What Has Kyoto Wrought? The Real Architecture of International Tradable Permit Markets

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Abstract

We investigate a central issue in the climate change debate associated with the Kyoto Protocol: the likely performance of international greenhouse gas trading mechanisms. Virtually all design studies and many projections of the costs of meeting the Kyoto targets have assumed that an international trading program can be established that minimizes the costs of meeting overall goals. This conclusion rests on several simplifying assumptions. We focus on one important issue that has received little, if any, attention: the interaction between an international trading regime and a heterogeneous set of domestic greenhouse policy instruments. This is an important issue because the Protocol explicitly provides for domestic sovereignty regarding instrument choice, and because it is unlikely that most countries will choose tradable permits as their primary domestic vehicle.

It is true that costs can be minimized if all countries use domestic tradable permit systems to meet their national targets (allocate permits to private parties) and allow for international trades. But when some countries use non-trading approaches such as greenhouse-gas taxes or fixed quantity standards -- which seems likely in the light of previous experience -- cost minimization is hardly assured. In these cases, achieving the potential cost savings of international trading will require some form of project-by-project credit program, such as joint implementation. But theory and experience with such credit programs suggest that they are much less likely to facilitate major cost savings, because of large transactions costs, likely government participation, and absence of a well functioning market. Thus, individual nations' choices of domestic policy instruments to meet the Kyoto targets can limit substantially the cost-saving potential of an international trading program. There is an important trade-off between the degree of domestic sovereignty and the degree of cost effectiveness. Moreover, there is a need to analyze the likely cost-savings from feasible, as opposed to idealized, international policy approaches to reducing emissions of greenhouse gases.

Key Words: climate change, tradable permits, international policy

JEL Classification Numbers: Q28, Q25

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1. INTRODUCTION

In order to address worldwide concerns about the risk of global climate change due to increased atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases, representatives of the world's nations gathered in Kyoto, Japan, in December of 1997, under the auspices of the Framework Convention on Climate Change (FCCC). That "Third Conference of the Parties" (COP3) produced the Kyoto Protocol, which includes provisions for four market-oriented policy instruments: bubbles; joint implementation; the Clean Development Mechanism; and international emissions trading.[1] In November, 1998, the Fourth Conference of the Parties (COP4) met in Buenos Aires, Argentina, and established a work plan to develop rules governing the implementation of the Protocol's provisions, including the four flexibility mechanisms (United Nations 1998).

This paper investigates a central issue of climate policy architecture:[2] the structure and potential performance of the Kyoto Protocol's international trading mechanisms in the presence of a heterogeneous set (that is, diverse types) of domestic greenhouse policy instruments.[3] We focus on this issue because the Protocol explicitly and prominently provides for domestic sovereignty regarding instrument choice, and because previous policy

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1 See: United Nations 1997, Articles 4.1, 6.1, 12.2, and 17, respectively.

2 The general importance of focusing on "policy architecture" and institutions in the global climate domain was first noted by Schmalensee (1998). Subsequent contributions include: Stavins (1997); Hahn (1998); Jacoby, Prinn, and Schmalensee (1998); and Cooper (1998).

3 Tietenberg, et al. (1998) recognize the significance of this question, but do not pursue it. They point out three logical possibilities for international trades: (1) where both parties (countries) have domestic emissions trading systems; (ii) where neither party has a domestic trading system; and (iii) where one party has a domestic emissions trading system and the other does not (see also, Joshua, 1998). In this regard, they also note that trading can either be inter-governmental (what we call ITQ) or inter-source (ITP or JI).

experience suggests that many or most countries may *not* choose tradable permits as their sole or even primary domestic vehicles.[4]

In Part 2 of the paper, we review the key elements of the Kyoto Protocol and subsequent international policy proposals that bear upon the design and implementation of an international greenhouse gas trading system. In Part 3, we examine emissions trading systems that are allowed under the Protocol. This leads us to the centerpiece of our analysis, Part 4, where we investigate different institutions needed to achieve cost-effective results under the Protocol. We do this by examining potential pairs of domestic instruments in a home and a foreign country, where each nation has available to it domestic tradable permits, domestic carbon taxes,[5] and domestic fixed quantity standards. For each such pairing, we identify the additional set of cross-border instruments the home government should allow to achieve the global least-cost solution. In Part 5, we conclude with a summary of implications for global climate policy and research.[6]

We find that although the Kyoto Protocol *can* provide for an internally consistent international tradable permit program, a fully cost-effective international emission trading program is not compatible with the notion of full domestic sovereignty regarding instrument choice. Costs can be minimized if all countries use domestic tradable permit systems to meet their national targets and also allow for international trades. But when some countries use non-trading approaches such as greenhouse-gas taxes or fixed quantity standards, cost-minimization is not assured. Achieving the potential cost savings of international trading in these cases will require some form of project-by-project credit program, such as joint implementation. But theory and experience with credit programs suggest that they are less likely to facilitate major cost savings, partly because of the large transactions costs that are involved. Our conclusion is that individual nations' choices of domestic policy instruments to meet the Kyoto targets can limit substantially the cost-saving potential of an international trading program. Our view, however, is that international permit trading remains an attractive approach to achieving global greenhouse targets. This suggests the need to analyze the likely cost savings from feasible, as opposed to idealized, policy approaches to reducing international greenhouse gas emissions.

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[4] Thus, we take the Kyoto Protocol as given, and investigate policies that can facilitate its targets being achieved. We do not address the fundamental question of whether the Protocol is itself efficient. For alternative views on that question, see: Administration Economic Analysis (1998); Nordhaus (1998); and Schelling (1998).

[5] Carbon taxes are charges on fossil fuels--coal, petroleum, and natural gas--set proportional to their respective carbon contents. We focus on CO_2, and hence carbon taxes, although the Kyoto Protocol applies to five other greenhouse gases as well: methane; nitrous oxide, hydrofluorocarbons; perfluorocarbons, and sulfur hexafluoride. CO_2 accounts for the bulk of global warming potential and has been the focus of most policy discussions.

[6] In a previous paper, we outlined major design questions associated with the creation of an international greenhouse trading regime (Hahn and Stavins, 1995), and in an appendix to the present paper, we examine major design elements. A detailed investigation of such design issues is provided by Tietenberg et al. (1998). A concise overview is provided by Fischer, Kerr, and Toman (1998).

