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A Proposal for the Design of the Successor to the Kyoto Protocol

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Abstract

The successor to the Kyoto Protocol should impose national ceilings on rich countries' greenhouse gas emissions and promote voluntary abatement by developing countries. Our proposal gives signatories the option of exercising an escape clause that relaxes their requirement to abate. This feature helps to solve the participation and compliance problems that have weakened the Protocol. We support the use of carefully circumscribed trade restrictions in order to reduce the real or perceived problem of carbon leakage.

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Abstract

A Proposal for the Design of the Successor to the Kyoto Protocol

We recommend that the successor to the Kyoto Protocol (“Kyoto II”) impose mandatory ceilings on rich countries’ greenhouse gas emissions and that it promote the participation of developing countries. Our proposal requires two major changes to the current Protocol, the use of an escape clause and the potential use of trade restrictions. The agreement must be seen as fair to developing nations. These countries will be subject to disciplines that prevent them from undermining the agreement in the short run, and they will be required to accept the principle that they will have to reduce emissions in the longer run. International trade in emissions permits plays a modest role in our proposal. The agreement should not attempt to prescribe the national policies (e.g. cap and trade or taxes or a hybrid) used to achieve reductions.

The escape clause gives signatories the option to reduce their abatement, provided that they pay a penalty. We discuss two mechanisms for imposing this penalty, either a monetary fine or WTO-sanctioned trade restrictions. The escape clause option is similar to the often-discussed “safety valve”, in that it puts a ceiling on actual abatement costs, thereby reducing the expected costs and the risk of membership. The escape clause proposal also helps to solve the problem of inducing nations to join the agreement and of inducing members to comply with their commitments. The severity of the (implicit or explicit) fine increases with the number of members. Therefore, a potential member’s decision to join the agreement increases other members’ incentive to abate. This added leverage promotes membership, helping to solve the participation problem. The absence of institutions that compel signatories to carry out their commitments has weakened the Kyoto Protocol. Our escape clause proposal addresses the enforcement problem by transforming an exotic commitment (reduction of emissions) into a familiar requirement (payment of an international financial obligation or adherence to a trade commitment). Institutions currently exist to help enforce these kinds of international commitments.

Developing nations are not required to reduce emissions in Kyoto II, which should be in force for no more than a decade. However, in order to be eligible to participate in the Clean Development Mechanism, developing nations are subject to trade disciplines that prevent them from undercutting signatories’ emissions reductions. Within developed countries, potential “carbon leakage” is either perceived as a problem or is used as an excuse for inaction. Kyoto II should allow nations incurring abatement costs to make border tax adjustments in order to minimize carbon leakage. We think that carefully designed trade disciplines can reduce the danger of leakage, removing it as a political obstacle, without undermining the current trade regime. We also see trade restrictions playing a role in pressuring developing nations to commit in principle to reducing emissions at a future round of negotiations, following Kyoto II.

1 Introduction

The primary design objectives of the successor to the Kyoto Protocol (“Kyoto II”) are to promote nations’ participation in and compliance with an agreement to reduce emissions. If nations do not sign the treaty, or if they sign it and then honor it only in the breach, other design details are irrelevant. The treaty must also set goals that at least approximately balance the costs and benefits of action, and provide mechanisms to reach these goals efficiently. The design of Kyoto II should be simple, so that nations are presented with a clear choice. Ultimately, the solution to the global problem of climate change will require a measure of compulsion; therefore, it is important that the design of Kyoto II is perceived as fair.

The design of Kyoto II begins with the recognition that control of climate change is a global public good. Nations’ sovereignty limits the possibility of compelling them to join an agreement and also limits the ability to compel them to comply with an agreement that they have joined. These limitations make it necessary to design the agreement so that it is in a nation’s interest to participate and to comply. It is also necessary to set the stage for future compulsion.

The following are the key ingredients to the proposed design:

- Developed country participants face mandatory country-specific ceilings on greenhouse gas (GHG) emissions, as under the Kyoto Protocol.
- The agreement covers a relatively short time span, no more than a decade; it makes commitments only about actions taken during that time period but sets out broad goals for subsequent periods.
- Developing countries are not required to make costly changes during Kyoto II but they face restrictions and incentives to ensure that they do not undercut the measures that developed countries take to reduce emissions. Developing countries are also put on notice that they will face obligations – not only opportunities – at the next round of climate change negotiations.
- Signatories to Kyoto II are protected from unexpectedly high abatement costs by being entitled to exercise an escape clause. The availability of this clause also promotes participation in the treaty and helps to solve the problem of enforcement.
- Exercise of the escape clause requires payment either of a monetary fine, or it triggers trade sanctions by other signatories – an act consistent with current World Trade Organization (WTO) law.
- The escape clause acts as a safety valve, putting a cap on a signatory’s costs of complying with Kyoto II.

- The treaty accepts the principle that by the next round of climate negotiations (following Kyoto II), WTO trade law will be made consistent with measures to prevent non-signatories from undermining the actions of signatories, and possibly also as a means of inducing non-signatories to join the next agreement.
- The treaty supports the continued development and use of the Clean Development Mechanism (CDM) and Joint Implementation (JI).
- In Kyoto II, the allocation of permits together with internationally tradable permits is not to be used as a means of providing a side-payment to induce membership (as was done under the Protocol to induce Russia's membership). The CDM and JI provide the primary means of taking advantage of opportunities for low-cost emissions reductions.
- In view of the randomness of abatement costs, the treaty allows international trade in emissions permits to achieve efficiency. The treaty also recognizes the potentially perverse effects of such trade.
- Together with the CDM, the JI, and international purchases or sales of permits, signatories can use any combination of domestic policies, e.g. command and control, cap-and-trade, and taxes, to achieve their targets. This decision is a domestic issue.
- The treaty encourages voluntary steps and agreements among parties outside Kyoto II, but recognizes that these are not substitutes for a multinational agreement with mandatory reductions.

