# MIT Joint Program on the Science and Policy of Global Change

## Supplementarity: An Invitation to Monopsony?

A. Denny Ellerman and Ian Sue Wing

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This report is one of a series intended to communicate research results and improve public understanding of climate issues, thereby contributing to informed debate about the climate issue, the uncertainties, and the economic and social implications of policy alternatives. Titles in the Report Series to date are listed on the inside back cover.

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# Supplementarity: An Invitation to Monopsony?

A. Denny Ellerman and Ian Sue Wing[1]

**Abstract**

*Article 17 of the Kyoto Protocol allows Annex B parties to meet their commitments by trading greenhouse gas emissions reductions "supplemental" to domestic emissions control. We demonstrate that implementing supplementarity by imposing concrete ceilings on imports of allowances in a market for tradable emissions rights gives rise to monopsonistic effects, even with price-taking behavior by both buyers and sellers. We assess the importance of this finding for Annex B emissions trading, in the context of the import and export provisions of the recent EU Proposal on supplementarity. Our results show that the proposal would reduce efficiency, and could significantly alter the distribution of the gains from trade in an Annex B tradable permits market.*

**Contents**



## 1. INTRODUCTION

Article 17 of the Kyoto Protocol allows Annex B parties to meet their commitments under the Protocol by greenhouse gas (GHG) emissions trading so long as such trading is "supplemental" to domestic emissions control. Supplementarity in this context refers to the level of imports of tradable emissions permits relative to abatement undertaken domestically.

The language of Article 17 clearly prohibits any party from relying entirely upon imported permits to meet its commitment, but this limiting case is implausible. Each party faces a schedule of identifiable GHG abatement opportunities, ranging in costs from near-zero to very high, and it is reasonable to assume that parties would utilize these opportunities in a cost-effective manner. Since every party would undertake some cheap domestic abatement, further elaboration of the meaning of the supplemental provisions of the Kyoto Protocol could be deemed unnecessary.

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Indeed, the Umbrella Group, consisting of Annex B parties that are not members of the European Union (EU), have adopted this interpretation; however, the EU and its members maintain that something more is required: an explicit quantitative limit, commonly referred to as a "concrete ceiling." To this end, the EU advanced a specific proposal to implement the supplemental provisions of the Kyoto Protocol at the June 1999 meeting of the Subsidiary Bodies in Bonn.

This paper analyzes the effects of a limit on permit imports under the usual analytic assumptions: namely, that all Annex B parties meet their Kyoto Protocol obligations and that free trade in permits among these parties is a realistic possibility. The paper proceeds in two parts. First, we address an aspect of supplementarity about which previous analyses have been remarkably silent: the inherently monopsonistic effects of a restriction[2] on permit imports. Then, we present and explain the EU proposal, which is more complicated than the simple quantitative limits that have been analyzed in earlier studies. In particular, we examine how various provisions of the EU proposal affect the efficiency and equity attributes of emissions trading in an Annex B market. A final section concludes, and a mathematical appendix presents proofs for the essential points made in the body of the paper.

## 2. THE MONOPSONISTIC EFFECTS OF SUPPLEMENTARITY

A number of studies have examined the effect of restricting permit imports,[3] and they present broadly similar conclusions, namely,

- Misallocation of resources that increases the global cost of compliance with the Kyoto target,
- Reduction in the gains from emissions trading for exporters of permits, and
- Reduction in the cost of meeting importers' emissions-control obligations for <u>some</u> levels of restriction.

The last point is an important one; however, several studies missed it entirely (Ellerman and Decaux, and Ellerman, Jacoby and Decaux), and others observed the effect without drawing the full implications. Both Bernstein *et al.* and Bollen *et al.* note the irony of results they obtain in which the US, which opposes such restriction, is made better off by it, while the EU, which advocates such restriction, benefits less or not at all. Criqui *et al.* produce results indicating that *all* importers of tradable permits gain for *some* level of restriction. They describe a U-shaped curve whereby the total cost for importers declines initially, as an import restriction of increasing severity is imposed, and then rises until it reaches the higher cost level associated with autarky.

These results describe the effects of monopsony, yet surprisingly none of these studies recognize that the implementation of supplementarity implies an exercise of monopsonistic

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[2] To avoid confusion in terminology, we use the term "restrict" in all its forms when referring to the effect of the supplementarity provisions, while "constrain" and all its forms refers to the emission reduction obligations under the Protocol. Thus, a restricted party will be a constrained party, but a constrained party is not necessarily restricted.