2. BACKGROUND: THE KYOTO PROTOCOL'S FLEXIBILITY MECHANISMS

The Kyoto Protocol contains seven major provisions.[7] First, the industrialized nations (the so-called "Annex B" parties) agree to reduce their emissions of six greenhouse gases by about five percent, on average, between 2008 and 2012, relative to 1990 levels. Different national emission reduction targets are used: the U.S. target is a seven percent reduction, for example; the European Union, an eight percent cut; Japan, a six percent cut; Russia, no change; and Australia, an eight percent increase. Second, trading of national emissions rights (targets) among Annex B parties (national governments) is allowed, but essentially undefined, as is project-by-project bilateral exchange of "emission reduction units"--joint implementation--among Annex B countries. Third, Annex B countries can receive credit, in an unspecified manner, for reductions accomplished in non-Annex B (developing) countries using the "Clean Development Mechanism" (CDM). Fourth, banking of emissions credits to subsequent periods is allowed, but targets for subsequent periods are not specified.[8] Fifth, nations are granted complete sovereignty in selecting domestic policy instruments to achieve their targets. Sixth, there are some ambiguous provisions for the counting of "sinks"--that is, carbon sequestration--principally through human-induced afforestation, reforestation, and retarded deforestation. Seventh, and finally, the Kyoto Protocol provides that the agreement enters into force only when it has been ratified by 55 nations, including Annex B nations that represent 55 percent of 1990 Annex B emissions. This last provision has the effect of making it unlikely that the Kyoto Protocol will come into force without ratification by the United States.[9]

In November, 1998, during the Fourth Conference of the Parties (COP4) in Buenos Aires, three major developments occurred. First, two non-Annex B (developing) countries--Argentina and Kazakhstan--announced that they would voluntarily take on emission reduction targets.[10] Although some observers began to speak of the "break up" of what had previously been described as the "G-77 monolith" of solid opposition to full developing country participation (Stevens, 1998b), there were no announcements of participation by potentially high-emitting developing countries, such as, China, India, Brazil, or Korea. Second, during the week of the Buenos Aires meeting, the U.S. government signed the Kyoto Protocol at United Nations headquarters in New York. Considering the fact that the U.S. Senate has gone on record as indicating that it will not ratify the Protocol until there is "meaningful

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[7] For a review of the Kyoto Protocol, its political economy, and major issues surrounding its implementation, see: Barrett (1998).

[8] Article 3.9 of the Kyoto Protocol indicates that commitments for future periods are to be initiated at least seven years prior to the end of the first commitment period. Hence, discussions of such commitments are to begin no later than 2005.

[9] Note that compliance tools are undefined in the Protocol.

[10] Kazakhstan, like the Russian Federation, is expected to have emissions well below its 1990 level in the 2008-2012 period, due to the severe economic recession that has occurred since the breakup of the Soviet Union. The target announced by Argentina is relative to a "business-as-usual" scenario in the 2008-20012 period; compliance with commitments relative to such hypothetical baselines is exceptionally difficult to verify (Stevens, 1998a).

participation" by developing countries (and President Clinton has stated that he will not submit the treaty to the Senate absent such progress), the New York signing had only symbolic value. But symbolism often matters in politics, and this action apparently won the United States delegation considerable credibility that paid off when further work on flexibility mechanisms was considered (Cushman, 1998). Third, the COP4 delegates adopted a work plan for the following two years, including schedules for simultaneous work on the development of rules for international trading, JI, and CDM (United Nations, 1998).

As mentioned earlier, the Kyoto Protocol contains four cooperative implementation and flexibility mechanisms: bubbles (Article 4.1); joint implementation (Article 6.1); the Clean Development Mechanism (Article 12.2); and international emissions trading (Article 17).[11] The international trading provision was adopted during the final, all-night session of COP3. Identification of "the relevant principles, modalities, rules, and guidelines" governing emissions trading was deferred to later conferences. After the Kyoto meeting, two major political proposals emerged: a "non-paper" that describes a flexible international trading regime, authored by the so-called "Umbrella Group" of Australia, Canada, Iceland, Japan, New Zealand, Norway, the Russian Federation, and the United States;[12] and a "non-paper" that favors a much more constrained trading program, authored by the United Kingdom on behalf of the European Union and its member states, plus Czech Republic, Slovakia, Croatia, Latvia, Switzerland, Slovenia, Poland, and Bulgaria.[13]

3. WHAT KIND OF EMISSIONS TRADING DOES THE PROTOCOL ALLOW?

The Kyoto Protocol provides--in some cases explicitly and in some cases implicitly--for several distinct types of emissions trading systems. Some of these are cap-and-trade programs, and some are emissions credit programs.

With regard to cap-and-trade systems, three categories have been discussed in the context of the Protocol. First, Article 17 clearly provides for nation-to-nation trading among Annex B parties. We call this "international tradable quotas" (ITQ), following the language adopted by the Intergovernmental Panel on Climate Change.[14] Second, because the Protocol explicitly recognizes the primacy of national sovereignty for the design and adoption of domestic policies intended to achieve national targets, the Protocol may be said to implicitly allow for domestic tradable permit systems among private entities; we call such domestic systems “tradable permits" (TP). Third, although the Protocol makes no mention of international exchanges of emission rights among private entities, there is discussion of this in

[11] Additional flexibility is provided by provisions on multiple gas averaging, the use of sinks, and intertemporal averaging.

[12] See: Australia, Canada, Iceland, Japan, New Zealand, Norway, Russian Federation, and United States (1998).

[13] See: United Kingdom of Great Britain and Northern Ireland (1998).

[14] See: Barrett, Bohm, Fisher, Kuroda, Mubazi, Shah, and Stavins (1996).

the two "non-papers," mentioned above, and it has been assumed in a number of studies.[15] We call such cross-border private transactions (from within Annex B nations with domestic TP systems) "international tradable permits" (ITP).[16]

With regard to emission credit programs, the Kyoto Protocol explicitly provides for joint implementation: project-by-project exchanges among private entities in Annex B countries. To some degree, this is the credit version of the cap-and-trade concept we refer to as ITP. Finally, the Protocol (and much subsequent discussion by delegates at COP4 in Buenos Aires) provides for Annex B countries to earn credits against their national targets by financing emission-reduction projects in developing (non-Annex B) countries. This is the Clean Development Mechanism (CDM). Hence, the Kyoto Protocol explicitly allows for ITQ (and JI and CDM), and implicitly allows for TP, thus rendering ITP a logical possibility. Why should we bother to consider this broad range of alternatives, especially when some are--at best--only implicit or logically possible? After all, the Protocol explicitly allows Annex B nations to engage in international emissions trading under Article 17, what we call ITQ. Is ITQ on its own sufficient to achieve international cost effectiveness? The answer, unfortunately, is "no."