Our objective is to provide an outline of the successor to the Kyoto Protocol, without attempting an exhaustive description. For example, we do not discuss the evolution of the CDM, although we recognize the importance of renewing it in Kyoto II. Other topics, such as carbon capture and the development of biofuels are also important, but they involve too great a level of detail to be included in the design of Kyoto II. Aldy and Stavins (2007) discuss other proposals for Kyoto II, some of which provide greater detail on issues that we ignore.

2 Mandatory ceilings

Kyoto II must involve mandatory country-specific ceilings on GHG emissions *to guarantee the environmental outcome of the agreement*. The objective is to achieve meaningful reductions in these emissions, not to provide politicians with an opportunity for self-congratulation. Our collective ability to reach this objective is uncertain, but as long as there is a chance we should pursue it.

We recognize the role of voluntary methods, and of agreements among small groups of countries, e.g. recent US efforts to promote technology transfers outside the Kyoto Protocol. Similar efforts should be encouraged, but they should not become substitutes to the kind of concerted multinational action needed to address the problem of climate change. Without mandatory ceilings for individual nations, there will be less incentive to engage in voluntary reductions, technology transfers, and other worthwhile goals.

Pessimists conclude that such an effort is doomed because of nations' inability to cooperate. Optimists think that the effort is unnecessary, either because the danger of climate change has been exaggerated, or because "win-win" alternatives will make it cheap to deal with the problem. The scientific consensus finds a high probability of a significant danger of climate change. The existing inefficiencies may be so large that major reductions in GHG emissions can be made cheaply. These kinds of win-win situations are far more likely to be identified and exploited if policymakers' minds are concentrated by mandatory ceilings.

We do not understate the difficulty of negotiating, ratifying, and enforcing a meaningful agreement on mandatory ceilings. The bulk of our design proposal addresses these difficulties.

3 The length of the agreement: response to new information

The agreement should last eight to ten years. This period is long enough to achieve real gains, and its brevity has two major advantages as well as several minor ones. First, it takes into account the *uncertainty and new information* surrounding both climate change and the costs of reducing greenhouse gas emissions. Second, it recognizes that there will likely be changing responsibilities across the developed and developing countries.

Climate science has improved over the past decade, but there is still disagreement about safe levels of greenhouse gas concentrations. Businesses making investments that last several decades need to adopt a planning horizon much longer than our proposed length of Kyoto II, and they would like to know the future pecuniary costs of carbon emissions. However, it is not possible for an international agreement to determine those distant costs. Instead, Kyoto II should provide a convincing signal that the world community is capable of taking measures to combat this global danger. A successful international agreement with a short duration sends a more powerful signal of this ability than does a sprawling and weak agreement. It is better to establish the principle that the world community can respond to science, rather than to attempt to predict today what the science will be ten years from now.

The costs of achieving any given level of greenhouse gas (GHG) abatement depends on the development of new technologies and on the success of institutions (e.g. markets). There is perhaps as much uncertainty about these future economic costs as there is about the envi-

ronmental costs caused by the accumulation of GHG stocks. The optimal trajectory of GHG emissions depends on the balance of economic and environmental costs.

The best that the current generation can do is to use current estimates of these costs, and of the uncertainty surrounding them, to calculate an optimal trajectory of emissions. Many “integrated assessment models” (IAMs) have undertaken this exercise, typically with a time of step of a decade. Kyoto II should seek to achieve the initial level of emissions (i.e. the level in the first time step) proposed by a “consensus” of these models. For indicative purposes only – not as a commitment – the agreement should specify the target level of GHG concentrations in 50 and in 100 years associated with this first step. This information promotes transparency and helps firms make long run plans; it is analogous to the kind of information that the US Federal Reserve provides. The short duration of Kyoto II provides a means of setting an efficient goal, given our current understanding of climate science and technology.

The second major reason for a short duration is that it makes it easier to incorporate changing responsibilities between the developed and the developing countries. For reasons discussed in the section on Fairness, developing countries are exempt from commitments during Kyoto II, but this exemption does not extend beyond that time. Kyoto II should establish the principle that developing countries will have to become engaged in the future, but not be too specific about the details of that engagement. A short-lived agreement makes it easier to establish the principle and retain the ambiguity.

There are secondary reasons for preferring a short-lived agreement. Climate change arises from the stock of GHGs, not from the emissions in any single period. The central role of stocks rather than flows makes the climate change problem inherently dynamic: the optimal policy is a trajectory of emissions, rather than the level of emissions in a given period. This dynamic feature might appear to militate in favor of a long-lasting agreement, contrary to our proposal for a short agreement. However, the commitment (or “time consistency”) problem creates an overwhelming argument for a short agreement. Society’s tendency to procrastinate in solving difficult problems is even greater than that of individuals: witness the inactivity in the US concerning the reform of social security or Medicare.

A long-lasting agreement magnifies society’s temptation to defer emissions reductions. In some cases this delay is socially optimal, e.g. when it results from the anticipation of improved technology. However, we want to design Kyoto II to resist the tendency to procrastinate. Instead of viewing the problem of controlling climate change exclusively as a dynamic optimization problem, it is useful to also think of it as a dynamic game amongst a succession of generations (Karp 2005), (Karp and Tsur 2007). The current generation can choose its own action. By altering the stock of GHGs and the institutional infrastructure that it bequeaths its successors, the current generation can influence future generations’ actions, but it is not able to

choose those actions. A short-lived Kyoto II is a means of forcing the current generation to recognize its limited influence on the actions of future generations. The short duration makes it impossible to score political points or to salve our consciences by promising to undertake costly actions in the future. Instead, we can only decide what actions we will take in the present.