[3] In particular, see the articles by Bernstein *et al.* (1999) and Bollen *et al.* (1999) in the special issue of the *Energy Journal* devoted to the Kyoto Protocol. Criqui *et al.* (1999), Ellerman and Decaux (1998), and Ellerman, Jacoby, and Decaux (1998) also address the effects of supplementarity in broader discussions of emissions trading.

power. Bernstein *et al*. dismiss their result as accidental ("very sensitive to assumptions about baselines and a variety of elasticities and other parameters," p. 247) and they stress that it should not be taken "as a strong guide to policy." Criqui *et al*. correctly identify the effects as a more general consequence of implementing restrictions, but cloud this central insight with a discussion of compensation of exporters. Bollen *et al*. mention monopsony, only to dismiss the possibility by arguing that "restrictions are not the result of monopsonistic optimizing behavior," as if intent were all that mattered. Other studies have discussed the potential exercise of market power in permit markets, but the focus has always been on the relation of that potential to the initial allocation of permits.[4] None have pointed out that a concrete ceiling provides a coordinating mechanism for restricting demand that could be as effective as overt collusion among buyers or the exercise of market power by a significant importer.

Monopsonistic effects are illustrated most easily by assuming a competitive market in which all agents are price takers. Such a market structure would be more likely to obtain if Annex B parties' assigned amounts were downloaded to agents within each economy and those agents were free to trade within or across borders. With no restrictions on emissions trading, a free-trade equilibrium would obtain in which the marginal costs of abatement would be equalized across sources, the global cost of compliance would be minimized, and the gains from trade maximized.

Any effective restriction on permit imports will change total cost for the restricted party, as well as for other market participants, and that change can be illustrated by the following differential.

$$dTC_i = [f_i(a_i) - p]da_i + m_i dp \tag{1}$$

For a party $i$, $dTC_i$ is the change in the total cost of emissions reduction, which may be achieved by undertaking abatement $a_i$ (a small change in which is written $da_i$) or importing permits $m_i$. The $i$th party's marginal cost of domestic emissions control is determined by a marginal abatement cost function $f_i(a_i)$, and it purchases emissions allowances in the market at price $p$ (a small change in which is written $dp$).

The change in total cost of abatement depends on two effects. The first term on the right-hand side describes the net change in domestic abatement cost and the second term describes the change in the cost of imports. For any party that is restricted from its free trade equilibrium, domestic abatement and the marginal cost of domestic control both increase. As a result, the first term on the right hand side is positive. Appendix A1 shows that a binding restriction on any party's imports will reduce the total demand for permits and thereby the market price of permits, so long as all other parties remain price-takers and face upward sloping marginal abatement cost curves. The second term is therefore negative and the net impact of the import restriction on total cost depends on the balance between these two terms. As illustrated graphically in **Figure 1**, the restricted importer gains whenever the deadweight loss triangle *ABC* is less than the rectangle *CDEF*, which represents the cost saving in remaining imports.[5]

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[4] For examples, see Westskog (1996); Bohm and Larsen (1994); and Baron (1999).

[5] Note that the difference between domestic marginal cost and the market price for remaining permit imports will create a rent that must be allocated in some manner.

Increasing the stringency of the import restriction from non-binding to autarky gives rise first to a net saving, which increases before it declines and eventually disappears as rising domestic abatement costs overwhelm the savings on import costs, as illustrated in **Figure 2**. This sequence reflects the evolution of the cost-saving and deadweight loss components discussed more fully in Appendix A3. With convex marginal abatement curves the internal deadweight loss increases monotonically as the restriction is tightened. As long as any permits are imported, the lower import price generates cost savings that offset the internal deadweight loss. These savings increase initially and then decline to zero as the autarkic limit is approached. The heavy line shows the net effect on the total cost of compliance. Net savings are maximized at $a_r*$, and any restriction up to the point $a_r**$ will reduce importers' total cost of abatement relative to free trade.