There are two primary reasons ITQ is not sufficient. First, recall that tradable permit systems translate non-cooperative, self-interested behavior into collective cost-minimization when the participants in the trading system are profit-maximizing or cost-minimizing agents operating in a competitive market (Baumol and Oates 1988). But nation-states are not simple cost-minimizing agents, and even if they were, they tend to lack the information required to make such cost-effective trades.[17] Absent something approximating the theoretical construct of atomistic, cost-minimizing firms operating in a competitive environment, there is no reason to anticipate that marginal abatement costs will be equated and a cost-effective allocation achieved.[18] Second, even if nation-states met these criteria, they would--at best--equate their *national* marginal abatement costs based on the use of domestic regulations that may not be

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[15] See, for example: Tietenberg, Grubb, Swift, Michaelowa, Zhang, and Joshua (1998).

[16] If the rules that are eventually developed to govern the ITQ system allow individual nations to devolve assigned amounts to domestic legal entities, then ITP's will become possible. Another possibility is the exchange of emission rights between an Annex B government and private entities in another Annex B country. Because governments would be one of the agents of exchange in such bilateral transactions, we assume that this instrument is inferior--in cost-effectiveness terms--to international tradable permits. We do not consider these instruments explicitly in our analysis, but we recognize that Russia might be a significant supplier of credits to other Annex B countries.

[17] There is very little research that direct examines the degree to which national governments would even attempt to cost-minimize in an international trading regime. Schwarze (1999) asserts that "broader geopolitical as well as cultural factors rather than narrow cost-effectiveness are the moving forces behind emissions trading among nations," and supports this claim--in part--by surveying actual JI projects executed under the Berlin Mandate of the Framework Convention on Climate Change.

[18] Bohm (1999), however, argues that governments actually do have incentives to behave as cost-minimizing agents and, further, that they tend to have the required information. There is some experimental evidence supporting this view (Bohm and Carlén, 1999).

cost-effective. Thus, total, international abatement costs could still exceed the cost minimum by a large margin, because source-level marginal abatement costs would not necessarily be equated within countries.

Recognizing this reality leads us to ask whether transboundary (international) inter-firm and intra-firm trades (international tradable permits or ITP's) can compensate for those deficiencies in the ITQ system and lead to a truly cost-effective outcome. The answer--in theory--is "yes." Consider, by way of analogy, the successful SO_2 allowance trading program being used in the United States to reduce acid rain.[19] What if the permits had not been allocated directly to coal-burning electrical utilities, but to the governors of the affected states? The governors, absent competitive market pressures and requisite information, and facing all sorts of political incentives, would probably not carry out an efficient set of trades. But if the governors devolved the respective property rights to legal entities within their respective jurisdictions, in particular, to the affected utilities, then those firms would face competitive pressures to carry out cost-effective intra-state and inter-state trades, thus undoing any "mistakes" made by the state governments.

It is in this sense that ITP's can--in theory--compensate for the inherent limitations of an ITQ regime. But notice in the above analogy the assumption that the governors had *devolved the property rights to legal entities* within their borders; in other words, each and every state had set up a tradable permit program with its borders.[20] This illustrates the nature of the problem we address below: the performance of the Kyoto Protocol's ITQ regime will depend in fundamental ways on the specific set of *domestic* CO_2 policy instruments that are adopted by participating nations.[21]

4. WHAT ADDITIONAL INSTRUMENTS ARE NEEDED TO HELP PROMOTE COST EFFECTIVENESS UNDER THE PROTOCOL?

Is the sort of permit trading directly allowed by the Kyoto Protocol likely to lead to a cost-effective outcome? We approach this question by investigating the potential performance of the Protocol's ITQ system (Article 17) in the presence of a heterogeneous set of domestic instruments because the Protocol provides for domestic sovereignty regarding instrument choice. International policy experience suggests that many or most countries may *not* choose tradable permits as their sole or even primary domestic vehicle. One important key exception, of course, is the United States. Even in the case of the United States, however, it is difficult to imagine a tradable permit system being adopted as the sole mechanism for

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[19] See: Schmalensee, Joskow, Ellerman, Montero, and Bailey (1998); and Stavins (1998).

[20] The Umbrella Group's "Non-Paper" makes the point this way: "Devolving the ability to trade would be likely to increase the number of trades, thus enhancing competition in the market. Private sector legal entities would have direct knowledge of their abatement opportunities and costs and would likely be better placed to make decisions based on this information than would governments" (Australia, et al. 1998, p. 3).

[21] Zhang (1998) recognizes the identity between a system in which "sub-national entities" can trade internationally and a system in which nations have established domestic tradable permit systems (and allowed legal entities to trade on the international market).

achieving a national CO_2 emissions target. More likely, a portfolio of instruments would be implemented, including a tradable permit system, fuel efficiency standards on particular products, and some types of charge mechanisms.

We examine potential pairs of domestic instruments in a home and a foreign country, where each nation has available to it: domestic tradable permits; domestic carbon taxes; and domestic fixed quantity standards. For each such pairing, we identify the additional set of cross-border instruments the home government should allow to achieve the global least-cost solution. Two types of trading instruments are examined: ITP, where at least one country has a domestic TP system; and JI (or CDM in the case of non-Annex B countries). To focus on the fundamental architectural problem, we assume perfect enforcement, no transaction costs, no uncertainty, no leakage, and no baseline problems, but when these assumptions are relaxed, the insights gained become more important.

The results of our analysis are summarized in Table 1, where nine principal instrument pairs are examined for Annex B countries, plus three additional cases when non-Annex B countries are included. The cells in the table identify a sufficient set of additional, domestic (cross-border) instruments that the home country can implement for international cost effectiveness to be achieved.[22] Each country can adopt one of three domestic instruments:[23] tradable permits, taxes, or quantity standards.[24]

4.1 A Simple Case: ITQ When All Nations Have Domestic Tradable Permit (TP) Programs

The single case that all design studies up until now have examined is the one case for which aggregate costs have been estimated: where participating countries have devolved their assigned amounts to domestic legal entities (adopted domestic tradable permit programs), *and* authorized regulated entities to engage in and be credited for international exchanges.[25] Under such circumstances, we have the textbook case of a fully-efficient tradable-permit market, as pictured in Figure 1.1.[26] If the initial ITQ allocations of abatement responsibilities

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[22] Where ITP and JI are both feasible, and one is needed, ITP is selected because it is likely to involve significantly lower transaction costs.