A short agreement is also easier to negotiate and allows nations to learn and improve the design of future agreements. In theory, an agreement that specifies what will be done in future contingencies may be attractive. However, this degree of detail is not practical and it also undermines the objective of simplicity. We can envisage many different dimensions across which we might achieve simplicity. For example, we could focus on particular sectors or provide targets for particular types of fuel or offer certain kinds of taxes and subsidies. The uncertainty and the time consistency problem described above favor achieving simplicity by making the agreement short. Within that constraint, we should be as ambitious as is politically feasible, consistent with current estimates of costs and uncertainty.

Several General Agreement on Trade and Tariffs (GATT) rounds preceded the establishment of the WTO. The benefit of international trade was probably more widely accepted than is the importance of action on climate change. The GATT rounds achieved limited objectives and created the institutional infrastructure that led to a more ambitious trade agreement. We anticipate that several Kyoto-style rounds will precede the establishment of a comprehensive and long-lasting agreement to control climate change.

4 Fairness and distributional equity

Industrialized countries should bear most of the near-term costs of reducing greenhouse gas emissions, for three reasons. First, climate change likely arises from the accumulation of GHG stocks, which are a by-product of the process that led to current levels of wealth. Second, rich countries are better able to pay for the needed emission reductions, conducted either by rich countries themselves or by developing countries (through CDM).

Third, climate change policy requires a two-pronged approach: abatement to reduce the potential climate-related damages, and adaptation to reduce the consequences of climate changes that occur. The abatement costs will arise in the near run, and the bulk of the adaptation costs will arise in the future, when and if major climate change actually occurs. The inability of the current generation to commit to future policies means that it is impractical for the rich countries to promise to discharge their moral obligation by requiring their children and grandchildren to pay for adaptation within developing countries in the future. The current generation in the rich countries must bear the cost today of reducing emissions. For this reason, our proposal for the design of Kyoto II includes mandatory ceilings on emissions levels, but it does not include

mandatory steps for adaptation (e.g. sea walls).

A focus on adaptation efforts at this time would be a distraction from the goal of achieving emissions reductions. It would raise questions that cannot presently be answered, e.g. determining whether a specific problem is related to GHG concentrations. It might give some countries political cover, tempting them to agree to contribute to future adaptation efforts while rejecting mandatory emissions ceilings. Introducing negotiations on adaptation complicates an already complicated agenda. We want to help simplify this agenda by focusing on the most urgent goals.

The emphasis on fairness has a practical implication. The acceptance of primary responsibility for causing the problem does not imply an open-ended commitment to bear all the costs, for all time, of its remedy. Kyoto II must set the stage for achieving the cooperation from developing countries that is needed to stabilize greenhouse gas stocks at a safe level. The rich countries should reaffirm their primary responsibility for the problem and accept that they are best able to pay to begin to solve it – a recognition explicit in the Kyoto Protocol. However, unlike the Protocol, Kyoto II should establish the principle that developing countries will in the future be obliged to undertake actions to reduce greenhouse gas emissions, and their current actions should prevent serious leakage from happening.

The asymmetry is striking. Rich countries have the responsibility to act immediately to reduce climate-related risks. However, they retain considerable bargaining power in the game that determines the form and the extent of the developing countries' cooperation. By taking action today – as distinct from making unenforceable promises to act in the future – rich countries position themselves to strongly influence the institutional structure that will promote future participation and compliance by all countries, and also to prevent non-participants from undermining the agreement (“leakage”). These institutional changes will involve reforms in trade law, discussed in Section 6

Diplomats will find more agreeable language in which to couch this asymmetry, but there should be no doubt of its existence. The US in particular has made developing country participation a *sine qua non* of its own engagement. The next US administration might soften that stance, but obtaining agreement from Congress will likely still require developing country participation. In any case, success in managing climate change does require developing country participation, and there is little prospect that rich countries would agree to the massive transfers that would be needed in order to buy this participation.

Developing countries, particularly China, India and Brazil, should be signatories of Kyoto II, in a special category as under the Kyoto Protocol. The primary cost to developing countries of participation is their acceptance of the principle of future obligations to reduce emissions. A secondary cost is that they bind themselves to trade disciplines needed to prevent leakage.

Membership also entails the responsibility to establish national carbon accounts. These will be used to set future ceilings, to assist in monitoring compliance with current disciplines, and as part of the process of developing regulatory infrastructure.

Participation confers three types of benefits on developing countries: it gives them a seat at the table in determining their future involvement and the current disciplines; it provides them with immediate benefits, including benefits derived from technology transfer; and it enhances the prospect of an agreement that will reduce the risk they face of climate-related damages (especially given their low adaptation abilities). In keeping with our recommendation to focus on current actions rather than future commitments, our proposal requires that developing countries accept the principle that they will reduce emissions in the future, without stating specific emissions ceilings.

Development and climate objectives can be linked. The world community announced Millennium Development Goals (<http://www.un.org/millenniumgoals/>) and rich countries made commitments to help developing countries achieve these goals. Developing countries' future climate-related actions can be conditioned on rich countries' efforts to reach the Millennium Goals. The trade disciplines necessary to prevent leakage can be conditioned on technology transfers. The developing countries can influence these outcomes only if they participate in the Kyoto II negotiations with a view to becoming signatories. Participation in the CDM and technology transfer under Kyoto II should be eligible only to signatories, thus creating an immediate benefit of joining. China, India and Brazil account for 63% of the current CDM projects, and 75% of the expected annual Certified Emissions Reductions (CERs) (<http://cdm.unfccc.int/Statistics/index.html>). Under Kyoto II, with expanded membership from rich countries and stricter ceilings, the value to developing countries of having the right to participate in the CDM market should increase substantially.

