuss a flaw in this logic using an extreme case where there are win-win situations, i.e. money-saving abatement opportunities *that society, firms or consumers do not exploit*.[17] The existence of a win-win situation means that absent a new policy intervention, agents will not undertake the abatement even though they would save money by doing so. Many people, particularly economists, are skeptical of the practical importance of win-win opportunities, so we also explain why the basic story does not change if we replace a win-win opportunity with opportunities having positive but low cost.

Figure 9 shows how the requirement to pass the financial test of additionality affects the allocation of abatement between developed and developing countries, and the emissions permit price. This figure assumes that there is fixed amount of required abatement, and that there are win-win opportunities in both groups of countries. The length of the horizontal axis, ab, represents the fixed amount of abatement (relative to the BAU level). This abatement can be undertaken in either OECD (or Annex I) countries or in developing countries. For example, the point d indicates that OECD countries carry out the amount of abatement equal to the length of the segment ad and developing countries carry out the amount of abatement equal to the length of the segment db. A movement from point d toward point e means that abatement shifts from OECD to developing countries.

The solid curve shows the marginal abatement costs in the OECD and the dashed curve shows the marginal abatement cost curve in developing countries. For both sets of countries, marginal abatement costs increase with the level of abatement. Both curves show that marginal abatement costs are negative for small levels of abatement, representing win-win situations. The efficient allocation of abatement requires that marginal abatement costs be equal in the two regions. The efficient allocation is for the OECD countries to carry out ad units of abatement and developing countries to carry out db units of abatement.

However, the first cb abatement units in the developing countries are win-win – the developing counties lower their costs by undertaking this abatement. Developing countries "should"

[17] Win-win situations exist, although there is considerable controversy over their importance. They typically arise because agents have inadequate information or cannot obtain certain kinds of insurance, or due to some other market failure. US Department of Energy (2008) states that over a two year period, simply providing firms with information on how they can reduce their energy bills led to actual savings of $125 million and potential savings in excess of $863 million, with actual emissions reductions of 7.4 Mt C02. Roland-Holst (2008) estimates that past California energy efficiency regulations, e.g. for appliances, saved households $56 billion during 1972 – 2006.

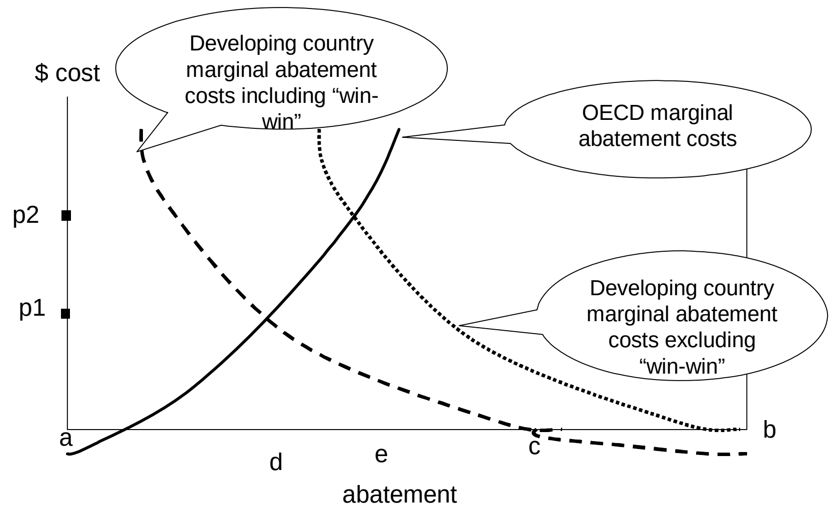


Figure 9: The equilibrium allocation of abatement and the equilibrium price, depending on the additionality requirement

be willing to carry out this abatement even in the absence of CDM payments, but the definition of “win-win” means that they would not do so. Those abatement activities fail the financial test of additionality. If they are disallowed under the CDM, the developing countries’ marginal abatement cost curve shifts to the right by the amount cb. The dotted curve shows the new marginal abatement cost curve, which excludes the win-win situations. Excluding the win-win projects increases OECD abatement from ad to ae, with a corresponding drop in developing country abatement, and an increase in the marginal cost of abatement from $p1$ to $p2$. The total cost of abatement also increases, indicating the reduction in efficiency.

Consider now the situation where the abatement opportunities are not literally win-win, but instead have small positive abatement costs, as is the case with many projects in developing countries. If it were possible to measure exactly the abatement costs, these projects would pass the financial test of additionality. In fact, costs are measured imperfectly; based on these measurements, the decision maker (perhaps implicitly) constructs a probability distribution for costs. A strict test of additionality requires that actual costs are positive with high probability. In the presence of measurement error, such a test is more likely to reject a low cost project than a high cost project. However, the low cost projects are precisely the ones that the CDM is designed to capture.

An important criticism of the CDM is that industrial gas projects produced a large fraction of CERs, as noted in Section 8.2. These projects were inexpensive or might have resulted in cost savings (i.e. were win-win); some of them might have been undertaken even in the absence of CDM payments.[18] If the projects would really have been carried out in the absence of CDM payments, then it is unfortunate that they passed the additionality test, because by doing so they caused bogus reductions to replace actual reductions, and they led to a financial transfer from Annex I to developing countries (primarily China) that did not achieve its objective.

However, if the industrial gas projects would not have been undertaken in the absence of CDM or a substitute program, the evaluation changes. One of the arguments in favor of the CDM is that it creates a market that brings together many buyers and sellers who are individually too small to manipulate the price. A virtue of the market is that, when it operates reasonably efficiently, firms use low cost opportunities for abatement before using higher cost opportunities. The fact that a large percentage of early CDM projects were low cost projects might be construed as evidence that the CDM was operating as a market should, not a sign of failure.

A related objection to the industrial gas projects is that they were too expensive. Wara and Victor (2008) state that Annex I countries paid €4.7 billion for CERs from these projects, which involved abatement costs of only €100 million. If CDM critics grant that the projects would not have been undertaken in the absence of Annex I intervention, they might still object that the Annex I countries paid too much for the CERs and in that respect the CDM was an inefficient subsidy (Wara 2007).

One response to this criticism is that it ignores a basic requirement of efficiency. In terms of Figure 9, the efficient allocation of the fixed amount of abatement is at point d where the marginal cost of abatement is the same in both regions, and equals the market price of permits $p1$. In a market setting, all agents pay or receive that price. *All* of the inframarginal permit sellers (firms in the developing countries with abatement costs strictly below $p1$) are paid "more than they need"; this "overpayment" is greater the lower are the firms' abatement costs. However, it is also true that *all* of the inframarginal buyers (firms to the right of point d, whose abatement costs are strictly greater than $p1$) pay "less than they are willing"; this "underpayment" is greater the higher are the buyers' abatement costs. Economists refer to this "overpayment" and "underpayment" as "surplus". A virtue of efficient markets is that they maximize the sum of buyer and seller surplus. Maximization of this surplus is equivalent to minimization of total abatement costs – obviously a desirable outcome.