[23] Most countries, including the United States, are likely to employ portfolios of domestic instruments, but we simplify our analysis to that of one instrument per country for analytical convenience. Were this simplifying assumption to be relaxed, our conclusions would be strengthened, not weakened.

[24] Specification of the necessary set of cross-border instruments depends on assumptions regarding the effectiveness of particular instruments. If, for example, two countries employ domestic TP systems, and ITQ is effective in equating marginal control costs across countries, then no additional instruments are needed. The cells in Table 1 that include only JI or CDM represent necessary instruments if ITQ is assumed not to be effective.

[25] We do not intend to suggest that authors of these studies would themselves necessarily claim that a truly cost-effective international emissions trading program is feasible. Analysis of the simple case can provide a useful benchmark; our point is only that the analysis ought not stop there, because the results of the simple analysis *can* be misleading. Also, of course, another case that has been estimated is the case of *no* trade.

[26] Note that figure numbers also refer to cells in the table discussed in the text.

Table 1: Instruments for Achieving Gains from Flexible Mechanisms Under the Kyoto Protocol[1]

DOMESTIC INSTRUMENT IN FOREIGN COUNTRY "F"		DOMESTIC INSTRUMENT IN HOME COUNTRY "H" (Annex B Country)								
		TP System			Carbon Tax			Fixed Quantity Standard		
Annex B Country	TP System	1.1 Devolution of Parties' Assigned Amounts to Legal Entities and ITP Authorization			1.2.1 $T_H<P_F$	1.2.2 $T_H=P_F$	1.2.3 $T_H>P_F$	1.3.1 $MC_H<P_F$	1.3.2 $MC_H=P_F$	1.3.3 $MC_H>P_F$
					Allow JI Hosting	–	Allow ITP Purchase	Allow ITP Purchase & JI Hosting	Allow ITP Purchase & JI Hosting	Allow ITP Purchase & JI Hosting
	Carbon Tax	2.1.1 $P_H<T_F$	2.1.2 $P_H=T_F$	2.1.3 $P_H>T_F$	2.2.1 $T_H<T_F$	2.2.2 $T_H=T_F$	2.2.3 $T_H>T_F$	2.3.1 $MC_H<T_F$	2.3.2 $MC_H=T_F$	2.3.3 $MC_H>T_F$
		Allow ITP Sale	–	Allow JI Funding	Allow JI Hosting	–	Allow JI Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding
	Fixed Quantity Standard	3.1.1 $P_H<MC_F$	3.1.2 $P_H=MC_F$	3.1.3 $P_H>MC_F$	3.2.1 $T_H<MC_F$	3.2.2 $T_H=MC_F$	3.2.3 $T_H>MC_F$	3.3.1 $MC_H<MC_F$	3.3.2 $MC_H=MC_F$	3.3.3 $MC_H>MC_F$
		Allow ITP Sale & JI Funding	Allow ITP Sale & JI Funding	Allow ITP Sale & JI Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding	Allow JI Hosting & Funding
Non-Annex B Country		4.1.1 $P_H<MC_{FP}$	4.1.2 $P_H=MC_{FP}$	4.1.3 $P_H>MC_{FP}$	4.2.1 $T_H<MC_{FP}$	4.2.2 $T_H=MC_{FP}$	4.2.3 $T_H>MC_{FP}$	4.3.1 $MC_H<MC_{FP}$	4.3.2 $MC_H=MC_{FP}$	4.3.3 $MC_H>MC_{FP}$
		–	–	Allow CDM Funding	–	–	Allow CDM Funding	Allow CDM Funding	Allow CDM Funding	Allow CDM Funding

[1]Instruments that can be allowed for by national governments; that is, one set of cross-border instruments for home country H to achieve the least-cost solution (with respect to participating nations and firms) from the use of flexible mechanisms under the Kyoto Protocol, assuming perfect enforcement, no transaction costs, no uncertainty, no leakage, and no baseline problems. P_F and P_H are the equilibrium prices of tradeable permits in countries F and H, respectively; T_F and T_H are the carbon tax rates in those countries. MC_H is shorthand for $MC_H(Q_H)$, the marginal cost for country H firms to achieve the aggregate quantity target, Q_H; likewise, MC_F is shorthand for $MC_F(Q_F)$; and MC_{FP} is shorthand for $MC_F(q_{AP})$, the project-specific marginal cost in (non-Annex B) foreign country F.

Figure 1.1

Home Instrument = Tradeable Permit System
Foreign Instrument = Tradeable Permit System