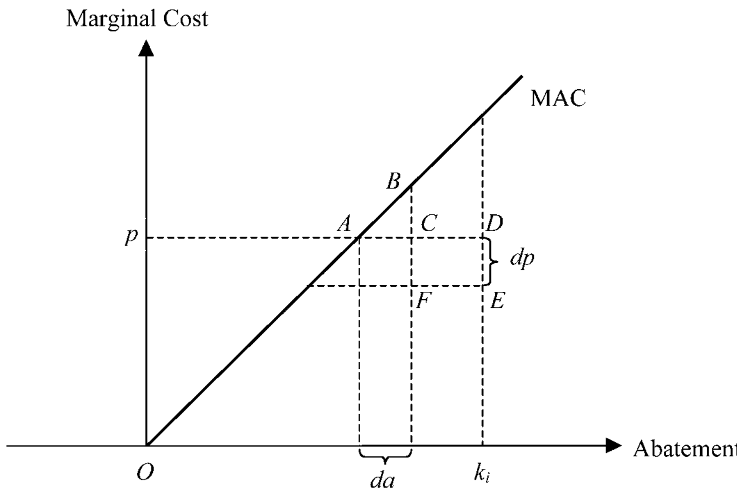


**Figure 1**. Effect of Import Limit on Restricted Importer

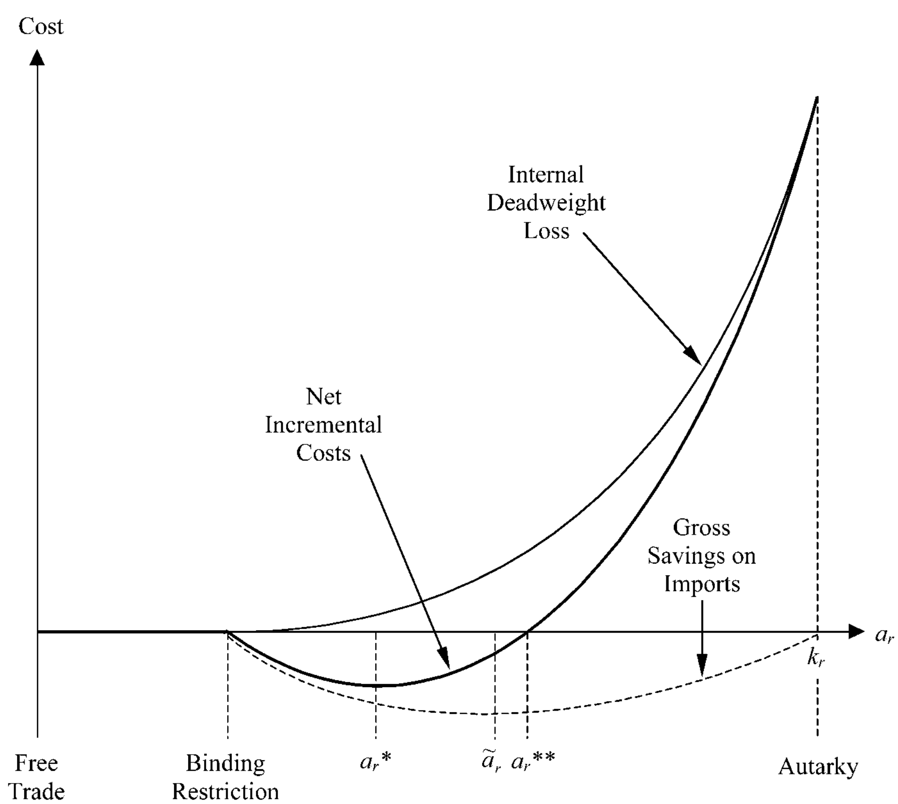


**Figure 2**. Internal Deadweight Loss and Cost Savings due to Import Restriction

The differential in equation (1) can also be used to explain the consequences of import restrictions for unrestricted importers and exporters. Since internal marginal abatement cost will equal the market price of permits for these parties, the first right-hand-side term is zero. Consequently, the effect of the import restriction is determined by the last term on the right-hand-side. For unrestricted importers ($m_i > 0$) total cost is reduced, while for exporters ($m_i < 0$) the negative cost (or benefit from trade) is diminished. For discrete changes in price and abatement, the effect on unrestricted importers is illustrated in **Figure 3a**. The cheaper price for permits leads these parties to import more and they gain both by the reduction in price for the previous level of imports and by the additional savings from displaced domestic abatement. An unrestricted importer is the demand-side equivalent of a non-cooperative fringe producer that produces more at the higher price maintained by a dominant monopolist. In this context, unrestricted importers buy more and bid the price up somewhat, thereby diminishing the price-depressing effects of the supplementarity limit, as demonstrated in Appendix A2.