Whenever a competitive market setting involves an upward sloping supply curve and a downward sloping demand curve, there is surplus. The distribution between buyers and sellers of the surplus is a transfer that does not affect efficiency. The fact that developing countries

[18] In some cases the gas plants may have been built in order to take advantage of the opportunity, created by the plants' existence, of earning CDM credits. This situation is one of the most extreme examples of getting the baseline wrong.

obtained substantial surplus from some CDM transactions is not necessarily a basis for criticism of the CDM.

However, the magnitude of the transfer – nearly €4.6 billion according to Wara and Victor (2008) – is eye-catching. Perhaps Annex I countries would have had more resources to spend on other abatement projects had they not made such large payments for the industrial gas projects. If the Annex I countries had a fixed abatement budget, and if the objective was to maximize the amount of abatement subject to this budget constraint, then there is an efficiency argument for paying as little as possible for each project. In this case, it is optimal for the regulator to pay the marginal cost for each project, i.e. to act as a discriminating monopsonist (a buyer with market power) *vis a vis* abaters in developing countries.

We noted that an implicit but widely recognized goal of the CDM is to give developing countries a financial stake in the success of international climate policy negotiations. To the extent that CER buyers are able to act as monopsonists *vis a vis* developing country sellers, the cost to Annex I countries of satisfying emissions ceilings decreases, but the financial benefit to developing countries of participation in the CDM also decreases. The CDM therefore becomes less useful as a bargaining chip to induce developing countries to make other, costly, concessions.

For this reason, it is probably not desirable – even if it were practical – for Annex I countries to extract all of the surplus from CDM transactions by paying only the abatement cost. However, Annex I countries are buying a public good; unnecessarily large payments for this good might undermine political support for the transaction. With the benefit of hindsight, it would have been a good idea to exclude from CDM a class of low cost abatement opportunities, such as the industrial gas projects, and to have bargained separately over the compensation for their undertaking. There is a great deal of room for negotiation over compensation when costs equal €100 million and willingness to pay equals €4.7 billion.

Wara and Victor (2008) and Haya (2007) provide another example of the limitation of the CDM. China is currently constructing new sources of energy at a rate sufficient to produce total US capacity within a decade. Virtually all of China's clean energy projects (hydro, wind and natural gas) are applying for CDM. Each of these projects in isolation displaces energy produced by more polluting and cheaper methods, and on those grounds appears to satisfy additionality. However, it seems implausible that none of these projects would have been built in the absence of CDM subsidies. This example suggests that many bogus projects might pass the test of additionality.

In other circumstances, the financial test of additionality might exclude legitimate projects. Collecting and analyzing the information to perform this test often involves significant costs. We noted that the test may be more likely to reject the projects for which the economic gains of acceptance are greatest. Due to measurement problems and other limits on information, higher abatement costs make it easier to establish additionality. But economic efficiency requires that we undertake low cost projects before high cost projects. The test of additionality might select the wrong projects, leaving the low hanging fruit. The prominence of industrial gas projects in the CDM portfolio shows that some of the low hanging fruit has been captured, but the absence of major CDM programs to reduce emissions in transportation (Sanchez 2008) and energy use (Niederberger 2008) indicates that other low hanging fruit remains.

Individual CDM projects typically involve a small number of parties. The CDM has not been successful in achieving emissions reductions where there are many small polluters, or where reductions would require substantial changes in government policies (e.g. energy policies). In the former case, the transactions cost are too large and the benefits too diffuse. In the latter case, the needed policy change cannot be achieved by negotiations between a government and a private firm interested in obtaining abatement credits.

The transport sector is a good example of the limitations of the CDM. Only two of the more than 1100 CDM projects (as of November 2008) involve transport, and three of the five transport sector methodologies approved by the EB have not led to any projects (Sanchez 2008). The "Berlin Strategy" for transport proposes reforms and new programs within the CDM and a new financing instrument outside the CDM.

Emissions in the transport sector are diffuse, making it impractical to contract separately with the many polluters. In addition, the value of carbon credits would be small compared to the investment cost of a public project such as construction of a mass transit system, making it extremely difficult for this project to pass the test of additionality. The GHG abatement benefits of such projects are perhaps greatest in developing countries where the data is poorest, making it difficult or impossible to conduct the kind of cost benefit study required by the financial test of additionality.

One of the several reforms suggested by the Berlin Strategy is to include the ancillary benefits, e.g. increased mobility and improved health due to reductions in pollution, in the cost-benefit analysis of transport projects. To the extent possible, all benefits and costs should be included in the calculation used to decide whether to undertake a project. However, it would be a mistake to introduce these kinds of considerations into the CDM process, which is already strained by the demands of evaluating a large number of highly technical proposals. The narrow focus of the CDM is a virtue. It is hard enough to determine whether a project will lead to GHG reductions. Attempting to make this determination while factoring in the magnitude and importance of health effects or the value of increased mobility makes a difficult job impossible. The CDM should not become another aid or public works agency. Sanchez (2008) recommends that the "current CDM process should be made more attractive for project proponents and investors by ... removing or minimizing barriers, such as the additionality requirement." By the nature of the decision problem, the financial test of additionality leads to both type I and type II errors. We conclude from the evidence suggests that it would be a mistake to weaken the test.

There are several more subtle problems with the financial test of additionality. They all arise because of the difficulty of measuring baseline emissions. Suppose for example that a firm can choose the status quo, with profits 10, action 1 with profits 11, or action 2 with profits 12; action 1 has the lowest emissions, and is the one that society would like to induce using the CDM. The correct baseline is action 2, since this has the highest profits and is the choice the firm would make in the absence of CDM payments; with this baseline, action 1 meets the financial test of additionality. However, since the firm has not yet made this choice, it might appear that the correct baseline is the status quo. With this baseline, action 1 does not meet the financial test of additionality, because action 1 has higher profits than the status quo. This example illustrates the difficulty of identifying the right baseline, a problem that can arise whenever there are more than two possible choices.

As a second example, suppose that there are only two options, the status quo and adoption of a new low emission technology. The new technology has higher *expected* profits than the status quo, but those profits are uncertain; they might be lower under the new technology. If the firm expects to get better information about the new technology in the future, it might want to delay adoption until the arrival of that information. It might nevertheless be socially optimal to adopt the new technology immediately, because of the benefits of reduced emissions. The new technology fails the standard financial test of additionality, because it is profitable (in expectation) even without the CDM payments. Again, the financial test of additionality gives the wrong answer because it uses the wrong baseline; the correct baseline is "continue using the old technology while awaiting information about the new technology", but a simple comparison of the expected profits suggest incorrectly that the baseline is "adoption of the new technology".

