Reducing Cost Uncertainty and Encouraging Ratification of the Kyoto Protocol[1]

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Introduction

Put into force, the Kyoto Protocol represents a significant commitment toward the goal of stabilizing atmospheric concentrations of greenhouse gases**.** Unlike the earlier United Nations Framework Convention on Climate Change (UNFCCC) that called for voluntary efforts to reduce greenhouse gas (GHG) emissions, the Kyoto Protocol establishes binding emission limits on participating countries. This shift from voluntary to mandatory action reflects a substantial elevation of the global commitment to mitigate the threat of climate change.

While the movement from voluntary action to firm commitments is the hallmark of the Kyoto Protocol, the adoption of commitments does not necessarily imply the need to adopt quantity targets as called for by Article 3 of the protocol.[3] Committing to reduce GHG emissions can be accomplished by means other than the imposition of binding quantity targets.

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[1] This paper has been prepared for the 2000 Taipei Conference on Policies for Greenhouse Gases /Reduction, and Pollution Control in Asian-Pacific Countries, November 30 – December 1, 2000, Institute of Economics, Academia Sinica, Nankang, Taipei Taiwan. The proposal put forth in this paper borrows heavily from the work of many groups and individuals. We are grateful for the ideas voiced by the Brazilian delegation to the UNFCCC; Warwick McKibbin and Peter Wilcoxen; Jennifer Morgan and Glenn Wiser; Marcus Schneider; and countless others who have contributed to the debate on international climate policy. We also benefited from financial support generously provided by the Wallace Global Fund For a Sustainable Future and the German Marshall Fund of the United States. None of these groups or individuals is responsible for the contents of this document, however. This proposal reflects the opinion of the authors and does not represent the position of Resources for the Future, or the Centre International de Recherche sur l'Environnment et le Développment.

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[3] Article 3 states:

"The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in

For example, the implementation of taxes on GHG emissions (most notably carbon dioxide emissions) is the obvious alternative to binding quantity targets. In a world where the cost of GHG abatement is known, any desired level of emissions can be attained with a tax mechanism (termed a "price instrument").

Economists are often asked if quantity instruments (binding quantity targets) and price instruments (for example, emission taxes) yield the same environmental result, is there any reason to prefer one over the other? In general, if the cost of limiting emissions is known with certainty and the benefits of reduced emissions are similarly known, then these two approaches are perfect policy substitutes. However, as Weitzman (1974) has pointed out, if either the costs or the benefits are uncertain, then one of these approaches may be more desirable (from a social welfare perspective) than the other. Pizer, in a series of papers (1996, 1997, 1998, 2000), used a world-scale, computable general equilibrium model, capable of explicitly incorporating uncertainty, to demonstrate that price instruments are preferable on social welfare grounds to quantity targets for the abatement of GHG emissions.

Pizer's results suggest that the binding quantity targets of the Kyoto Protocol are not the socially optimal policy mechanism with which to implement "commitments" under the UNFCCC. However, it is likely the case that few world leaders are familiar with Weitzman's theoretical results or Pizer's empirical work. And even if they were, the politics of global climate policy would, in their view, trump the ideas put forth by a band of economists. Moreover, in the unlikely case these leaders were persuaded by the economist's arguments, they would argue that the negotiation of the protocol has gone too far to think about abandoning the quantity targets and trying to develop and negotiate a new price-based approach.

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accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012."

The purposes of this paper are threefold. First, we set aside the economic social welfare arguments and argue there are significant political reasons to advocate a switch from a quantity-based to a price-based GHG abatement approach. Moreover, we argue that the quantity target imposes political difficulties so great that unless they are addressed, the protocol will not enter into force. Second, we show how a movement from a quantity-based approach to a price-based approach can be effected with only simple alterations to the protocol, thereby avoiding the need to re-open the Kyoto process and renegotiate the targets, as some have suggested. Finally, we implement our proposal in the context of a simulation model and examine the affect of the proposal on global GHG emissions.