In summary, rich countries need to acknowledge their responsibility and their ability to take the first steps to deal with the risks of climate change. It is not in the interest of developing countries to claim that their lack of responsibility for existing GHG stocks and their relative poverty exempt them from all obligations; those facts merely defer their obligations. With an emphasis on fairness, Kyoto II should establish the principle that developing countries will have to reduce their emissions in the future, and in the meantime are not permitted to undermine efforts made by developed countries.

5 Participation and compliance

Nations' sovereignty limits the world's ability to design an international agreement that compels participation and compliance. Here we suggest how the agreement should be designed

at the negotiation stage, in order to promote participation and compliance. We interpret the participation that actually occurs as the equilibrium to a “participation game”, in which nations act out of self-interest in deciding whether to join an agreement that has previously been negotiated. The absence of a supranational institution with the ability to punish non-participants means that a non-cooperative Nash equilibrium is a reasonable equilibrium concept for the participation game. In addition, we think that a simple multi-stage game, rather than a supergame or a complicated dynamic game provides the most useful framework. Our choice of the multi-stage game is consistent with our recommendation that Kyoto II have a short duration. There are also technical reasons for adopting this formulation.¹

5.1 The basic proposal

Our central recommendation is to include an escape clause in the agreement (Karp and Zhao 2007). 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 a simple 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; we have in mind the participation game amongst developed countries, those who will be called upon to incur costs during Kyoto II.

The combination of escape clause and fine has an obvious and important role in providing insurance, similar to the role of a safety valve in emissions trading. Nations who sign the agreement are assured at the outset that the economic cost of compliance does not exceed the

¹The Folk Theorem of supergames shows that there are typically many non-cooperative equilibria based on punishment strategies when the game is (possibly) repeated infinitely often. Some of these equilibria have outcomes that are close to or equal to the outcome under perfect cooperation. We do not think that the infinite horizon setting provides the best modeling framework, both because of our emphasis on the short duration of Kyoto II and because requiring renegotiation proofness can undo the cooperation achieved in punishment equilibria.

magnitude of the fine. (A more sophisticated menu of partial escape clauses provides even better insurance.) 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). 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, a nation that invokes the escape clause is reimbursed by the amount $\frac{F}{n}$, so the actual cost of invoking the escape clause is $\frac{(n-1)F}{n}$. The actual fine increases with n , the number of signatories. The important consequence of this design is that by choosing to participate in the agreement, a nation unilaterally increases the fine that any other signatory must pay in order to invoke the escape clause. Although the nominal fine, F , is determined by negotiations that precede the participation decisions, each potential signatory can influence other signatories' actual fine, and thus their abatement decisions. 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.² Abatement of GHGs is a global public good. 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 (at this time) to lead to highly imper-

²There 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.

fect compliance. There is no effective sanction for not achieving a target level of abatement. The Kyoto Protocol's short duration – a feature that we advocate retaining for Kyoto II – 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.

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. Thus, although the fine does not completely solve the compliance problem, it greatly reduces that problem. We anticipate that there will be some contingencies under which a nation does want to exercise the escape clause. Therefore, it must be possible to collect the fine.

5.2 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 attractive alternative. Because these sanctions are imposed against a partner who willingly entered into the environmental agreement, the sanctions are consistent with WTO law (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. 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. Thus, 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 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 the population 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. 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 under existing WTO rules. Thus, using the trade alternative during the Kyoto II years will help set the stage for a more ambitious and more contentious use of trade policy.

5.3 Other considerations

Other features of the agreement will also promote one or more of the goals of efficiency, participation, and compliance. These are noncontroversial, so we merely mention them.

Greenhouse gasses are a stock pollutant, so actual damages or risks depend on aggregate emissions over an extended period, rather than emissions within a period. When abatement costs fluctuate over time, it is efficient to allow countries to bank and borrow emissions credits. Therefore, we support the creation of an intertemporal market, for the same reason that in Section 7 we support an international market. To avoid the obvious moral hazard problem, a nation that owes emissions credits should not be allowed to sell credits on the international market.

The Kyoto Protocol entered into force only after a “ratification threshold” was reached. This kind of contingency is seen as a means of encouraging participation. We are not opposed to using a similar device in Kyoto II, but we are skeptical of its efficacy. Section 7 discusses Russia’s “contribution” to reaching the threshold in the Protocol.

A similar, but perhaps more useful device is to condition the level of abatement by members on the actions of non-members. The EU is using this strategy in an attempt to encourage US participation. There appears to be little risk to this strategy, but we do not expect it to make a substantial contribution to the success of Kyoto II. However, a viable strategy is to link the actions of non-members during Kyoto II to design of Kyoto III. For instance, members to Kyoto II as a group might commit to joint efforts of linking Kyoto III with trade sanctions if there is sufficiently severe carbon leakage during Kyoto II.

6 Extending the role of trade policy

Kyoto II should recognize the importance of trade reform in achieving climate-related objectives. This reform has two themes, to encourage liberalization of markets for “green” products and technology and to provide levers that promote membership and compliance while discouraging non-signatories from undercutting the agreement. There is an obvious tension between the two reforms, because one discourages trade restrictions and the other permits the extension of these restrictions. Therefore it is important to be clear that the objective of both reforms is to achieve an economically efficient climate change agreement. The negotiations leading to Kyoto II may make only modest progress in achieving these reforms, but the principle underlying them should be clearly stated.