In all of these cases, the test of additionality is flawed because it is difficult or perhaps impossible to identify the correct baseline. The test has to balance the risk of rejecting bonafide and accepting bogus projects. The nature of the decision problem implies that both of these types of error will occur. We caution against efforts to weaken the test of additionality in an attempt to finance a larger number of bonafide projects. A related issue is that even if the test correctly identifies a bonafide project, the market sets the price of the CERs. The price therefore depends on the cost of the high cost (marginal) projects. If this price is vastly higher than the abatement cost of the inexpensive projects, the transfer to the seller is large. The large transfer and the increase in the overall cost of emissions reductions might erode support for the CDM within developed countries. When we can identify a class of low cost projects, it may make sense to exclude these from the CDM and achieve the emissions reductions using a sector agreement (Section 8.4).

8.4 Broadening the scope of developing country abatement

There are several proposals for replacing or complementing the CDM with mechanisms to increase the scale and the scope of developing country abatement. Ward (2008) discusses the use of “Sector no-Lose Targets”, which set sectoral emissions targets in developing countries and reward the host country for exceeding the goal. Baron, Reinaud, Genasci, and Philbert (2007) describe sectoral approaches for iron and steel, aluminium and cement. Victor (2008) proposes a sectoral approach that he calls the Climate Access Deal (CAD), in which a developing country negotiates a range of reforms, financed at least in part by OECD countries. These reforms would satisfy the country’s obligation under an international climate agreement. Victor provides detailed examples of potential agreements, especially in China and India.

It is unlikely that a single model will fit all of the different ways of promoting developing country participation in reducing emissions, and we encourage the construction of a portfolio of approaches. Here we address three central questions: (i) Should a mechanism target policy reform or emissions level? (ii) Should a mechanism target a sector, cutting across national boundaries, or should it be restricted within a nation? (iii) How should the mechanism be financed?

There are two broad approaches to measure a country’s contribution to reducing global emissions. First, we might identify policies, such as subsidies for energy consumption, or trade restrictions that promote carbon-intensive domestic fuel over cleaner imported fuel. The agreement might stipulate a particular set of reforms of these policies, and reward the country depending on the extent of its actual reform. The alternative measures a country’s level of emissions relative to a baseline, and bases the reward on the difference between the two. Fischer and Morgenstern (2008) provide a comprehensive comparison of these alternatives.

An advantage of using policy-based targets is that these tend to transfer risk from the developing country to the global community; the later may be better able to tolerate this risk. The developing country has considerable control over its trade and subsidy policies. It has less control over the actual level of emissions. If the developing country’s reward is based on emissions, it faces a high level of risk, since its reward might depend on factors beyond the country’s control, e.g. the success of new technology. It faces little risk if its reward is conditioned on the policies that it does control.

The countervailing argument is that emissions depend on the policies that the country implements, not those on the books. The international agency overseeing the agreement may have difficulty in monitoring the enforcement level. Many countries have strict environmental policies that are honored in the breach. It might be easy to circumvent a policy-based agreement by making reforms and either not implementing them or using other policies to offset their effects.

There are other practical reasons for preferring an emissions-based agreement. We would like to have a basis for comparing abatement efforts and achievements across countries. This kind of comparison can never be exact, but it is much harder under policy-based agreements. Evaluation of the effects of policy changes rely on models (e.g. computable general equilibrium or engineering models) that quantify the effect of policy reform on emissions levels. These models are complex, making them difficult for anyone other than the model-builder to understand and evaluate. The model results are also likely to be sensitive to assumptions and parameter choices that have limited empirical grounding. These considerations make the modeling exercise vulnerable to special interests and make it hard to reach consensus. Although these kinds of models have an important role in helping us to think through the likely effects of policy reform, we discourage relying on them to evaluate a country's contribution to the goal of emissions reductions.

We can finance the emissions-based agreement using the sale of emissions reductions credits, as under the CDM, and as described below. In order to finance a policy-based agreement we would need to create a large international fund, making direct transfers from that fund to the country. Alternatively, we could translate the policy change into emissions units which are then sold; that process requires using economic models to estimate the emissions reductions due to policy changes, a suggestion that we oppose.

Emissions-based targeting requires a baseline. We discussed above some of the difficulties of constructing these for smaller projects. There will be different kinds of problems in obtaining baselines for the sort of broad-based activities we are interested in here, where what matters is the aggregate level of emissions for a collection of projects, not the emissions of a single project. In some cases, it will be possible to use statistical data to build forecasts of future BAU emissions (the baseline). For example, Auffhammer and Carson (2008) demonstrate the power of econometric methods in forecasting China's GHG emissions.

It is important that the international agency that regulates these programs (call it "Agency for Reduction of Emissions in Developing countries" or ARED as a placeholder) have a professional staff of applied econometricians to produce these estimates. A blue-ribbon panel of energy economists and econometricians should be convened to determine the statistical methods that are to be applied. These statistical methods correspond to the "methodologies" used to assess baselines in the CDM. The ARED professional staff, guided by the findings of the blue-ribbon panel, produces the estimates, replacing the DOEs of the CDM. The blue-ribbon panel must also provide approved methodologies for estimating baselines where statistical data is not available.

The data and programs used for the estimates should be made available to interested parties, including the country whose baseline is being estimated, and environmental NGOs. The former want to see a high baseline estimate in order to increase the eventual estimate of emissions reductions, and the NGOs want to be sure that an exaggerated baseline does not lead to bogus emissions credits. These interested parties should be allowed to file "friend of the regulator" briefs, after the fashion of *amici curiae* in legal proceedings, helping to maintain a high level of conduct by the ARED staff. In cases of major disputes ARED's executive body is able to call on a panel of outside experts, similar in caliber to members of the blue-ribbon panel.

We do not want to understate the difficulty of estimating the baseline, or to exaggerate the ability of a blue-ribbon panel to set out exactly the methodologies that should be used. For example, baseline emissions estimates are likely to be sensitive to parameters such as the baseline rate of adoption of new technologies or processes, or the rate of technical progress. These parameters cannot be precisely estimated. We cannot hope to produce precise estimates, but we can at least strive for neutrality and transparency.

The professional ARED staff must be technically more highly qualified than the average staff in the DOEs, increasing administrative costs. However, the cost of each baseline estimate will be spread over a much larger volume of reduction, relative to CDM projects, so transactions costs per unit of reduction should be much lower here.

As with the "sector no-lose target" proposal, the developing country should receive a number of emissions credits that depends on the difference between measured emissions and the baseline. The credits would be maintained in a registry until the country that owns them decides to sell them. The developed country signatories, those with mandatory targets, should be able to use these credits in the same way as CERs.