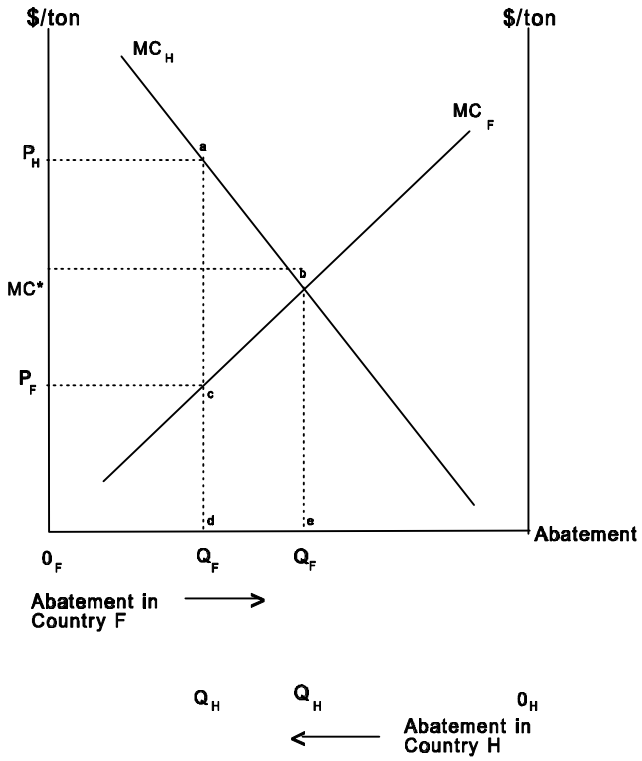


Figure 1.2.1

Home Instrument = Carbon Tax
Foreign Instrument = Tradeable Permit System

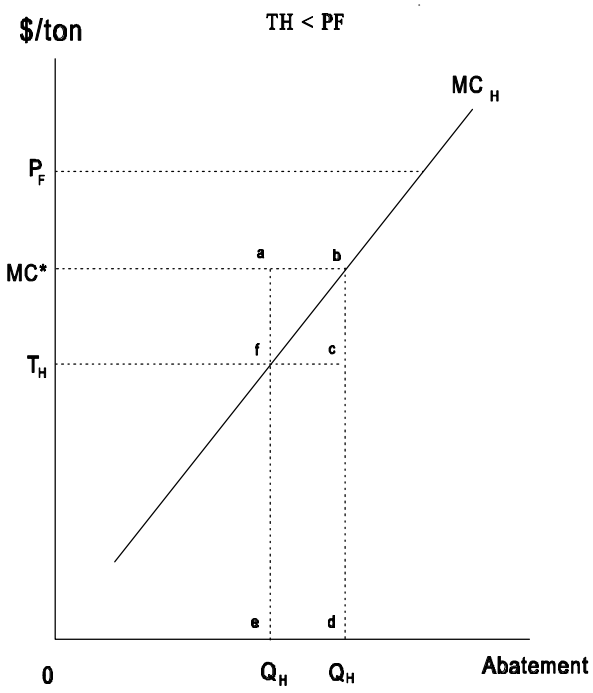


Figure 1.2.3

Home Instrument = Carbon Tax
Foreign Instrument = Tradeable Permit System

TH > PF

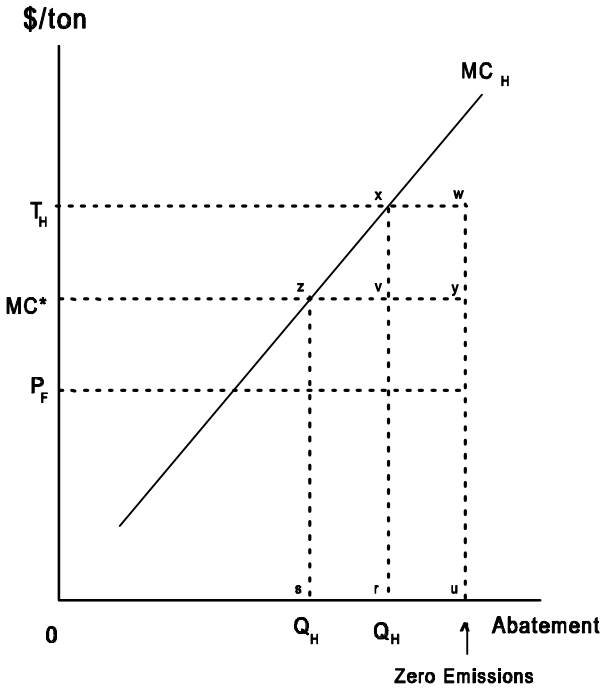
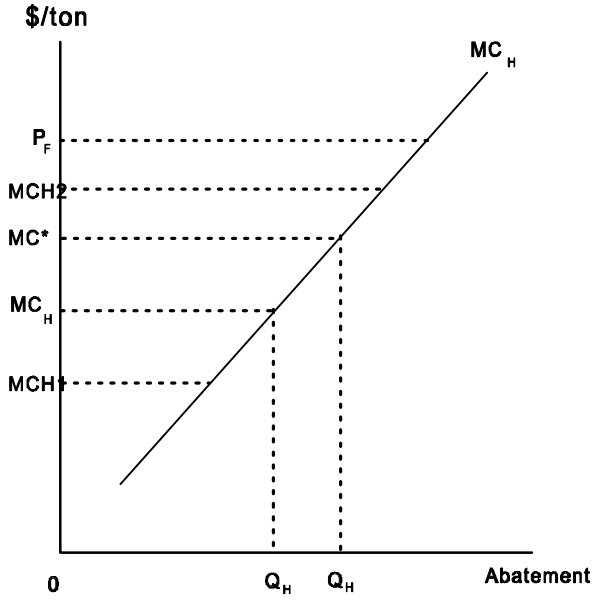


Figure 1.3.1

Home Instrument = Fixed Quantity Standard
Foreign Instrument = Tradeable Permit System

MC H < P H



to the home country's (H's) government and to the foreign country's (F's) government are Q_H and Q_F, respectively, then a combination of domestic (TP) and international trading (ITP) can be expected to lead to the cost-minimizing allocation of responsibility, Q_H' and Q_F', at the equilibrium permit price, MC^*.

This initial case--where both parties--have established appropriate domestic tradable permit regimes, is summarized in cell 1.1 of Table 1.[27] This is an attractive case. There would be a very large number of participants in the international scheme, increasing the total number (and amount) of transactions, improving market liquidity, and reducing the likelihood of nations exercising market power (Zhang, 1998). And, as suggested earlier, individual firms--with knowledge of their technological options and opportunity costs--would have the incentive and the ability to cost minimize.[28] Not only is this an attractive case in normative terms; it is also a relatively "easy" case. The design issues are well defined, and it is relatively straightforward to predict costs by equating marginal abatement costs in a suitable simulation model.[29] But, although this may be an attractive and easy case, it is most certainly *not* the only case, and, in fact, it may be a relatively minor case, given the environmental and fiscal policy histories of the Annex B nations.[30]

We turn next to the more interesting, more difficult, and more realistic cases where at least one of a pair of trading nations has adopted something other than a domestic permit trading system as its internal policy approach.

4.2 ITQ in the Presence of Heterogeneous Domestic Instruments

Given the three instruments we are considering, there are five other possible pairings of domestic climate policy instruments for Annex B countries: TP and a carbon tax; TP and a fixed quantity standard; a fixed quantity standard and a carbon tax; carbon taxes in both countries; and fixed quantity standards in both countries. We examine each in turn.

4.2.1 TP and a Carbon Tax

It is helpful to consider two variants of this pairing, one where the home country employs a carbon tax (cell 1.2 in Table 1), and the other where the home country employs a TP system (cell 2.1). In the first case, we initially consider a situation where the home carbon

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[27] Cell 1.1 refers to all three cells--1.1.1, 1.1.2, and 1.1.3--noted in the table. Similar notation applies to other cells.

[28] Zhang (1998) notes some potential disadvantages of ITP's relative to a pure ITQ system: greater administrative complexity; and a perceived loss of control by national governments over their ability to meet their national targets.

[29] Even in this "easy case," there are a host of challenging design issues that need to be considered. See, for example: Harrison (1997).