The benefits of liberalizing markets for green products and technologies are non-controversial and potentially large. It may be difficult to achieve this liberalization, for the same reason that

it is difficult to reform other sectors where significant distortions remain, such as agriculture. Kyoto II's support for the principle of open markets should include a criticism of the infant industry argument and other justifications for trade restrictions. For example, the US tariff on biofuels is a component of US agricultural policy, although supporters of this tariff invoke the infant industry argument. Removal of the tariff would make it easier to achieve a sensible policy for biofuels, in addition to benefitting exporters like Brazil. In the developing countries, removal of trade restrictions on clean energy technologies could lead to substantial economic gains and to reductions in GHG emissions (World Bank 2008).

The second type of reform, which would make it easier to use trade as a lever to achieve climate objectives, is controversial. Environmentalists and trade economists have debated for years whether the mandate of the WTO should be extended in order to attempt to influence environmental policy (Guzman 2002) (Cone 2002). Until recently at least, trade economists have been broadly united in opposing such an extension. Under WTO rules this extension would require the agreement of all members, an unlikely outcome given the opposition of many developing countries. Even if such a consensus could be obtained, economists' general view has been that the gains from trade are so great, and so vulnerable to erosion, and that the dangers of climate change are so modest, that the environmental tail should not try to wag the trade dog. As long as this perception persists, it makes sense to quarantine environmental objectives from trade policy. An alternate view is that globalization of world markets is on a sound footing and that the risks of climate change are substantial. Under this view, it makes sense – even to an economist who understands the Principle of Targeting – to use trade policy to achieve environmental goals.

Trade policy can be linked to environmental policy in order to encourage participation in an agreement; it can also be used to encourage signatories to comply and to prevent non-signatories from undermining the agreement. The most aggressive use of trade policy, requiring participation in a climate agreement in exchange for access to markets, is unlikely to be productive at the present time and should be discouraged. It is better to use positive incentives, such as the right to participate in the CDM market and easier access to green technology, as means of encouraging membership. However, trade taxes that discourage nations from undermining the agreement should be allowed. In 2007 some EU politicians proposed a “Kyoto tax”, aimed primarily at the US. EU Trade Commissioner Mandelson opposed this tax, partly on the grounds that it would be politically counterproductive. World Bank simulations show that the tax would have led to a substantial reduction in US exports to the EU (World Bank 2008). We support a “Kyoto tax”, largely for political reasons, as discussed below.

Carbon leakage is the process by which stricter emissions standards in one place encourage higher emissions elsewhere, as production of dirty goods move to places with weaker envi-

ronmental standards (Kallbekken 2007). The magnitude of carbon leakage is uncertain, but some estimates put it at less than 20% (Intergovernmental Panel on Climate Change 2001). 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). The weakness of the evidence may be partly 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, and partly because of statistical (e.g. endogeneity) and measurement problems. It would be rash to conclude, on the basis of this evidence, that the policies needed to achieve substantial GHG emissions reductions would result in only modest leakage of emissions. Politicians in signatory countries would be reluctant to undertake the experiment needed to obtain stronger statistical evidence.

Trade policy provides the best hope of encouraging countries to join a climate change agreement and of persuading 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. The extent of this risk is a matter of dispute. The evidence of the past thirteen years shows that the WTO is capable of taking a nuanced view of the relation between trade and environmental protection (Neumeyer 2005). WTO dispute resolution panels have been willing to designate as disguised protectionism some policies ostensibly aimed at environmental health, e.g. in the disputes between the US and the EU involving hormone-fed beef and GMOs. However, the WTO does not instinctively regard environmental policies that restrict trade as disguised protectionism. The Appellate Board’s 1998 decision in the “shrimp and turtle” case recognized the legality of trade restrictions used to protect the global environmental commons. Some trade economists were concerned that this decision would lead to environmental protectionism against developing countries (Bhagwati 2004), but there is little evidence of this occurring.

The shrimp-turtle decision provides modest but insufficient scope for using trade policy to achieve environmental goals within the confines of existing WTO law. Moreover, precedence has little force in WTO and other international law. Other aspects of WTO law directly oppose using trade policy for environmental goals. The WTO allows countries to make border tax adjustments to offset domestic taxes, including those designed to achieve environmental goals. However, only direct taxes can be offset in this way. For example, a carbon tax could be offset if carbon were directly exported, but the price of a product that embodies carbon cannot be adjusted at the border in order to reflect the price of the carbon content. Therefore, border tax adjustments of the sort proposed by the EU’s “Kyoto tax” are likely not WTO legal.

One route to introducing trade policy as a lever for international climate policy is to revise the WTO. This revision would probably be opposed by most developing countries. The developed countries succeeded in including intellectual property protection (TRIPS) in the WTO, and they failed to obtain a multinational investment agreement (MIA). Both measures faced developing country opposition. Therefore, success in reforming the WTO to accommodate trade policies that prevent leakage and encourage reductions in GHGs is likely to be difficult. However, these measures are arguably more important to developed countries than either TRIPS or the MIA, and they also benefit developed countries, even if the benefit/cost ratios are different for the two groups.

Developed countries would argue that the expansion of the legal use of trade policies increases the prospect of a successful climate change agreement, and that developing countries will be among the principal beneficiaries of that agreement. Developing countries are likely to regard this argument as paternalistic, and to think that the expansion harms them. The situation with TRIPS was analogous, but the evidence on the side of the developing countries' position in that case was stronger. During the Uruguay Round, where the WTO was negotiated, developed countries made "concessions" in their agricultural policies partly to persuade the developing countries to accept TRIPS. For the reform that we advocate, the *quid pro quo* could be other changes that promote reductions in GHGs. Perhaps the best example of such a change is the relaxation in licensing restrictions for technologies that reduce carbon emissions.