The impossibility of precisely determining the baseline means that the developing country might receive either more or fewer credits than it "deserves". Because we never observe the contrafactual baseline, it is not possible to determine even *ex post* whether the country received too many or two few credits. If the world community decides that the danger of overestimating the baseline is greater than the danger of underestimating it, the estimated value might be decreased by, for example, 10%, so that the country does not obtain excessive credits. Alternatively, the number of credits might be capped.

A different kind of risk occurs because the actual level of emissions is a random variable, i.e. the developing country cannot control it exactly, or at least cannot do so with costs that are known *ex ante*. It is possible to reduce both the developing country's and the world community's exposure to this kind of risk by putting a floor and a ceiling on the number of credits that the country receives. However, there should be a substantial range between the floor and the ceiling, so that the developing country has a strong incentive to take actions that reduce emissions.

It might also be desirable to adjust the baseline in a manner that takes into account trade issues. Section 6.3 recommends that countries that do not adopt national emissions ceilings be required to surrender emissions permits that accompany their exports of carbon-intensive commodities. An alternative relieves a developing country of this obligation if it signs and adheres to a sector no-lose target. The baseline can be adjusted downward (thus reducing the number of credits) to reflect the added value to the developing country of this sectoral agreement.

Section 8.3.2 describes the two types of error, and the corresponding risks, when applying the test of additionality under the CDM. Sectoral policies offer a means of dealing with these risks and also the possible problem of "excessive" payments for low cost abatement. It might be desirable to exclude from the CDM a group of investments such as the industrial gas projects or the clean energy projects in China, because of the uncertainty of additionality and/or because of the large difference between the market price and the abatement cost. The number of credits that ARED awards to the host can reflect the uncertainty or the low cost. For example, suppose that the clean energy projects in China reduce expected emissions by 5% of a baseline, but there is an estimated 50% chance that these reductions are not really "additional". Under the CDM, the EB is supposed to make a binary decision, resulting in either zero credits or credits equal to 5% of the baseline. ARED has the discretion to reduce the number of credits, e.g. by allocating half of the 5% of baseline to account for the uncertainty of additionality. Similarly, in the case of the industrial gas projects, it might reduce the number of credits to account for the low abatement costs.

In principle, the EB could be given the same kind of discretion to make adjustments under the CDM, but that would be a poor remedy. The EB should continue to be responsible for developing technical criteria and seeing that the criteria are applied fairly. The CDM should continue to allow the price of CERs to be set by the cost of marginal projects, even when this means that those CER sellers with low abatement costs obtain large rents. It is not practical to require the EB to apply technical criteria and avoid political influence, and also give it the kind of discretion proposed for ARED. Whereas the EB is supposed to function as a neutral market regulator, ensuring the "quality" of CERs, ARED is supposed to act as an agent that bargains with developing country governments in an effort to obtain low cost reductions in emissions. In this bargain, it considers both the uncertainty of additionality and the size of payments. ARED's charter should contain language ensuring that its actions do not cause unacceptable environmental damages or harm to vulnerable populations. However ARED's brief is to obtain a large number of low cost emissions reductions. ARED finances these reductions by awarding

Production, market concentration and trade in aluminium, cement, iron and steel

	Aluminium (2004)		Cement (2005)	Steel (2005)
	Primary	Secondary		
Total production (Mt/year)	29.9	7.7	2,284	1,130
% traded	75%		6%	32%
Share of 10 largest firms	54%		< 25%	26.4%
Emissions				
Total emissions (MtCO2 eq.)	391		1,930	2,165
% total GHG emissions	0.9%		4.6%	5.2%

Source: IISI, 2006; Watson et al, 2005, Vieillefosse, 2006.

Figure 10: Production, markeet concentration and trade in aluminium, cement and steel. From Baron et al (2007)

CERs.

This suggestion for financing the no-lose sector target introduces considerable uncertainty into the CER market. Each CDM project is small relative to the aggregate, so the success or failure of any one project would have negligible effect on the price of CERs. However, there is great uncertainty about the number of permits that will result from a sectoral contract, and those permits compete directly with the CERs. This uncertainty is an added reason to impose a price floor on CO2e permits, as discussed in Section 4.4.

The possibility of using sectoral policies that cut across countries has also been widely discussed. A small number of sectors, including aluminium, cement and steel are among the most likely candidates for these policies. Trade is important in identifying the candidates because of concerns about loss of competitiveness and carbon leakage. Trade accounts for a high fraction of aluminium and steel production, and these industries are quite concentrated; trade in cement is significant, and cement produces a large fraction of GHG emissions (Figure 10).

Cross country sectoral policies might impose production or intensity standards, which might differ for OECD and developing countries. The standards in OECD countries might be additional to or in lieu of other constraints, such as a ceiling on emissions. The expenses needed to satisfy the standards in developing countries would have to be subsidized by an international fund. Using a cross-country sectoral policy appears to be relatively straightforward, a major source of its appeal. Low emission technologies/processes are identified and the industry is induced to use these.

In the interest of pursuing as many avenues as possible to achieve reductions, we do not discount this kind of policy. However, it appears that we can obtain most if not all of its advantages by using a combination of other policies discussed here. We can achieve emissions reductions in OECD signatories using a cap and trade system or an emissions tax. We can achieve emissions reductions in developing countries by using either the CDM or a variant of the sector no-lose target policy discussed above. We can use trade policy, as discussed in Section 6, to allay concerns about carbon leakage and loss of competitiveness, and to nudge developing countries toward adoption of cleaner production methods.

We have already described some reasons for skepticism regarding policy-based targeting. It might be difficult to insure that policy reforms are really implemented, and that they are not undercut by offsetting policy changes elsewhere in the economy. It is certainly difficult to measure the emissions reductions associated with a policy change.[19] Unless we measure those reductions, and give the developing country marketable credits for them, we need a substantial international fund to finance the reforms. Creation of that fund presents a significant challenge. We would not like to see an international climate agreement rest on the success in meeting that challenge.

Despite these caveats, policy-based targeting has a role in international climate negotiations. This paper emphasizes the importance of quantitative targets, but negotiations cannot be reduced to a string of numbers – even a very long string. Countries should be encouraged to reform policies that are economically inefficient and that lead to high emissions. It is important to know all the steps that a country has taken to reduce its GHG emissions. In the give and take of negotiations, this information provides the context in which we evaluate success in reaching numerical targets. Both developing and developed countries should maintain an inventory of policy reforms. That inventory can include assessments of the quantitative effects of those reforms; but those assessments will always be received with a grain of salt.

8.5 Limits on OECD imports of emissions credits

The Kyoto Protocol imposes limits on the extent to which Annex I countries are allowed to use CDM and JI credits to satisfy their emissions targets. A "morality-based" argument asserts that rich countries should not be able to "buy their way out of" the need to reduce emissions.