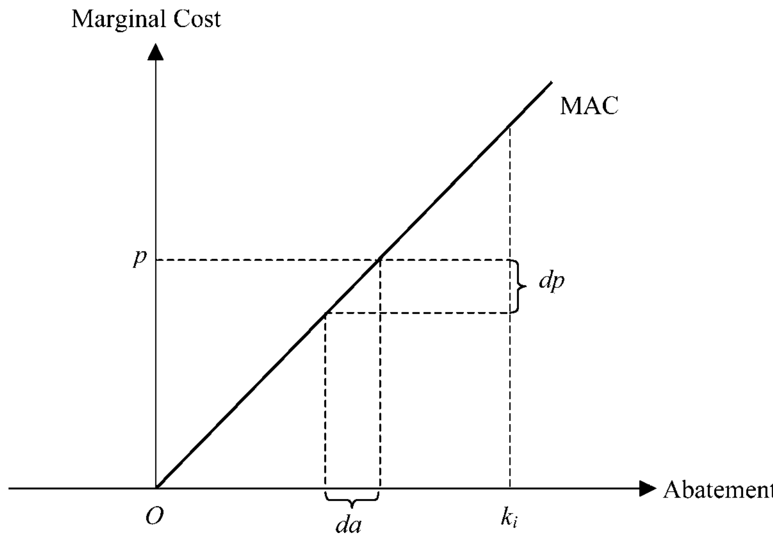


**Figure 3a**. Effect of Import Limit on Unrestricted Importer

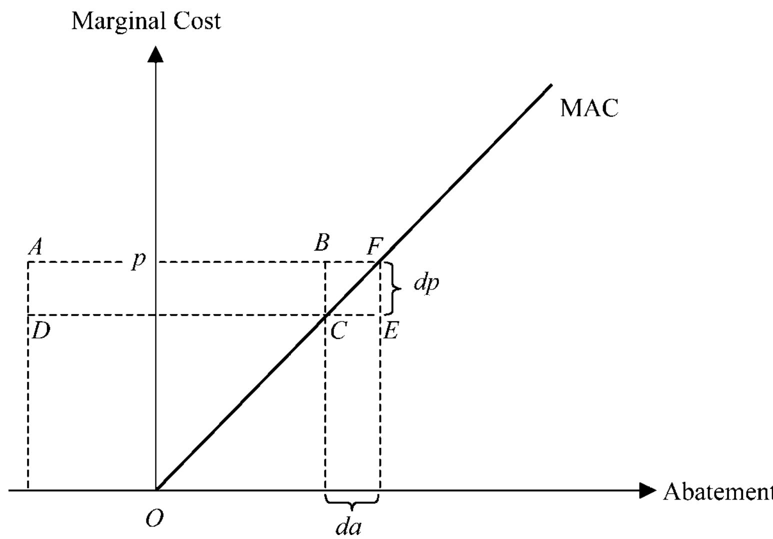


**Figure 3b**. Effect of Import Limit on Competitive Exporter

**Figure 3b** illustrates the case of the price-taking exporter. The net reduction in demand for imported permits causes the price to fall and exporters to abate less (*da*). Exporters lose by the amount, *ABFCD*, most of which (*ABCD*) is an income transfer to importers. The small triangle, *CEF*, represents the global deadweight loss on the exporters' side of the market, and there will be a corresponding deadweight loss on the importers' side of approximately equal magnitude.[6]

[6] The exact amount of the loss on the importer side would depend upon the slope of importer marginal abatement curves and the existence of unrestricted importers. If all importers were restricted and the slopes of importer and

For import restrictions that are not too stringent, it is easy to see that the magnitude of the income transfer will be far larger than the global deadweight loss. Nevertheless, as the restriction binds more tightly, the deadweight loss on both sides of the permit market increases until this effect overwhelms the income transfer.

An interesting point is reached when the restricted import demand is less than the quantity of hot air. The clearing price for permits will not be well defined at this point since permits have great value to importers but the supply available at zero cost exceeds demand. In keeping with the assumption of price-taking behavior, we assume a price of *epsilon* (equal to one dollar per megaton (MT)) to cover transaction costs and to clear the market for the permits that can be exported. At this point, the free market value of the hot air has been entirely transferred to the importers and all the remaining deadweight loss occurs on the importer side. The term $dp$ in equation (1) becomes zero, and there are no further income transfers to mitigate the costs incurred by importers as the restriction is tightened further.