[30] On the other hand, it should be recognized that domestic greenhouse-gas emissions trading systems are at least receiving consideration in a number of countries, in addition to the United States: Australia (Young, Lee, Lack, Hemming, and Musdilak, 1998); Canada; Denmark; New Zealand (New Zealand Ministry for the Environment, 1999); Norway; and the United Kingdom (Haites, Eric, personal communication, February 20, 1999).

tax rate, T_H, is less than the equilibrium permit price in the foreign country, P_F, with MC^*, the international equilibrium shadow price of carbon, lying between the two. As is illustrated in Figure 1.2.1, firms in country B with marginal abatement costs given by MC_H would initially abate at level Q_H. Because abatement costs are higher in the foreign country, as indicated by the higher value for P_F, firms have an incentive to increase their abatement to $Q_{H'}$, increasing their abatement costs (by trapezoid fbde), and saving tax payments (equal to rectangle fcde), if they can generate saleable credits greater in value than their net cost (triangle fcb). Since there is a carbon tax, not a domestic tradable permit system in the home country, the best the firms can do is host JI projects, financed by the foreign country or its firms. Thus, in order for costs to be minimized in this case, the home country must allow for JI project hosting (see cell 1.2.1).[31]

Next, consider a situation where the home carbon tax rate, T_H, is greater than the equilibrium permit price in the foreign country, P_F, with MC^* again functioning as the international shadow price of carbon.[32] As illustrated in Figure 1.2.3, firms in country B would initially carry out abatement at level Q_H, paying taxes on residual emissions (equal to rectangle xwur). Because abatement costs are less in the foreign country (i.e. P_F is less than T_H), firms now have an incentive to reduce their abatement to $Q_{H'}$. This reduces their overall costs (by trapezoid zxwy) if they can purchase ITP's from the foreign country at MC* and be granted exemptions from the domestic tax (equal to the number of ITP's purchased multiplied by T_H). In order for costs to be minimized in this case, the home country must allow for ITP purchases and tax exemptions (see cell 1.2.3).

Now we can briefly consider the converse situation where the home country employs a TP system and the foreign country uses a domestic carbon tax. As illustrated in Figure 2.1.1, if the home country's domestic permit price, P_H, is less than the carbon tax, T_F, in the other country, then there is an incentive for the home country to increase its abatement if firms can sell ITP's to the other country (cell 2.1.1). If, on the other hand, the domestic permit price exceeds the foreign tax rate, then cost effectiveness can be achieved only if funding of JI projects is allowed (cell 2.1.3).

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[31] It is also logically possible that the government could adjust the home carbon tax to equal the international shadow price (and engage in government-government (ITQ) transactions). But since our premise is that governments are unlikely to engage in a cost-effective set of trades, it is not clear that it is any more likely that governments will continuously and appropriately change their domestic taxes to match international shadow prices. Furthermore, for governments to carry out such actions, they require knowledge of their domestic marginal abatement costs. If a nation is utilizing domestic tradable permits or a domestic carbon tax, then it can infer its marginal abatement costs, but if it is employing a fixed quantity standard internally, it does not have a simple way of estimating its domestic marginal abatement costs.

[32] The cases where marginal costs are already equated within and across countries such as cell 1.2.2, are not considered because they are unlikely to occur in practice.

Figure 2.1.1

Home Instrument = Tradeable Permit System
Foreign Instrument = Carbon Tax

PH < TF

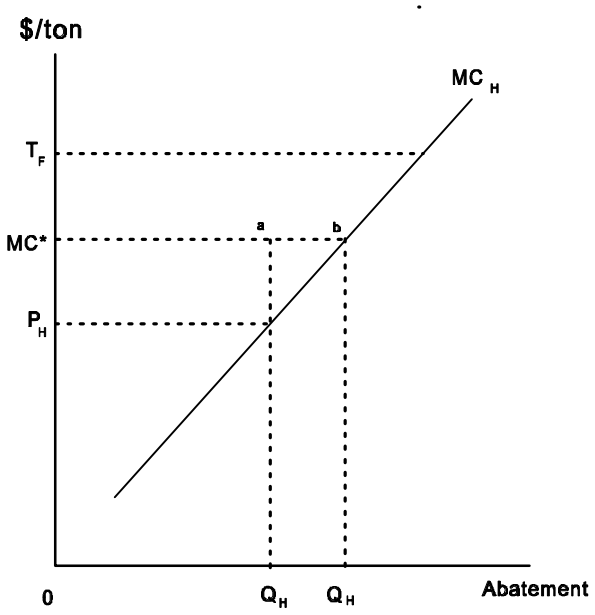


Figure 2.2.1

Home Instrument = Carbon Tax
Foreign Instrument = Carbon Tax

TH < TF

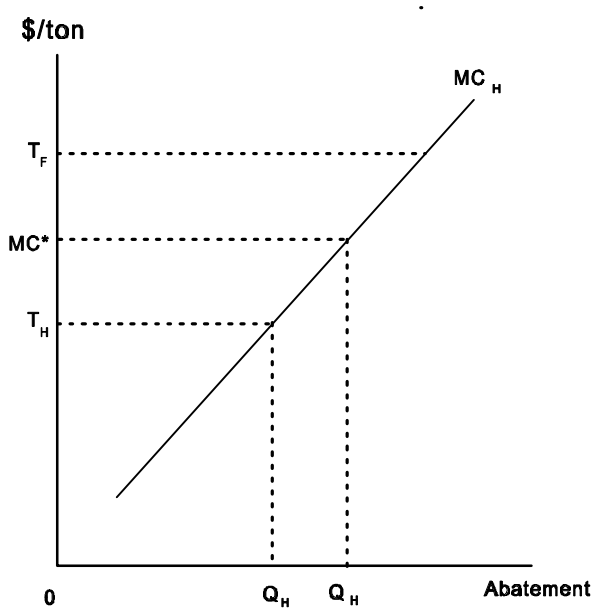
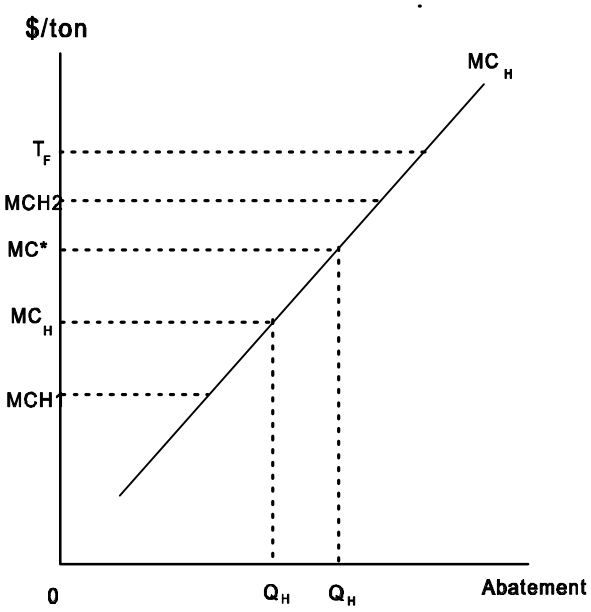


Figure 2.3.1

Home Instrument = Fixed Quantity Standard
Foreign Instrument = Carbon Tax

MCH < TF



4.2.2 TP and a Fixed Quantity Standard

If the home country employs a fixed quantity standard and the foreign country employs a tradable permit system (cell 1.3), then marginal abatement costs for any particular source (e.g. MC_{H1} or MC_{H2}) can be either greater or less than the international shadow price of carbon.[33] Hence, in order for cost effectiveness to be achieved, the home government must allow both for ITP purchasing and JI hosting, regardless of whether national marginal abatement costs, MC_H, are greater than, equal to, or less than (Figure 1.3.1) permit prices in the other country.