Arguments with an apparent economic rationale invoke some kind of market failure. For example, OECD countries may not capture learning by doing that is external to the firm, if domestic firms can satisfy their targets by importing permits. These kinds of arguments should

[19] It is substantially more difficult to measure emissions reductions associated with a policy reform than to measure the baseline needed to calculate credits under the sector no-lose targets. In the former case we need to estimate emissions in the absence of a policy reform – which is equivalent to estimating the baseline with the sector no-lose target. In addition, we need to determine how the policy affects emissions. That determination is much harder than simply measuring actual emissions. After all, policies are merely one of many determinants of emissions.

be countered by a request to identify the exact market failure, and then to explain why a trade restriction (on emissions permits) is the appropriate remedy. The Principle of Targeting, discussed in Section 6, makes the point that there are usually more efficient means of correcting market failures.

In addition, market failures exist both in OECD and developing countries. The same kind of market failure that causes the equilibrium with trade in emissions permits to lead to too little OECD abatement and therefore too much trade in emissions permits, might also cause this equilibrium to lead to too little abatement in developing countries, and therefore too little trade in permits. The interaction of these market failures might cause the (second-best) optimal trade policy to encourage rather than to restrict imports of permits from developing countries.

General economic principles do not support limits to OECD purchases of abatement credits from developing countries. However, such limits will almost certainly be part of any international climate agreement. Provided that a substantial level of imports is allowed, we think that the economic costs of the limits are of relatively unimportant. Since the limits are likely to enhance public support of the agreement, we endorse the limits.

These limits have the potential to raise trade disputes under WTO rules, if owners of CERs are restricted from importing them into signatories with mandatory emissions reductions. This problem seems minor, but as a matter of caution the agreement should stipulate that every signatory is allowed to restrict the import and export of emissions permits to whatever extent it wishes. Since only signatories have any interest (or ability) to trade these permits, this stipulation will remove the matter from WTO oversight.

8.6 Graduating countries from the CDM to the JI

Murphy, Cosbey, and Drexhage (2008) discuss a partial replacement of the CDM with the JI. This proposal imposes aggregate emissions restrictions on middle-income developing countries, such as China, and allows them to use the JI mechanism to sell permits. These countries "graduate" from their current status to that of middle-income signatories. This proposal uses the initial allocation of permits, with the opportunity for subsequent trade, as a side payment to induce countries to accept targets. Russia would have been unlikely to have joined the Protocol in the absence of this kind of transfer.

There may be future cases where permit allocation and the option to trade can be used to encourage membership. However, we think that it should not play an important role in promoting membership in the next agreement; we recommend using the CDM or the kinds of extensions discussed in Section 8.4 as means of achieving efficient reductions in emissions.

A simple example shows why the CDM (or sectoral agreement) can achieve the same outcome as that obtained using the side payment via trade. Suppose that two groups of countries, A and B, would each produce 200 units of emissions under business as usual, and that the efficient way to reduce total emissions by 100 units is for each group to reduce emissions by 50 units. Members of Group A (the developed countries) agree to set a ceiling of 100 units of emissions, thereby achieving a 100 unit reduction. Under the CDM or a sectoral agreement, group A can pay group B (the developing countries) to achieve a 50 unit reduction, and achieve the balance of the target domestically. Alternatively, suppose that the two groups both join the agreement, and they split the total allocation of 300 units of emissions permits in such a way that, after trade, members of Group B have the same level of welfare as under business as usual. In this example, the first alternative has only group A agree to reduce emissions, and it uses the CDM or a sectoral agreement to achieve the efficient allocation; the second alternative uses the allocation of permits together with trade to induce group B to agree to reduce emissions. The outcome is the same.

This example shows that the CDM or sectoral agreement can achieve the same efficient outcome as using allocation and trade to induce membership. One might argue that there is an inherent advantage in having group B commit to a binding emissions ceiling, possibly as a means of promoting increased participation in the future. There are offsetting reasons for preferring the continued reliance on the CDM or on sectoral agreements. Countries that accept a mandatory ceiling, together with the opportunity to export permits, face a downside risk caused by the uncertainty of the future price of permits and the future abatement costs within the developing countries. This risk is diminished or absent when developing countries negotiate a collection of CDM or sectoral projects. The fact that CDM projects or sectoral agreements can be negotiated individually and over a period of time, rather than at the time that the international climate agreement is signed, improves information and reduces uncertainty.

There may also be a public relations advantage to induce developing country to participate using the CDM or sectoral agreements, rather than a large allocation of permits together with the right to sell these. In either case, transfers from developed countries finance the developing country participation. If developing countries are induced to join by means of the allocation of permits and trade, it will be apparent to citizens and politicians in the rich countries that they are paying the developing countries for the right to emit GHGs, a right they previously enjoyed for free. This recognition might undercut popular support for the agreement. To the extent that developing countries obtain surplus in a CDM transaction or sectoral agreement, there is also a payment from the rich to the developing country. These kinds of payment may be less likely to produce public outcry in rich countries. They are more diffuse and they have the character of a payment for services; the sale of credits obtained as an inducement to ratify the agreement looks more like the sale of something that the buyer previously gave to the seller.

We do not yet know the public response to the cross country transfers that will likely be required from a meaningful international agreement. There appears to be little public awareness of CDM transfers. Ellerman (2008) estimates that in 2006 the value of the UK's net import of emissions credits from the ETS equaled £350 million, about one tenth of one percent of the value of its imported goods and services for that year. A British anti-EU organization attempted to use UK payments as evidence of the costs of EU membership, but that campaign was not successful. From a public relations standpoint, it is better to have firms rather than governments make payments, and these should be represented as payments for inputs – as indeed they are – rather than as subsidies or development aid.

8.7 Summary

A successful agreement requires substantial emissions reductions in developing countries. The CDM has generated a large volume of low cost emissions reductions. Procedural reforms would enhance the CDM, but we oppose the removal or softening of the requirement of additionality. One or more alternative mechanisms, such as a within-country sector no-lose target or cross country sectoral targets are needed in order to scale up the emissions reductions. These mechanisms should be funded primarily through the sale of emissions permits. OECD countries are likely to retain limits on the import of emissions credits from developing countries; we should be sure that these limits are generous. We discourage attempts to induce a country to accept a binding ceiling by means of offering a generous ceiling and the opportunity to export permits.

9 Land use, land use change and forestry (LULUCF)

Land use change, especially deforestation, is a major contributor to GHG emissions. In 2004 deforestation and decay of biomass was the third largest source of anthropogenic GHG emissions, smaller than energy supply and industry but larger than transportation, contributing over 17% of the total emissions (IPCC (2007), Figure 2.1). Deforestation, especially tropical deforestation, is more prominent in developing nations, with most deforestation occurring in South America, Africa and Southeast Asia ((IPCC 2007), Chapter 9). LULUCF also represents a low cost way of reducing carbon emissions; Eliasch (2008) estimates that including the forest sector in a trading system could halve the cost of a 50% reduction in emissions by 2030. Nepstad et al. (2007) estimate that over 90% of Amazonian deforestation could be avoided at a cost of $5/tC02e, a fraction of abatement costs in developed countries. Lal, Kimble, Follett, and Cole (1998) estimate that the U.S. cropland's overall potential of carbon sequestration is 75-208

MtCO2e/year, approximately 1-3% of 2007 total U.S. emissions of GHGs.