The explanation of monopsonistic effects presented above can be made more concrete by solving for the prices and quantities that clear the permit market. To do this we employ a set of marginal abatement cost (MAC) curves, a prediction of business-as-usual (BAU) emissions, and a set of Kyoto commitments for aggregate Annex B regions. The technique of solving for the market equilibrium using MAC curves is described in Appendix A4. The MAC curves are generated for the year 2010 from runs of the MIT Emissions Prediction and Policy Analysis (EPPA) model version 3.0, as explained in Ellerman and Decaux (1998).[7] EPPA is a recursive-dynamic computable general equilibrium simulation of global economic activity, energy production and use, and carbon emissions (Babiker *et al*., in preparation). It divides the world into 12 regional economies, each represented by eight production sectors and inter-linked by trade in energy and non-energy commodities. EPPA also predicts emissions of non-$CO_2$ greenhouse gases, but these are omitted from this analysis in order to maintain the transparency of the central results.[8]

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exporter MACs were equal, then the total global deadweight loss would be twice the sum of the exporter triangles corresponding to *CEF*. If some importers are unrestricted, the importer deadweight loss will be greater since the lower price will induce unrestricted importers to take up some of the restricted demand. In fact, the slopes of the MACs are not greatly different, as indicated by the values for the parameter $\beta$ in the next footnote.

[7] The MACs are constructed by imposing progressively stringent proportional constraints on carbon emissions in Annex B regions, and by using a least-squares procedure to fit a constant elasticity function to the model results in price-abatement space. The approximations take the form $mc_i = \alpha_i a_i^{\beta_i}$, whose coefficients for the six Annex B regions are shown in the table below: The six regions are the United States, Japan, the 15 states of the European Union, other OECD nations, former Soviet Union, and European Economies in Transition.

| | **USA** | **JPN** | **EEC** | **OOE** | **FSU** | **EET** |
|---|---|---|---|---|---|---|
| $\alpha$ | 0.0113 | 0.1164 | 0.0373 | 0.1444 | 0.0643 | 0.1883 |
| $\beta$ | 1.5682 | 1.6809 | 1.4903 | 1.5914 | 1.3918 | 1.5511 |

[8] The net effect of including the non-$CO_2$ gases on both permit imports and the incidence of import restrictions is unclear, since their inclusion not only augments cost-effective domestic abatement options but also increases the quantity of GHGs that parties are required to control. As shown by Reilly *et al*. (1999), inclusion of these gases leads to lower autarkic marginal costs of abatement and lower total costs of meeting the Kyoto commitments.

The prediction of BAU carbon emissions is taken from the reference scenario in EPPA 3.0 and the cost implications of the Kyoto commitments using the EPPA-generated MACs and BAU emissions are given in **Table 1**. The EPPA reference scenario is a relatively high emissions forecast, which results in greater abatement and higher costs than some others. The recently published reference forecast in the 1999 International Energy Outlook (hereafter, IEO99) published by the Energy Information Administration of the US Department of Energy (USDOE, 1999) is also included in Table 1 for comparison.

**Table 1**. Cost Projections with EPPA MACs (EPPA and IEO99 Reference Emissions)

| | **EPPA Reference** | **IEO99 Reference** | **EPPA Reference** | **IEO99 Reference** |
|---|---|---|---|---|
| | **Baseline Emissions** (MT Carbon) | | **Kyoto Reduction**[a] (MT Carbon) | |
| Annex B | 4,762 | 4,344 | 865 | 447 |
| USA | 1,850 | 1,790 | 598 | 538 |
| Japan | 351 | 322 | 93 | 64 |
| Western Europe | 1,189 | 1,021 | 327 | 159 |
| Other OECD | 309 | 275 | 94 | 60 |
| Eastern Europe | 275 | 270 | -45 | -50 |
| FSU | 788 | 666 | -202 | -324 |
| | **Autarkic Marginal Cost**[b] (1995 US$) | | **Autarkic Total Cost** (Billion 1995 US$) | |
| Annex B | 94 | 35 | 102.4 | 55.2 |
| USA | 256 | 217 | 59.5 | 45.4 |
| Japan | 238 | 126 | 8.3 | 3.0 |
| Western Europe | 208 | 71 | 27.4 | 4.5 |
| Other OECD | 201 | 98 | 7.3 | 2.3 |
| Eastern Europe | - | - | - | - |
| FSU | - | - | - | - |
| | **Free Trade Total Cost**[c] (Billion 1995 US$) | | **Free Trade Import Share** (%) | |
| Annex B | 32.5 | 6.1 | | |
| USA | 38.2 | 15.1 | 47 | 69 |
| Japan | 5.6 | 1.6 | 42 | 54 |
| Western Europe | 20.0 | 3.5 | 41 | 38 |
| Other OECD | 5.5 | 1.4 | 38 | 48 |
| Eastern Europe | -7.4 | -2.3 | - | - |
| FSU | -29.5 | -13.1 | - | - |