The Political Difficulty of Quantity Targets

The difficulty raised by quantity targets begins and ends with compliance. As the protocol currently reads, a country would be in compliance with the protocol if its GHG emissions were at or below its assigned amount during the compliance period, or it purchased assigned amounts or Clean Development Mechanism (CDM) credits on the world market to cover any short fall. Assuming some meaningful penalties for noncompliance, a country will ratify the protocol only if it believes it can comply with its assigned quantity target.

But governments face vast uncertainty as they attempt to develop and implement polices and measures intended to comply with their Kyoto commitments. This uncertainty involves both the likelihood of meeting a quantity target with a given set of polices, as well as the political and economic cost of meeting the target. We argue that the presence of these uncertainties is a major political stumbling block to ratification of the protocol.

Consider a country that wishes to use a comprehensive carbon tax to meet its Kyoto commitment. The country employs the best energy-economy models at its disposal to choose the level of a carbon tax to meet the emission target. The country's policymakers then succeed in clearing all the political hurdles needed to pass the tax into law. However, to the country's great dismay, it finds out years later (during its commitment period) that the tax was too low, due perhaps to incorrect baseline assumptions or some other modeling inadequacies. This country acted in good faith, made politically difficult decisions, and paid the economic cost of the tax, now only to be told that it is not in compliance with its commitments and thus subject to sanctions.

What went wrong? The answer is that a country choosing a tax-based approach will always be uncertain with regard to its ability to meet a quantitative emission target due to the reality of less than perfect modeling and economic forecasting. The situation is even worse for a country that chooses to use a mix of polices and measures, which might include taxes, tradable permits, and prescriptive measures like efficiency standards. In this case, the difficulty of modeling any mix of these approaches is greater than modeling the tax alone, potentially giving rise to even larger errors.

The dictates of politics will generally lead countries to choose policies and measures that aim to keep economic costs as low as possible. This political incentive suggests that most forecasting errors (due to incorrect economic assumptions or models) will lead to an undershooting of abatement targets. If a country wanted to reduce its compliance uncertainty it could do so only by building in a margin of safety (e.g., legislating a carbon tax 50% higher than that predicted by the models) and thereby raising expected costs. However, all things equal, the greater the expected cost, the less likely is a country to ratify the protocol.

The uncertainty over the likelihood of hitting a quantity target deters ratification. Even if countries were willing to undertake high levels of effort, in terms of political and economic cost, to abate GHG emissions, not knowing if that level of effort would be "good enough" in terms of Kyoto compliance will deter these countries from taking on commitments. Conceptually, a country could impose a fully upstream carbon permit system and meet its Kyoto emission target with certainty. While such an approach hits the compliance target, it does so at the expense of wholly uncertain GHG control cost. This situation is the exact opposite of the problem discussed above when attempting to set the right carbon tax. In the permit case, you know the emission level, but you can't know with certainty the cost. In the tax case, you know the cost with certainty (in terms of the tax), but you can't know the emission reductions that would result.

The binding-quantity emission requirements make the cost of participation in the Kyoto Protocol difficult to estimate and potentially quite high. Unexpected economic growth, the availability of alternative fuels, the development of new technologies, and the details of international implementation all lead to uncertain estimates for both the required reductions and the cost of those reductions in individual countries. Uncertainty about these costs has led many countries to question both whether they should ratify the agreement and, once they do, whether all of the participating countries will be able to meet their targets by the end of the commitment period in 2012.

Transforming a Quantity Target to a Price-Based Approach: A Proposal

In a sense, the compliance mechanism of the protocol is at once both the cause of problems and the answer to those same problems. The quantity-based approach of Kyoto can be replaced with a price-based approach by the simple addition of a few lines of text to the

compliance article. In particular, we propose allowing countries that have not sold their permits abroad to pay a fixed price per ton to a suitable international agent to cover any excess emissions at the end of the first commitment period in 2012.[4] We suggest a compliance payment of $50 per ton of carbon. The revenue generated from these payments would then be used to acquire emission reductions from other countries.