An alternate and probably more practical way to introduce the trade lever is to include it in Kyoto II rather than as part of a reform of the WTO. We noted above that the use of trade sanctions would be legal under current WTO law, provided that the sanctions are imposed against a signatory to the climate agreement and are consistent with that agreement. We propose that the agreement entitles signatories to impose a border tax adjustment against other signatories in order to offset a cost disadvantage, above some minimal level, caused by stricter climate policies. Climate change policies might lead to small cost increases over much of the primary and secondary sectors, but the minimal level (below which costs increases are ineligible for a border tax adjustment) will prevent a general increase in tariffs. In practice, the few sectors that face substantially higher costs because of environmental measures receive offsetting subsidies designed to protect the sector. These offsetting subsidies must be included in the calculation of the border tax, so that this tax provides compensation for the environmental policy's net costs to the domestic industry. This modification limits the ability to use the border tax adjustment as a means of disguised protectionism. Signatories have the right to object to border tax adjustments using the WTO dispute resolution process. Thus, the border tax adjustment protects against carbon leakage for only the sectors that face the greatest costs of complying with climate policy.

In view of the requirement to include offsetting subsidies, and the discipline imposed by the WTO process, the aggregate effect of the border tax adjustment might be quite small – as we would hope. However, the political effect could still be substantial, by making it harder to argue that leakage undercuts domestic reductions in GHG emissions and harms domestic industries.

Under our proposal, the border tax adjustment can be used only against signatories. It would most likely be used when trading partners have very different climate-related obligations, as with trade between developed and developing countries. This fact makes it particularly important to obtain developing country participation. Although developing countries are not required to reduce their emissions while Kyoto II is in force, the border tax adjustment limits their ability to take advantage of reductions in emissions in developed countries.

7 Tradeable emissions

International trade in emissions permits can provide a means of transferring income from one signatory to another (McGinty 2007) and it can increase efficiency when there is uncertainty in abatement costs, (Webster, Paltsev, and Reilly 2007). However, the use of tradable permits has an ambiguous effect on the incentive to impose strict emissions limits, and it can discourage participation in an agreement. We discuss these trade-related issues here.

7.1 Emissions trade as an indirect side-payment

When abatement costs are known with certainty, the correct allocation of permits achieves efficient abatement without trade. Trade can still be useful, because together with the allocation of permits it provides a means of making a side payment, or bribe, to induce more countries to join the agreement. 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 Kyoto II; we recommend using the CDM as a means of achieving efficient reductions in emissions. A simple example shows why the CDM 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 (BAU), and that the efficient way to reduce 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, group

A can pay group *B* (the developing countries) to achieve a 50 unit reduction, and achieve the balance of the target domestically. In the interest of specificity, assume that group *A* captures all of the surplus from this exchange. 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 to achieve the efficient allocation; the second alternative uses the allocation of permits together with trade to bribe group *B* to agree to reduce emissions. The outcome is the same. This example assumes that under both alternatives group *A* captures all of the surplus from achieving the emissions reduction efficiently. Of course, there is no reason to assume that the division of surplus is the same under the two alternatives, but neither is there a presumption that one alternative leads to a division of surplus more favorable for one of the groups.

This example shows that the CDM 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 CDM. There is considerable uncertainty about the level of permits that would be required to compensate developing countries for agreeing to an emissions ceiling, because we do not know the future price of permits or their future abatement costs. There is much less uncertainty about the costs and benefits of a collection of CDM projects, because these are negotiated individually and at a later time. Therefore, it is simpler to negotiate developing country participation in a collection of CDM projects, compared to inducing them to participate as full members in Kyoto II.

Inducing membership by means of permit allocation and trade is also a bad idea because it obfuscates what should be kept clear, and it makes transparent what should be left vague. The extent of a nation's sacrifice should be kept clear. Russia did not make a sacrifice by ratifying the Protocol, but it scored political points from the EU by joining. (One hypothesis is that Russia's adherence to the Protocol was a *quid pro quo* for EU support of Russia's accession to the WTO.) The EU wanted Russia to join in order to achieve the threshold necessary for the Protocol to come into force, thereby increasing pressure on the US. If it is worth including a threshold level of membership in the terms of the agreement, then it should not be possible to reach the threshold by legerdemain.

The extent to which a climate treaty results in transfers from rich to developing countries should be kept vague. 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. This recognition will undercut

popular support for the agreement. To the extent that developing countries obtain surplus in a CDM transaction, there is also a payment from the rich to the developing country. This kind of payment is not likely to produce public outcry in rich countries.

The discussion above involves the possible use of permit allocations and trade in order to induce developing countries to agree on emissions reductions. Some countries may be on the cusp between joining and not joining, and the allocation of permits together with trade might be enough to persuade them to join. However, Joint Implementation (JI) can be used with these countries to achieve efficiency, just as the CDM is used with developing countries. For the reasons given above, it is better to induce these countries to join by giving them an allocation of permits acceptable to them, rather than manipulating the allocation so that they will gain from trade.

7.2 Emissions trade to account for cost uncertainty

Thus far we have considered the role of trade in inducing membership; we recommend that trade not be used for this purpose. The other role of trade is to achieve efficiency *ex post* (after negotiation and ratification). Even if the allocation was chosen so that in expectation trade balances are zero, there would still be scope for trade because actual marginal abatement costs are random. We favor allowing international trade in permits in order to take advantage of the efficiency gains arising from this randomness. Of course, to the extent that commodity trade is a substitute for factor trade (i.e. to the extent that the factor price equalization theorem holds), trade in emissions permits is not necessary to achieve efficiency. There are two other points to be made about emissions trade.