*Notes*: [a] Negative entries indicate predicted emissions below assigned amount, or "hot air."
[b] Annex B entries are the clearing prices for an Annex B market with trading.
[c] Negative entries denote net benefits, or export revenues less abatement cost.

Several points that emerge from the comparison of these two forecasts should be kept in mind in an analysis of supplementarity. First, relatively small changes in predicted emissions can have large effects on parties' abatement requirements and the characteristics of an emissions trading market. Annex B emissions are only 9% less in the IEO99 forecast than in the EPPA 3.0 reference case (4.34 GT *vs*. 4.76 GT), but the amount of abatement required to meet the Kyoto commitments is half as much (0.45 GT *vs*. 0.87 GT) and the costs are less by the same proportion or more. Since the ceiling is fixed, the difference between the forecasts is fully reflected in the amount of required abatement, which is the primary determinant of cost. Second, since lower growth implies less required abatement, lower permit prices, and greater reliance on imported permits, the probability that any given concrete ceiling would be binding increases with lower growth forecasts. Third, assumptions about the growth in emissions have a much greater effect on total costs when trading is assumed than otherwise. For instance, when no trading is assumed, total Annex B costs are about half as much with the lower growth IEO99 forecast than with the higher growth EPPA reference case. When unrestricted trading is assumed, total costs in the low growth forecast are one-sixth the amount of the higher growth case. Trading makes hot air available and there is more of it when exporters' emissions grow slowly.

Finally, it should be noted that both of these forecasts agree on one new feature that reflects emissions growth since 1990. Earlier analyses typically showed that Japan would face considerably higher marginal cost of abatement without trading than other Annex B regions, and therefore that it would be the party gaining the most from emissions trading, as well as from certain levels of restriction. The US now occupies that position, or shares it with Japan depending on the forecast, due to the greater rate of economic and emissions growth during the 1990s in the US compared to Japan, the EU or most other OECD countries.[9]

**Figure 4** uses the curves first developed by Criqui *et al.* (1999) to show the effect on total cost of the Kyoto reduction as the import restriction moves from none at all to complete prohibition. For ease of analysis and exposition, we define the ceiling as the minimum percent of domestic