It is our belief that in order to succeed, the Kyoto Protocol cannot demand strict emission limits regardless of costs. As noted above, in many countries uncertainty about the cost of participation is one of the primary political/economic objections to the protocol. There are several ways in which compliance costs can be limited. The protocol already includes a number of flexibility mechanisms designed to reduce these costs; emissions trading, the CDM, joint implementation, inter-gas trading, and the use of carbon sinks all help reduce the cost of compliance by increasing the range of options available to each country. Even if all of these features are effective, however, they only reduce costs, not limit them, nor do they reduce the uncertainty over them. Unexpected circumstances can still lead to high and possibly unacceptable costs associated with the Kyoto targets.

Our proposal specifically limits costs by providing a fixed-price alternative to domestic reductions or international permit purchases**.** Since countries can choose to pay the compliance payment on each ton of excess emissions, no country would be obliged to spend more per ton on GHG abatement than the established compliance payment. It is essential, however, to limit this option to countries that choose not to sell permits abroad in order to avoid excessive permit banking. The actual level of the payment must reflect a consensus among countries about how hard they are willing to work to reduce emissions. A high payment may not provide a useful

[4] This agent would be established by the protocol. It could be an entity similar to the CDMBoard, or it might be a suitable private entity, for example, an international bank.

compliance alternative. A low payment may lead some countries to put forth less domestic effort than the consensus desires.

A compliance payment is not the only way to limit costs. Another alternative is to require countries to subtract any excess tons at the end of 2012 from their commitment in the next budget period, perhaps with an additional tonnage penalty. Or, countries could be required to solicit outside technical assistance in order to establish a more effective domestic policy. A third possibility is that a country with excess emissions could be required to demonstrate that it undertook appropriate policies and measures to try to meet its target. Mechanisms like these have the advantage in that they do not necessarily require any extraterritorial payments by countries with excessive emissions. However, the mitigation incentives associated with these mechanisms are unclear and, depending on the actual design, could be too weak to encourage an adequate domestic effort or too onerous to limit costs.

A successful compliance mechanism should assure adequate domestic effort. The fundamental goal of the Kyoto Protocol is to reduce greenhouse gas emissions. With strict emission limits, it is relatively easy to verify whether a country achieves this goal: emissions are counted and compared to permit holdings. Alternative compliance options raise the question of how to determine whether a country has seriously tried to reduce emissions. In such situations where obligations are not easily measured, participants could choose either to trust one another or to specify complex and invasive verification procedures.

Instead of requiring trust or invasive verification, our proposal provides economic incentives to ensure domestic effort. When properly implemented, these incentives encourage participating countries to meet the Kyoto goals based on their own self-interests. The advantage

of the proposed approach is that the incentive is transparent and involves a minimum of subjective measures and administration.

The alternative of a fixed payment per ton of carbon creates incentives to identify and undertake emission reductions that are less costly than the payment**.** With a $50 compliance payment per ton, a country with 1 million excess tons could pay $50 million to remain in compliance. If additional domestic reductions are available for $20 per ton, however, the country could save $30 million by undertaking those domestic reductions and avoiding the compliance payments. While such incentives will not force a country to undertake every feasible reduction, they provide a constant pressure to do so. By using the revenues from the compliance payments to reduce emissions in other countries, we assure that participating countries either put forth the desired level of domestic effort or actually spend more to reduce emissions elsewhere.

To avoid any manipulation or abuse of the collected payments, a reverse auction would be held to purchase emission reductions in the second commitment period. Annex I countries as well as developing countries offering project-based credits approved through the CDM would be allowed to bid. The CDM will assure the legitimacy of the project-based credits in developing countries. Bids would consist of an offer to sell a specific number of Annex I permits or CDM emission credits at a specific per-ton price. This process is the reverse of a typical auction where participants offer to buy a product at a specific price: here, the participants offer to sell a product (emission reductions).

To complete the auction, an agent for the parties to the protocol would collect the bids and establish the successful auction price. The auction price would be a per-ton amount. Bids that offer permits at or below the auction price are accepted and receive the full auction price; the remaining bids are not accepted. The auction price would be chosen to exhaust the accumulated

compliance payments while purchasing as many tons as possible. After establishing the price, the agent would direct funds from countries choosing to make compliance payments to the successful bidders. Because every bidder would receive the same price per ton, there is no incentive for a country to overstate its minimum acceptable price. A single bidder overstating its minimum acceptable price would not influence the eventual auction price but would reduce its own likelihood of winning the auction.