Several features of LULUCF make it different from mitigation measures in other sectors. Forestry and soil serve both as sources and sinks of GHG. As sinks, one of their most distinctive features is *non-permanence*: biomass and soil carbon sequestration is reversible. Tree cutting and biomass decay release the sequestered carbon; the amount and time path of released carbon depend on the end use of the wood products. Some actions, such as burning the wood, immediately release carbon, but in most cases the release occurs years after a tree is cut. Carbon sequestered in agricultural soils through conservation tillage can be entirely released when the farming practice switches back to conventional tillage. Consequently, the flow of carbon removal through sequestration activities such as afforestation and reforestation differs from that arising from other mitigation measures, such as switching to clean fuel. In the latter case, a unit of carbon that is not released during a period is permanently "removed" from the atmosphere. However, a unit of carbon sequestered in a forest can be released in the future if the tree is burnt, or cut and the wood eventually decays. Thus, a ton of carbon sequestered is different from a ton of carbon avoided through other mitigation measures.

The rate of carbon sequestration is non-constant and is subject to the influences of natural forces beyond human control. On a typical sequestration path, the initial rate is low, gradually picks up, and then decreases until it reaches the saturation level, after which the rate could become negative (i.e., carbon starts to be released). The growth rates of trees and crops and thus the carbon flow are also influenced by forces of nature such as rainfall, temperature, and fire. The relationship between sequestration activities and carbon flow is complicated and uncertain, and it is difficult to separate the human from natural causes of changing carbon flows.

There are two broad categories of LULUCF activities, afforestation and reforestation (A/R) and reducing emissions by decreasing deforestation and forest degradation (REDD). Our principle policy conclusions are:

- Sellers rather than buyers should bear the risk arising from the impermanence of emissions reductions under both A/R and REDD.

- A reformed CDM may be able to capture the benefits of A/R activities. A treaty that relies on the CDM for this purpose should encourage aggregators to package the temporary CERs in order to reduce risk and provide a homogenous product. Sectoral agreements can also achieve A/R benefits.

- Substantial REDD activities will require sectoral agreements. These agreements should be negotiated by the host and an international agency whose sole objective is to obtain a large number of low cost emissions reductions – as distinct, for example from having development objectives.

- If both A/R and REDD use sectoral agreements, then the goal should be to link these closely, by means of a national inventory of LULUCF emissions.

9.1 LULUCF under the Kyoto Protocol

Due to their special features, the Kyoto Protocol treats differently the GHG emissions and removals from LULUCF and from other sectors. For Annex I nations, Article 3.3 of the Kyoto Protocol requires mandatory accounting for net GHG emissions (or removals) due to human-induced land use changes and forestry activities since 1990, but limits these activities to afforestation, reforestation and deforestation (ARD). Article 3.4 expands, on a voluntary basis, the included LULUCF activities to cropland, grazing, land and forest management, and revegetation. The accounting rules are also different for Articles 3.3 and 3.4 activities. ARD uses "gross-net" accounting, which measures changes in carbon stocks during the commitment period. Article 3.4 activities uses "net-net" accounting, measuring the difference in the emission and removal amounts in the current relative to the base year.

The CDM includes only limited LULUCF activities for developing nations, namely afforestation and reforestation (A/R). The treaty caps the Annex I CDM credits from A/R to an average of 1% of the country's base year emissions. The first commitment period (2008-2012) does not allow credits for reducing emissions from deforestation and forest degradation (REDD) due to concerns about accounting and monitoring methodologies and leakage.

Partly due to the non-permanence of carbon sequestration, the credits an Annex I nation obtains from an A/R CDM project are temporary, and must be renewed or replaced by new credits after a specific period. Temporary CERs (tCERs) expire at the end of the commitment period following the period during which the credits are issued. Long-term CERs (lCERs) expire at the end of the crediting period, usually 20 years with a renew option or 30 years without a renew option. An A/R project is examined every five years during the crediting period to determine whether the forest still exists (Hohne, Wartmann, Herold, and Freibauer 2007) . Buyers of the credits assume the liability of replacing the credits with new ones if the forest is destroyed. Buyer liability and the temporary nature of the A/R credits lead to lower prices of A/R credits: they are worth about 25% of CERs from other sectors (Eliasch 2008). The number of A/R projects in CDM has also been extremely low, accounting for less than 1% of all CDM projects in the pipeline and about half percent of potential 2012 CERs (Rocha 2008).

9.2 Impediments to capturing LULUCF reductions

LULUCF projects in CDM share many of the problems with other CDM projects, including high (in most cases, higher) transaction costs, difficulty in establishing additionality, and un-

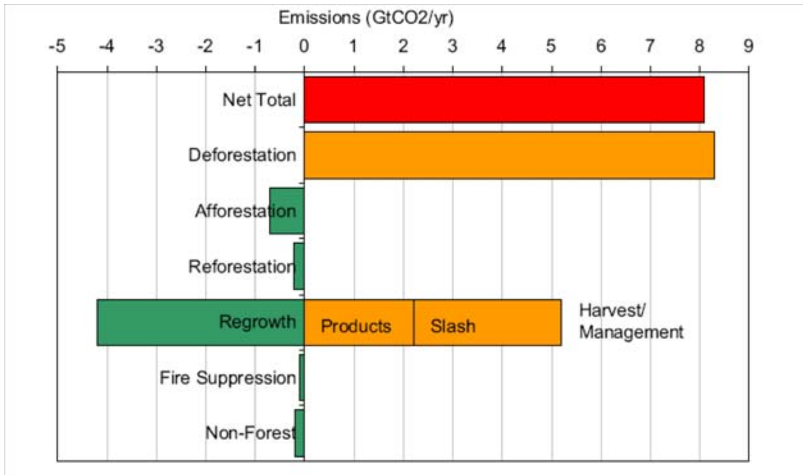


Figure 11: Sources of Emissions from Global Land Use Change 2000 (Figure 2, Annex 7.f, Stern (2007))

certainty regarding future credits. The following limitations of the CDM are especially relevant for LULUCF:

- Narrow scope of included activities, particularly the exclusion of REDD. This limitation is especially important, given the much higher scale of GHG emissions from deforestation than removal from A/R activities (Plantinga and Richards 2008), (Schlamadinger et al. 2007). GHG emissions from deforestation are eight times as large as the removal from A/R. (Figure 11).

- Temporary credits and uncertainty about future reversal of sequestered carbon contribute to the lukewarm acceptance of A/R credits. The EU-ETS does not accept these credits. The extremely small number of A/R projects means that the CDM misses many low cost mitigation options in developing nations.