7.2.1 The effect of emissions trade on the incentive to abate

Although our proposal for Kyoto II requires that ceilings on emissions are determined at the negotiation stage, prior to ratification, we recognize that there may be some “adjustment” in ceilings once membership has been determined.³ How does the ability to trade permits affect participants’ incentive to adjust their abatement levels? An instinctive answer (for an economist) is that because trade enhances efficiency, making it cheaper to achieve any level of abatement, trade is likely to encourage greater levels of abatement. This answer is correct

³Standard models in the theoretical literature on international environmental agreements assume that the level of abatement is chosen only after countries have decided whether to join (Barrett 2003),(Carraro and Siniscalco 1993). The basis for this timing assumption is the belief that countries cannot make commitments at the negotiation stage which would not be in their interest to honor once they had ratified. We think that this is too extreme a view of countries’ inability to make commitments, but there is some truth to it. Hence, our recognition that there may be adjustments after ratification occurs.

if society has a budget for abatement and chooses the highest level of abatement consistent with that budget. The answer is not correct in general if society chooses the optimal level of abatement by balancing marginal benefits and costs. Although trade certainly lowers total and average costs (when countries have different costs), it can either lower or increase marginal costs. Thus, the effect of trade on the incentive to abate is ambiguous in general (Karp 2008).

A simple example (based on our work-in-progress) shows why trade might reduce the incentive to abate. Suppose that each country has the ability to abate at most one unit. Marginal costs in each country are constant, up to the one-unit capacity. Each country obtains 1 unit (e.g. \$100 billion) of benefit for one unit of abatement that occurs anywhere in the world; this is a global pollutant. Each country's cost is a random variable with support greater than 1 and expected value equal to 2. (Costs are in the same units as benefits, so 2 represents \$200 billion.) To keep the example simple, suppose that the costs are independently distributed.

After having decided whether to participate in the agreement, a country learns its own costs, but this information is not verifiable, so the group decision cannot be conditioned on individual cost realizations. (Countries would have an incentive to exaggerate their costs, in order to be given a lower required level of abatement.) Since the benefit to a country of abatement is 1 and the actual cost is always greater than 1, it is not in any country's self-interest to abate.

Suppose that there are 3 signatories and that an agreement requires each signatory to abate at its maximum level. We are now at the "adjustment stage" where the signatories decide collectively whether to modify or even eliminate the target. Suppose that, as with most participation games in this literature, the adjustment decision is made by a supranational agent who wants to maximize the collective welfare of the signatories, ignoring the welfare of non-signatories. First consider the case where international trade in permits is not permitted, because for example the countries did not develop the institutional structure needed to govern this trade. In this case, it is in the collective interest of the signatories to carry out the agreement: the expected total costs are $3 \times 2 = 6$ and the total benefits are $3 \times 3 = 9$.⁴ Suppose instead that the countries are able to trade permits amongst themselves. In this situation, the statistical problem is a bit more complicated. The collective marginal benefit of a unit of abatement is 3 (since each participant obtains the marginal benefit of 1). If the expectation of the highest cost (the third order statistic) is greater than 3, and the expectation of the second highest cost (the second order statistic) lies between 2 and 3, then it is optimal for the countries to agree on only two units of abatement. Since costs are not verifiable, the group requires each country to achieve $2/3$ of a unit of abatement, and allows them to trade in order to achieve this target. In this example, the ability to trade reduces the total level of abatement by 33%.

⁴The assumption of constant marginal costs and constant marginal benefits mean that in the absence of trade it is always in the interest of the countries that ratify the agreement to either abate to capacity or not to abate at all.

7.2.2 The effect of emissions trade on the incentive to join

The anticipation that the supranational agent will adjust the required level of abatement, conditional on actual membership, and that emissions permits will be tradable, has a more subtle effect on the incentive to join the agreement. The Nash equilibrium to the participation game requires that participants do not want to leave the agreement, and non-participants do not want to join. These calculations involve the payoffs of members and non-members.

Moving from a regime that prohibits trade in permits to one that allows trade changes the payoffs of both members and nonmembers. In an earlier paper we conjectured that this change would reduce the equilibrium membership (Karp and Zhao 2007) and work-in-progress confirms that conjecture. Because world welfare is very sensitive to the aggregate amount of abatement, and much less sensitive to whether this abatement is achieved in the most efficient manner, allowing trade is likely to reduce aggregate welfare, along with reducing aggregate abatement.

The previous subsection noted that trade can reduce the amount of abatement, conditional on the level of participation, and this subsection notes that trade can also reduce the level of participation. These theoretical possibilities, together with the reasons for not using trade to provide a mechanism for side-payments (to induce membership) are strong enough to make us skeptical that international trade in permits will contribute significantly to the design of Kyoto II. However, trade does have a place in achieving the efficient reduction of emissions, and we support its use for that limited purpose.

8 The optimal form of regulation

Several papers examine the optimal form of regulating stock pollutants such as GHGs when regulators are imperfectly informed about firms' costs (Hoel and Karp 2001), (Hoel and Karp 2002), (Newell and Pizer 2003), (Karp and Zhang 2006). The usual comparison is between taxes and cap-and-trade. The consensus from this literature is that taxes are more efficient than cap-and-trade policies for controlling GHGs. There are several reasons for this conclusion, but the most fundamental is that the evidence supports a relatively flat marginal damage curve for GHGs. Although the qualitative conclusion that taxes are more efficient than cap-and-trade is quite robust, the magnitude of the gain from using taxes depends on the variance of the cost uncertainty, a parameter which is itself very uncertain. A more complicated policy, e.g. an optimal two-part tax (equivalent to a cap-and-trade with a price ceiling), could obviously dominate either the tax or the cap and trade policy.