Importantly, this proposal would require a minimum of administration. Reporting requirements already established under the protocol track the permit holdings of Annex I countries. Existing mechanisms for evaluating CDM projects establish the legitimacy of developing country credits. The only administrative activities would be collecting the bids, establishing the consequent auction price, and directing funds from countries making compliance payments to those with winning bids.

Our proposal would limit the cost of participating in the Kyoto Protocol, ensure that countries take suitable action, and create clear incentives for GHG mitigation worldwide. The fixed compliance payment provides an unambiguous signal of the consequences of excess emissions. Countries could participate in the protocol and design domestic programs with complete certainty about their financial commitment and a clear incentive to reduce emissions. Because the financial incentive would apply to everyone, countries would be assured that all participants would make a reasonable effort to reduce emissions without any need for invasive or complicated domestic reviews. By using a reverse auction to distribute the revenue, the proposal avoids any opportunities to manipulate or misuse the revenue.

These benefits result from a simple payment ($50 per ton of carbon) that countries would pay in lieu of domestic reduction or purchases of foreign permits, with the revenues distributed

via a reverse auction to countries offering additional reductions. In addition to existing reporting requirements and CDM certification, the proposal would require little effort to implement while providing transparent incentives to all participants.

Despite the potential for relaxation of the Kyoto emission limits, adoption of the compliance payment mechanism would increase the likelihood of timely ratification and successful implementation. In that sense the proposed payment mechanism can accelerate the progress towards the longer-term goal of stabilizing atmospheric concentrations of GHGs.

Policy Simulations

The Simulation Model

Moving to a price-based policy from a quantity-based approach gains certainty over cost at the expense of certainty over the number of tons to be emitted. Since each country's emissions will likely exceed their allocated amounts if the cost of abatement on the world market exceeds $50 per ton, it is instructive to examine how much of the aggregate Kyoto Commitment would be met under the proposed price-based scheme.

To perform this analysis we have employed a simulation model based upon the modeling results published in the special issue of the *Energy Journal*, May 1999 (hereafter *EJ*). Articles in this issue of the *EJ* report detailed costs of compliance estimates with the Kyoto Protocol for twelve different models[5] affiliated with the Energy Modeling Forum, at Stanford University. In the introductory essay to the volume, Weyant and Hill (1999) state:

> "… the objectives of this study were the same as for previous EMF studies: (1) identifying policy-relevant insights and analyses that are robust across wide ranges of models, (2) providing explanations for differences in results from different models, and (3) identifying high priority areas for future research," pp. vii.

The simulation model employed in this paper is based on the *EJ* results and is described briefly below, A detailed presentation can be found in Ghersi (2000).

Each of the modeling teams participating in the EMF effort was asked to analyze four distinct global GHG abatement regimes. These were: (1) a no trading regime where all countries were required to meet their target solely through domestic action, (2) an Annex B trading regime where countries of Annex B are permitted to trade allocated amounts, (3) the double-bubble

which divides Annex B into two trading blocs—the EU and the rest of Annex B, and (4) full global trading which admits the full potential of the CDM to bring forth GHG reductions in the developing world. Each model analyzes the four abatement regimes for each of four regions: the United States, the European Union, Japan, and Canada, Australia and New Zealand—the CANZ group.

The results provided in Weyant and Hill (1999) permit one to extract pairs of marginal abatement cost and tones of GHG abated for each model, abatement regime and region. Ghersi (2000) extracts these pairs and uses them to calibrate the functions,

$$p_{ijk} = a x_{ijk}^{\ n}$$

where p_{ijk} are the marginal cost of abatement regime *I* in region *j* produced by model *k*, x_{ijk} are the GHGs abated with similar indexing, and *a* and *n* are parameters.