In response to the first criticism, COP11 in 2005 initiated a two year study on expanding LULUCF activities to include REDD, and the Bali roadmap in 2007 proposed creating incentives to finance reductions of LULUCF emissions.

The next climate agreement should broaden the scope of LULUCF activities included without undermining the integrity of credits generated through CDM. The agreement should include and encourage REDD in addition to A/R activities in developing nations. The scale of deforestation is larger than A/R, especially in developing nations: during 2000-2005, the world forest area decreased at an average rate of 7.3 million ha per year, with most of the decrease occurring in tropical areas including Africa (at 4m ha/year) and South America (at 4.3m ha/year) ((IPCC 2007), Table 9.1). More importantly, at least in the short run, the carbon mitigation benefits from reducing a hectare of deforestation are greater than those from a hectare of A/R. Tropical forests also provide rich ecosystem services such as biodiversity.

The next agreement needs to resolve several important design issues in order to capture the benefit of REDD and to provide accurate carbon crediting. REDD has much higher potential for intra-country and inter-country leakage than A/R and mitigation measures in other sectors. Enforcement of a logging ban in one place increases incentives for logging (including illegal logging) elsewhere. For example, China banned domestic logging in 1999 in response to a series of severe floods in 1998 that resulted from deforestation. "Myanmar ... was soon to fill the void created by Beijing's ban, followed by Indonesia, Malaysia and Papua New Guinea, among others" (Macan-Markar 2006). China's log import jumped from 4.8 million cubic meters in 1998 before the ban to 10.1m m^3 in 1999 and 13.6m m^3 in 2000 ((Sun, Katsigris, and White 2004), Figure 2).

The lack of alternatives for logs used in wood products creates a high potential for leakage in deforestation. When carbon policy increases the cost of coal, a firm can replace coal with natural gas or renewable energy inputs. These substitutes moderate the cost increase caused by the carbon policy and reduce the potential for leakage. However, REDD activities in one developing nation, and the lack of substitutes for logs, greatly increase the incentive for logging elsewhere.

The next agreement must provide a set of principles and guidelines to specify the methodologies used to calculate the baselines and to establish additionality if a project based approach is adopted. The amount of REDD equals emission reductions from *avoided* deforestation and degradation, relative to what would have happened without the policy intervention. This net-net accounting method differs from the gross-net approach adopted for A/R activities. A/R credits equal the amount of carbon sequestered, calculated by comparing carbon stocks before and after A/R activities. This accounting method is more straightforward and less controversial, but is not appropriate for calculating REDD credits. A/R removes carbon, using land as a sink, while deforestation and forest degradation lead to GHG emissions. In this regard, REDD resembles mitigation measures in other sectors that produce CERs for mitigation activities, measured against a baseline or contrafactual without the intervention from CDM. IPCC (2000) presents a starting point towards guidelines and methodology for calculating the baselines.

Both REDD and A/R face the problem of non-permanence. Asset fixity of many mitigation investments in other sectors causes an initial investment to create, with high probability, future reductions in GHG emissions. For example, a clean fuel plant continues to use clean fuel once the plant is built. In contrast, a project that avoids deforestation (e.g., by subsidizing eco-tourism or farming on existing land areas) needs to be maintained in order to prevent future destruction of the forest. Current investment in REDD does not guarantee future credits, requiring continuous investment in the future. Non-permanence leads to uncertainties about future credits from REDD projects and reduces demand for REDD CERs. It also means that avoided carbon might not be fully credited after the initial investment and project approval.

The success of REDD projects requires actions of many small scale local land users, and is thus more susceptible to the tragedy of commons. Local land users participate on a voluntary basis only if the expected benefits of participation overcome their opportunity costs and the inertia of past practices. In some cases, success also requires preventing illegal logging, further increasing the costs of monitoring and enforcement.

9.3 Alternatives for the next agreement

The project based approach under CDM has not succeeded in generating buyer interests in A/R projects and CERs and it excludes REDD. Schlamadinger et al. (2007), Rocha (2008), and IPCC (2007) (Chapter 9) suggest a number of reforms to increase emissions reductions from LULUFC, that would reduce the transaction costs by simplifying procedures, increase certainty of future commitments, and build buyer and investor confidence and capacity.

For A/R activities, non-permanence rather than leakage presents the greatest challenge. Procedural reform should therefore target non-permanence and its impacts on the liability of A/R CER purchasers. We recommend transferring liability from buyers to sellers, and using "aggregators" to scale up A/R activities

The main reason for assigning liability to buyers, as under the current system, is that their location in Annex I countries makes it easier to "collect" if the A/R project does not fulfill its promised reductions: the buyer has to replace the CER when it becomes invalid. Sellers enjoys a kind of "limited liability", making it harder to collect from them. The remedy is to make sure that this limited liability is large enough to avoid moral hazard. The seller receives tCER credits at regular intervals, e.g., five years, during the lifetime of the A/R project. An audit at the beginning of each interval verifies compliance, e.g. the presence of trees. The seller receives tCERs for the next interval only if the project passes the audit. Any overpayment from the previous interval is a debit against future activities by this seller. Since the seller is in a much better position, compared to the buyer, to ensure compliance, the seller should bear the liability.

To reduce transaction costs and to scale up A/R activities, the new agreement should encourage aggregators to contract with multiple A/R projects in order to form portfolios that offer long-term carbon credits at a scale sufficiently large to be transacted in international carbon markets. A long-term credit is backed by a sequence of tCERs, with the aggregator assuming liability of replacing tCERs at their expiration by new tCERs, CERs, or other carbon credits.

(This system already exists to some extent with the gCERs discussed in Section 8.2.) Certified auditors, hired by the EB, regularly examine aggregators' portfolios to check the authenticity of carbon credits. If an aggregator includes a large number of A/R projects in a portfolio and if it does not imbed a bias that either exaggerates or understates the carbon savings, the law of large numbers implies that the portfolio faces a smaller level of reversal risk.

The US has successfully used aggregation of carbon credits from short-term soil sequestration projects that are traded at the Chicago Climate Exchange. Some project developers have developed portfolios of emission reduction projects for many years and gained considerable experience. For instance, Ecosecurities (at http://www.ecosecurities.com), a publicly listed project developing and consulting company, has portfolios containing up to 118 million carbon credits, and has helped develop several hundred CDM projects. Aggregators provide a mechanism of transforming A/R credits into credits that are homogeneous to credits from other sectors in the CDM.

Whereas procedural reform of the CDM might raise the demand for A/R activities, project based approaches are probably not appropriate for REDD activities. The transaction costs associated with REDD projects are likely to be higher than A/R projects, since the former involve many small land users, are easily reversible, and require enforcement against illegal logging. Non-permanence is also a greater problem, leading to more uncertainty about future credits. In addition, a REDD project needs to be compared with a baseline or contrafactual that is difficult to establish on an individual basis. The higher potential for intra-country and inter-country leakage further erodes the value of REDD CERs. Sectoral agreements are more effective in solving all of these problems.