Based on this research, we encourage nations to use a tax rather than cap-and-trade to

achieve their national targets. Other authors, examining the same evidence, prefer a cap-and-trade policy to a tax policy (Stavins 2008). Public distaste for taxes, the lack of public understanding of the price effects of the two types of policies, and the political power of carbon-intensive industries, are such that most countries are likely to opt for a cap-and-trade policy, or even worse, a command and control policy. This choice is of second order importance when considering the goal of obtaining an agreement that imposes mandatory ceilings on national GHG emissions. Nations must be allowed to choose how to satisfy these ceilings.

If, as in our view, taxes are more efficient than quantity restrictions, why do we support an agreement that uses country-specific emissions targets, rather than a global carbon tax? In fact, a global carbon tax is probably a more efficient means of achieving emissions reduction (Nordhaus 2007). However, we think that an agreement that uses quantity restrictions has a much better chance of being negotiated and ratified than one based on a global tax. Perhaps Kyoto III will use taxes.

9 Conclusion

Our design for Kyoto II includes many of the important features of the Kyoto Protocol. We regard it as absolutely essential that Kyoto II involve mandatory emissions ceilings. We support the continued development and use of the CDM and JI. To maintain flexibility, Kyoto II, like its predecessor, should have a short lifetime.

Our proposal departs from the Protocol in two main respects. First, our design includes an escape clause, which has three desirable features. The two most important features are that it encourages membership and it helps to solve the enforcement problem. The escape clause also caps the potential cost of joining the agreement.

The second departure is that our design recognizes that trade policy must eventually be used in order to prevent leakage and possibly also to induce countries to join the agreement. Trade economists may blanch at this proposal, but the changing relative costs of weakening the trade order and risking environmental catastrophe make it a necessity. All countries, including developing countries who are not responsible for existing stocks, but are partly responsible for increasing stocks, must also come under the discipline of an international climate agreement.

References

- ALDY, J., A. KRUPNICK, R. NEWELL, I. PARRY, AND W. PIZER (2008): "Climate Economics and Policy," RFF Working Paper.
- ALDY, J. E., AND R. N. STAVINS (2007): *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World*. Cambridge University Press.
- BARRETT, S. (2003): *Environment and Statecraft*. Oxford University Press.
- BHAGWATI, J. (2004): *In Defense of Globalization*. Oxford University Press, Oxford.
- CARRARO, C., AND D. SINISCALCO (1993): "Strategies for the International Protection of the Environment," *Journal of Public Economics*, 52, 309–328.
- CONE, S. M. (2002): "The Environment and the World Trade Organization," *New York Law School working paper*.
- COPELAND, B., AND M. TAYLOR (2003): *Trade and the Environment: Theory and Evidence*. Princeton University Press.
- (2004): "Trade, Growth and the Environment," *Journal of Economic Literature*, XLI(1), 7–71.
- GUZMAN, A. (2002): "Global Governance and the WTO," *UC Berkeley School of Law Research Paper No. 89*.
- HOEL, M., AND L. KARP (2001): "Taxes and Quotas for a Stock Pollutant with Multiplicative Uncertainty," *Journal of Public Economics*, 82, 91–114.
- HOEL, M., AND L. KARP (2002): "Taxes Versus Quotas for a Stock Pollutant," *Resource and Energy Economics*, 24, 367 – 384.
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2001): "Climate Change 2001: Mitigation Working Group III contribution to the IPCC 3rd assessment report," <http://www.ipcc.ch/SPM040507.pdf>.
- KALLBEKKEN, S. (2007): "Why the CDM will reduce carbon leakage," *Climate Policy*, 7, 187–211.
- KARP, L. (2005): "Global Warming and hyperbolic discounting," *Journal of Public Economics*, 89, 261–282.

- (2008): “Correct (and misleading) arguments for using market-based pollution control technologies,” <http://are.berkeley.edu/karp/marketbasedfMarch1.pdf>.
- KARP, L., AND Y. TSUR (2007): “Time perspective, discounting and climate change policy,” Unpublished working paper; <http://are.Berkeley.EDU/karp/>.
- KARP, L., AND J. ZHANG (2006): “Regulation with Anticipated Learning about Environmental Damage,” *Journal of Environmental Economics and Management*, 51, 259–280.
- KARP, L., AND J. ZHAO (2007): “A proposal to reform the Kyoto Protocol: escape clauses and foresight,” <http://are.berkeley.edu/karp/KyotoReformFeb07.pdf>.
- MCGINTY, M. (2007): “International environmental agreements among asymmetric nations,” *Oxford Economics Papers*, 59, 45 – 62.
- NEUMEYER, E. (2005): “The WTO and the environment: its past record is better than critics believe, but the future outlook is bleak,” *Global Environmental Politics*, 4, 1–8.
- NEWELL, R., AND W. PIZER (2003): “Regulating Stock Externalities Under Uncertainty,” *Journal of Environmental Economics and Management*, 45, 416–32.
- NORDHAUS, W. D. (2007): “To tax or not to tax: alternative approaches to slowing global warming,” *Review of Environmental Economics and Policy*, 1(1), 26–44.
- STAVINS, R. (2008): “Addressing climate change with a comprehensive US cap-and-trade system,” Harvard University, John F Kennedy School of Government.
- STIGLITZ, J. E. (2006): “A New Agenda for Global Warming,” *Economists’ Voice*, pp. 1–4.
- UNITED NATIONS ENVIRONMENTAL PROGRAMME (1999): *Environment and Trade – a Handbook*. United Nations, <http://www.unep.ch/etu>.
- WEBSTER, M., S. PALTSEV, AND J. REILLY (2007): “The hedge value of emissions trading under uncertainty,” Working paper MIT Joint Program on the Science and Policy of Global Change.
- WORLD BANK (2008): *International Trade and Climate Change*. World Bank.