Unfortunately, the four EMF regions leave out several Annex B countries, in particular, the former member countries of the Soviet Union—often termed the economies in transition (EIT)—and the rest of the world (ROW). To deal with the EIT, Ghersi (2000) constructs a linear marginal abatement cost curve from the EMF results. He uses the Annex B equilibrium trading price and the tons of GHG abated in the non-EIT Annex B countries to calculate the amount of GHGs that must have been abated in the EMF models by the EIT to hit the Kyoto target. This calculation yields a price-quantity pair through which one can pass a linear marginal abatement cost curve with a zero intercept. However, there is good reason to believe that some of the tons

[5] Two of those models, GRAPE and CETA, giving estimates for one zone only (Japan and the United States respectively), were dropped. POLES, a French model not part of the EMF, is added to the study based on data provided by its modelers.

are "hot air"[6] and that the marginal abatement cost of these tons is zero. Ghersi calculates the EIT abatement to be 474 million metric tins of carbon (MtC)[7] and assumes (with reasonable justification) that 200 million MtC of this is hot air.

As noted above, EMF results are supplied for a global trading regime, which generates a world equilibrium price. This price is passed to each marginal abatement cost curve for each region and the new curve developed for the EIT. The total tons abated at that price in each region and the EIT is calculated and subtracted from the Kyoto target. The tons lacking are assumed to be supplied by the ROW through such things as the CDM. This calculation again provides a single point on a ROW marginal abatement cost curve and Ghersi passes a linear function through this point and the origin.

In summary then, Ghersi has constructed for each of the EMF models, a marginal abatement cost curve for: the United States; the European Union; Japan; Canada, Australia, and New Zealand (CANZ); the economies in transition (EIT); and the rest of the world (ROW). For simplicity, and in an attempt to draw out some notion of central tendency, we average across all the individual model results in the simulations performed for this paper.

There are a variety of reasons to believe that even with the best of market institutions, the EIT and the ROW will be unable to supply GHG reductions at the maximum amounts suggested by the EMF model runs. The likelihood that allocated amounts from the EIT and CDM tons from the ROW will be less than the maximal amount is discussed by many of the authors of the *EJ* papers. To take this reality into account, we cut by half the amount of available EIT tons beyond

[6] A term used to suggest that these are not real reductions or similarly, the marginal cost of reducing a hot air ton is zero.

[7] This the average calculated across all the models.

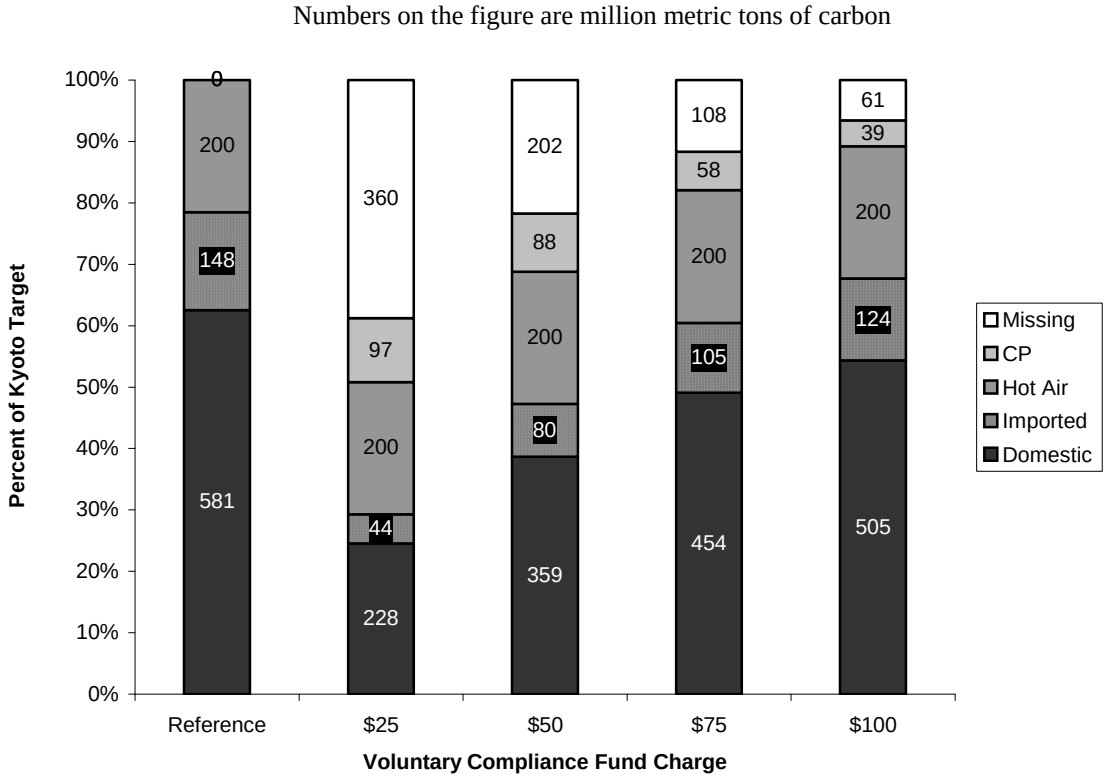
the 200 MtC of hot air, and the ROW tons were reduced by 75%. These reductions were employed parametrically in all of our simulations.