As with the non-forestry sectoral agreements such as transportation, calculation of REDD credits requires a baseline – the level of emissions in the absence of policy intervention. All the difficulties in calculating this baseline discussed in Section 8.4 arise here. In addition, nature's influence in determining emissions from deforestation and degradation, the tremendous degree of heterogeneity both within and across national borders in the types of forests and management practices, and the many types of human drivers of deforestation and degradation, all combine to exacerbate these difficulties. The problems of estimating this baseline effectively rule out a project based approach.

The level of the baseline affects the distribution of surplus between buyers and sellers, not the efficiency of using REDD. Developing country hosts and an international agency of the sort described in Section 8.4 should negotiate compensation for REDD activities, and this compensation should be financed by sales of emissions credits having the same value as CERs. The extremely low cost of emissions reductions from LULUCF means that the potential surplus to be shared by buyers and sellers is large. The international agency and the developing country host should be able to strike a bargain that ensures, at least with high probability, that there is additionality, and also provides adequate compensation for the host.

The sectoral agreement should establish an explicit mechanism to guard against future resumption of deforestation and degradation. One possibility is to adopt a mechanism similar to tCERs: issue short term payments or credits on fixed intervals (e.g., five years), with future payments/credits contingent on future auditing results. Alternatively, a portion of payments/credits can be reserved as insurance against future deforestation and degradation.

Although sectoral agreements can help avoid intra-country leakage, inter-country leakage still poses a serious problem unless all developing nations with significant REDD potential participate. For nations that participate in CDM but not sectoral agreements on REDD, the privilege of CDM and technology/adaptation assistance should be linked to the absence of such leakage. As with other sources of carbon leakage, trade measures such as border tax adjustment and the requirement to submit carbon credits of exports of wood products can be applied. The fact that the international agency is a principal in negotiating the sectoral agreements, rather than merely an arbiter, helps in preventing one nation from using REDD activities occurring elsewhere to improve its own bargaining position – a different kind of leakage.

The EU has announced a continued ban on A/R CERs (generated by the CDM) in phase III (2012-2020) of the ETS.[20] In addition to concern about the integrity of the permits, the EU is worried about the possible glut of permits in the market. Our proposal for a price floor (Section 4.4) guards against that danger. If the EU ban persists, sectoral agreements could be used to promote A/R activities in developing nations. Following the inclusion of A/R in the Kyoto Protocol, signatories made progress in areas of accounting, monitoring methodologies, baseline methodologies, and reporting guidelines, further helping the implementation of sectoral agreements for A/R (IPCC 2000).

If the next climate treaty uses sectoral agreements for both A/R and REDD, it becomes necessary to specify the linkage between the two. At one extreme, the national inventory (NI) approach completely links the two sectoral agreements. The NI approach “accounts for any measurable changes in terrestrial carbon” (Plantinga and Richards 2008); it compares a nation’s total estimated carbon stock in each year with a national target stock. NI sets a combined target, merging REDD and A/R activities into one package, which can also include other activities such as agricultural soil carbon sequestration. Deficits or surpluses from REDD and A/R can offset each other.

At the other extreme, the two sectoral agreements can be completely de-linked or weakly linked. If a developing nation signs on to one sectoral agreement, e.g., an A/R agreement, net emissions from A/R activities are calculated, without necessarily accounting for changed emis-

[20]Revised EU ETS Directive, http://ec.europa.eu/environment/climat/emission/ets$_{p}ost2012_{e}n.htm$

sions from deforestation and degradation. The de-linked approach allows different accounting rules and different values of REDD and A/R credits.

Each type of linkage has advantages and disadvantages. Given that both REDD and A/R involve land use changes, it is natural to link the two types of activities. In a de-linked system, a nation may decide to opt out of one “hard" sector and participate only in the “easy" sector, creating the potential for cross-sector leakage. On the other hand, a de-linked system promotes development of sector-specific guidelines, methodologies, and accounting rules. A failure in implementing one sectoral agreement need not undermine the implementation of the other sectoral agreement. When the international community has different degrees of capacity to implement A/R and REDD agreements, a system in which the two sectoral agreements are imperfectly linked might be appropriate. Our judgement is that if the agreement achieves A/R by means of a sectoral agreement (rather than a project based method) then there should be some linkage between A/R and REDD sectoral agreements at the beginning of the new treaty. As implementation capacities for REDD and A/R activities become comparable, the two should be closely linked using national inventories

Partly because of the influence of natural forces beyond human control, measuring GHG emissions from deforestation and forest degradation is complex and filled with uncertainties. The same problem arises for other sectors (Section 8.4) but may be much greater with LULUCF. Benndorf et al. (2007) propose that sectoral commitments involve policy reforms rather than GHG emissions targets. These “cause-oriented” commitments help developing countries establish regulatory capacity and policies that address not only GHG emissions but also other domestic needs such as development and adaptation. We are less optimistic that cause oriented commitments will lead to much concrete progress towards REDD. In many nations, environmental failures arise not because of the absence of environmental policies but the lack of effective enforcement. Due to moral hazard, the incentive to enforce major changes in land use is weak without concrete emission goals.

We therefore recommend that sectoral policies use emissions measurements. Emissions can be estimated using remote sensing technologies coupled with ground level land-based or activity-based measurements (Plantinga and Richards 2008), (IPCC 2000). The measurement data can also help separate human-induced changes from natural events. The key is to maintain transparency and consistency across nations. A technical committee should continue working to develop and apply measurement methodologies.

9.4 Summary

A reformed CDM may be able to incorporate A/R activities, but we doubt that this mechanism will generate substantial REDD activities. The latter are likely to rely on sectoral agreements. Sellers should bear the risk arising from the impermanence of reductions under both A/R and REDD. If the agreement uses the CDM or some other project based mechanisms to achieve A/R, then aggregators should be encouraged to package tCERs into credits that have the same value as CERs from other sectors.

Where sectoral agreements are used, an international agency should bargain with developing country hosts over compensation for reforms. The compensation should be financed by awarding the host country emissions credits, which have the same status as CERs. It is necessary to estimate a baseline to compare with observed emissions in order to calculate the number of emissions credits. The fact that emissions reductions are very cheap in LULUCF means that they generate a great deal of economic surplus, and therefore it is especially important to obtain them. The low cost also means that it is possible to choose a conservative baseline, one that insures that the reductions are genuinely "additional" and that the compensation does not lead to "excessive" transfers to the host country.

If signatories use sectoral agreements to achieve both A/R and REDD, the goal should be to link these using a national inventory. Initially, the two sectors might be imperfectly linked.

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