Not surprisingly, in the converse situation, where the foreign country employs a fixed quantity standard, the analogous conditions hold, namely the home country must provide for ITP sales and JI funding (Figure 3.1.1, cell 3.1).

4.2.3 Carbon Tax and a Fixed Quantity Standard

When the home instrument is a carbon tax and the foreign instrument is a fixed quantity standard, as illustrated in Figure 3.2.1, then no matter what the relation between domestic marginal abatement costs and the tax rate in the other country, if cost effectiveness is to be achieved, it is necessary for the home country to allow JI hosting and funding, since in this case JI is the only international instrument that can be employed (cells 3.2). When the home instrument is a fixed quantity standard (Figure 3.2.1), and the foreign instrument is a carbon tax, the same results hold: cost effectiveness requires that the home country allow JI hosting and funding (cells 3.2). In both cases, there is a need to equate marginal control costs in the country with the quantity standard, and JI is the only available instrument.

4.2.4 Carbon Taxes in Both Countries

When both countries utilize domestic carbon taxes (Figure 2.2.1, for example, where T_H is less than T_F), then joint implementation is again the only instrument that can be used to exchange "emission rights" internationally in order to equate marginal abatement costs. Depending upon the relationship between the home country's carbon tax rate and the rate in the foreign country, it becomes necessary for the home country to allow JI hosting or funding (cells 2.2.1 and 2.2.3, respectively).[34]

4.2.5 Fixed Quantity Standards in Both Countries

The final relevant category for pairs of Annex B countries is illustrated in Figure 3.3.1 for the case where marginal abatement costs in the home country are less than marginal abatement costs in the foreign country for a given allocation of emission reductions. Because

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[33] The fixed quantity standard is assumed to be implemented in a way that marginal costs of control differ across sources.

[34] It is logically possible that the government could enter into ITQ exchanges in an international market when home and foreign carbon taxes are not equal, and thereby receive gains from trade. But our premise is that governments are unlikely to engage in a cost-effective set of such trades.

Figure 3.1.1

Home Instrument = Tradeable Permit System
Foreign Instrument = Fixed Quantity Standard

$P_H < MC_F$

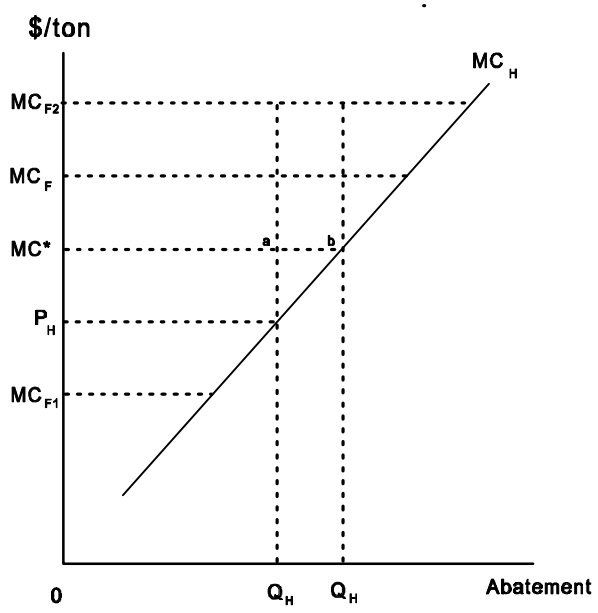


Figure 3.2.1

Home Instrument = Carbon Tax
Foreign Instrument = Fixed Quantity Standard

$T_H < MC_F$

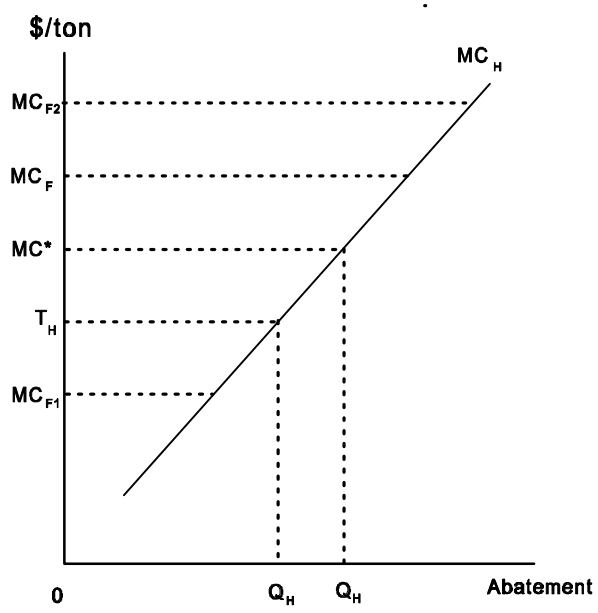
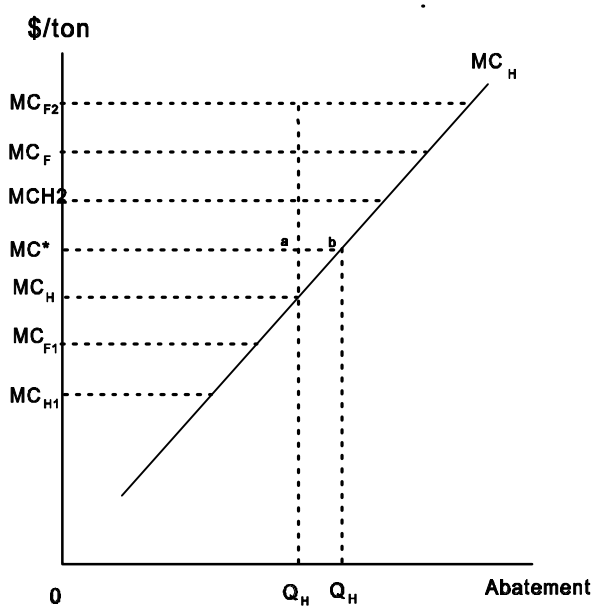


Figure 3.3.1

Home Instrument = Fixed Quantity Standard
Foreign Instrument = Fixed Quantity Standard

$MC_H < MC_F$



of the use of fixed quantity standards in both countries, any relationship can hold between source-specific marginal abatement costs in the two countries. As a result, it is always necessary for the home country to allow both JI hosting and funding if cost-effective exchanges are to take place.