The Simulation Results

We perform five simulations using the Ghersi model. The first simulation referred to as the reference case assumes that all four regions—the United States, the European Union, Japan, and Canada, Australia and New Zealand (CANZ)—meet their Kyoto target through a combination of domestic action, purchased credits (assigned amounts and CDM credits) and through purchased "hot air." In the other four simulations we model a compliance regime like the one proposed in this paper where a country may be in compliance by meeting its target or paying a fixed amount (the compliance payment—CP) for each ton emitted in excess of the Kyoto target. The four simulations differ by the amount of the charge ($25, $50, $75, $100).

Figure 1 presents the results of the five simulations. In the Reference case, the four regions reach their Kyoto targets with a combination of "hot air" (22%), imported credits (16%), and domestic action (63%). The marginal cost of abatement in this CDM-constrained global trading world is $122 per ton. A CP of $25 per ton causes the four regions to miss their targets by almost 40%. However, at a CP of $50 per ton, almost 80% of the commitment is reached, and over 90% at $100 per ton.

Figure 1: Greenhouse Gas Abatement n 2010



While even a $100 per ton CP charge does not guarantee that the four regions will meet their Kyoto commitments, it does guarantee a source of international finance for developing countries through the reverse auction discussed above. A CP of $50 per ton generates a fund of over $17 billion to fund GHG abatement projects.[8] Over the long term, introducing inducements for developing countries to reduce GHG emissions will be become ever more important.

[8] Our simulations suggest that this fund grows to $18 billion when the VCP is $75 per ton, but declines back to the $17 billion range at $100 per ton.

Concluding Remarks

We have argued on both welfare theoretic and political grounds that the quantity-based approach of Kyoto is not only suboptimal, but it in fact obstructs the very action negotiators of Kyoto wanted—firm commitments to take action to limit GHG emissions. The fact that the quantity targets leave the cost of Kyoto compliance unbounded, makes it very difficult for many countries to agree to the commitment and ratify the protocol.

We have proposed a slight alteration to the protocol that serves to bound the cost of compliance with certainty and thereby remove what we believe to be the major barrier serving to thwart ratification. Our proposal adds a third leg to the compliance stool and allows countries to come into compliance with their Kyoto commitments by: a) meeting their assigned amount target, b) purchasing assigned amounts or CDM credits on the world market to meet the short-fall, or c) paying a fixed compliance payment on all tons emitted in excess of the assigned amount (net of any tons purchased on the world market) to an agent of the UNFCCC to be used to secure assigned amounts or CDM credits on the global market.

The agent of the UNFCCC would solicit bids from Annex 1 countries and from providers of CDM credits in a reverse auction, and then expend the funds collected from the compliance payments to purchase offered tons. The reverse auction is incentive compatible with truthful bidding and ensures providers of CDM credits a market place without excessive market power on the buyer side.

Our proposed compliance option does not guarantee that all countries will hit their Kyoto targets. Of course, in reality there is nothing in the existing compliance approach that makes such a guarantee. However, the simulation modeling reported in this paper suggests that a politically acceptable compliance change of $50 per MtC gets the four regions almost 80% of the way

toward meeting their Kyoto goals. If 20% less than Kyoto is the price of ratification, we argue this seems like a deal we should all take seriously.

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