4.3 Bringing Developing Countries into the Picture

The final row in Table 1 allows for the possibility that the foreign country is a non-Annex B (developing) country. When the home (Annex B) country employs a domestic TP system, there is an incentive for exchanges only if the domestic permit price, P_H, exceeds project-specific marginal abatement cost, MC_{FP}, in the non-Annex B nation. In this case, the home country must allow for CDM funding to be credited in the domestic tradable permit program (cell 4.1.3). Likewise, when the Annex B country uses a domestic carbon tax, then an incentive exists for exchange with the developing country only if the domestic tax rate, T_H, exceeds the project-specific marginal abatement cost, MC_{FP}, in the non-Annex B nation, and the home country allows for CDM funding to yield tax credits in the domestic program (cell 4.2.3). Finally, for those Annex B countries that employ domestic fixed quantity standards, incentives for individual sources to carry out exchanges can exist regardless of the relationship between national marginal abatement costs, MC_H, and project-specific marginal abatement cost, MC_{FP}, in the non-Annex B nation. In this case, the Annex B country must allow for CDM funding to provide exemptions from the domestic quantity standards.[35]

The general impression that emerges from Table 1 is that the likelihood of cost effectiveness being achieved, in many cases, will depend upon the set of cross-border instruments that are adopted to complement the use of diverse domestic climate policies. Contrary to what is often assumed, ITP's may play a relatively minor role, unless--of course--the major nations choose to adopt domestic tradable permit systems. Under the current structure of the Kyoto Protocol, an ITQ system operating in the world of heterogeneous domestic instruments might mainly be supplemented by the employment of project-based joint implementation exchanges, which are expected to bring with them significant transaction costs,[36] thereby reducing the overall cost effectiveness of the system.

5. IMPLICATIONS FOR POLICY AND RESEARCH

Virtually all quantitative analyses of the costs of international action to address the threat of global climate change have implicitly assumed one of the following: (1) that all countries adopt a domestic tradable permit system as their vehicle for achieving their target; or (2) that all countries adopt either a domestic tradable permit system or a domestic

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[35] For an assessment of the potential relationship between CDM and international emissions trading, see: Toman, Kopp, and Cazorla (1998).

[36] See, for example: Lile, Powell, and Toman (1998). Further, given the substance on-going international negotiations regarding potential rules governing the admissibility of projects for joint-implementation purposes, it is unlikely that the set of acceptable JI projects would approximate the true cost-effective allocation.

greenhouse gas tax instrument *and* adopt a tax rate that equals the international equilibrium permit price. If either of those assumptions is valid, then an international tradable permit system can be expected operate in a highly cost-effective manner. But if neither of those assumptions are valid--which we believe to be the more likely outcome--then our analysis has several implications for global climate policy and research.

First, a truly cost-effective international emission trading program is *not compatible* with the notion of full domestic sovereignty regarding instrument choice. The international rules of the trading system need to facilitate the set of domestic, cross-border exchanges that are also necessary. Unfortunately, governments may not find it in their interests to provide for the full set of cross-border instruments. For example, governments have incentives to discourage international permit trading to maintain revenues from domestic carbon taxes.[37]

Second, with most combinations of domestic policy instruments, a significant fraction of Annex B international exchanges would have to be in the form of joint implementation (and CDM in the case of exchanges with non-Annex B nations). But, JI (and CDM) will likely involve relatively high abatement costs and transaction costs. Thus, the overall cost effectiveness of the system will fall short of the theoretical ideal.[38] Future research should examine the design not only of "optimal" systems, but also feasible ones, such as "ITQ plus JI." In addition, other multi-instrument systems, which involve more than one policy instrument, should be examined both within and across countries. Indeed, most countries can be expected to adopt more than one type of domestic policy instrument to address this problem.

Third and finally, real-world abatement costs associated with the execution of a feasible program may be much greater than implied by simulations of the cost-effective solution. Analysis is needed of the costs of international trading in the context of diverse types of domestic policy instruments.

In summary, we find that although the Kyoto Protocol *can* provide for an internally consistent international tradable permit program, a fully cost-effective international emissions trading program is not compatible with the notion of full domestic sovereignty regarding instrument choice. Costs can be minimized if all countries use domestic tradable permit

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[37] In addition, trading in any country will be severely restricted, contrary to some of the more extravagant claims that have been made. Only entities that are directly regulated domestically will have a strong incentive to engage in international trades. For example, if the United Kingdom uses domestic, upstream carbon taxes as its principal instrument for meeting its targets, then utilities in the country will have no incentive to participate in international exchanges. Since upstream carbon taxes impose the tax on fossil fuels at the point of production or import, their effect is to change relative prices of energy sources downstream, such as for electrical utilities. In such a situation, a utility cannot be granted a government waiver from tax liability in exchange for purchasing credits overseas, since it is not, in fact, paying the tax directly, simply a higher price for some fuels. In theory, the government could grant a subsidy to the utility, proportional to the relative tax on various fuels, but this would require knowledge of the actual structure of tax incidence.

[38] Most researchers would make this argument even more strongly in the case of CDM, because of the baseline problems associated with the participation of countries that do not have explicit caps on emissions. A somewhat more optimistic view is provided by Kerr and Hargrave (1998).

systems to meet their national targets and allow for international trades, as well. But when some countries use non-trading approaches such as greenhouse-gas taxes or fixed quantity standards, cost-minimization is not assured. Achieving the potential cost savings of international trading in these cases will require some form of project-by-project credit program. But theory and experience with credit programs suggest that they are less likely to facilitate major cost savings. Our general conclusion is that individual nations' choices of domestic policy instruments to meet the Kyoto targets can limit substantially the cost-saving potential of an international trading program. Our view, however, is that international permit trading remains an attractive approach to achieving global greenhouse targets. This suggests the need to analyze the likely cost savings from feasible, as opposed to idealized, policy approaches to reducing international greenhouse gas emissions.

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