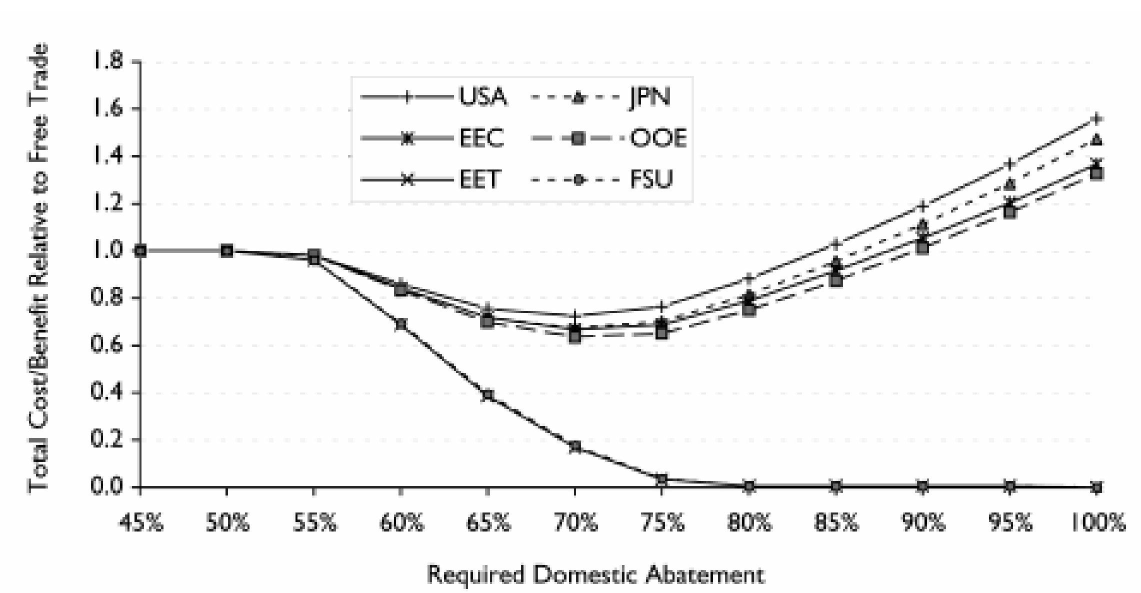


**Figure 4**. Effect of Import Restriction on Total Cost (EPPA Reference)

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[9] When equal percentage reductions are required, Japan still has the highest marginal cost of abatement; however, Japan's lower economic and emissions growth in the 1990s has substantially lessened the reduction required of Japan as a percentage of BAU emissions, when compared for instance with the US (20% *vs*. 30% in the IEO99 forecast and 26% *vs*. 32% in the EPPA reference case).

abatement required. This percent ranges from 0% representing no restriction (free trade) to 100% representing an absolute prohibition on international permit trading (autarky). Thus, a limitation restricting permit imports to no more than 25% of the required abatement can be expressed equivalently as a requirement to abate at least 75% domestically. In Figure 4, the total cost of the Kyoto reduction associated with given levels of restriction is expressed relative to the total cost under free trade, or in the case of the exporting regions, the total benefit with free trade.

For importers, the consequences of a concrete ceiling fall into one of three categories. The first includes levels of restriction that would not bind on any importing region, such as, in the EPPA 3.0 reference forecast, a ceiling requiring up to 53% domestic abatement (prohibiting imports of more than 47% of the total requirement). Any concrete ceiling within this interval will have no effect on costs since all importing parties would be abating at least this much domestically. The second category contains all levels of restriction that result in lower total cost for importers than that associated with free trade. This second subset will be least inclusive for the importer facing the highest autarkic marginal cost and the most inclusive for the importer with the lowest autarkic marginal cost. For instance, using the EPPA 3.0 reference forecast, this range begins at 53% required domestic abatement for all parties, but ends at 84% for the US and at 90% for the OOE. The third subset includes all levels of restriction that increase importers' total cost above that associated with free trade. This subset is the complement to the second, and it runs from 84% to 100% for the US and from 90% to 100% for the OOE.

The experience of the exporting regions is the same as that for importing parties over the first interval—no effect—but it is quite different as soon as the first importing party is actually restricted. Thereafter, the benefits associated with free trade are diminished continually until the point is reached, in this case when 80% domestic abatement is required, at which the demand for imports is less than the available hot air. At this point, exporters undertake no abatement, and, with price-taking behavior, they are assumed to sell whatever hot air is demanded for a token sum of one dollar per MT.

The reduction in the gains from trade from import restriction and the distribution of those gains are illustrated on **Figure 5**, which plots the aggregate gains by importers (the four OECD regions) and exporters (FSU and EET) along the horizontal and vertical axes, respectively. The point labeled free trade identifies the maximum gains from trade and the distribution of those gains resulting from the Kyoto allocation of assigned allowable amounts (AAUs) and the EPPA 3.0 reference forecast. The dashed line passing through the free trade point is the emissions trading equivalent of a budget line representing all possible allocations of the maximum gains from free trade between importers and exporters.[10] Any point lying between this line and the origin indicates a loss of efficiency, which can be measured by the perpendicular distance from that line. The 45° line indicates all points at which the gains from trade are evenly split between

[10] Given the EPPA 3.0 reference forecast and the assumption of competitive market structure, any other point on this line could be attained by a redistribution of assigned amounts between importers and exporters in what is a simple illustration of the Coasian Theorem applied to GHG emissions trading. For instance, if the allocation of AAUs agreed to at Kyoto resulted in greater allocations to the OECD economies and commensurately fewer to the FSU and Eastern Europe, the free trade point would have been moved to the right along this line, and *vice versa*.

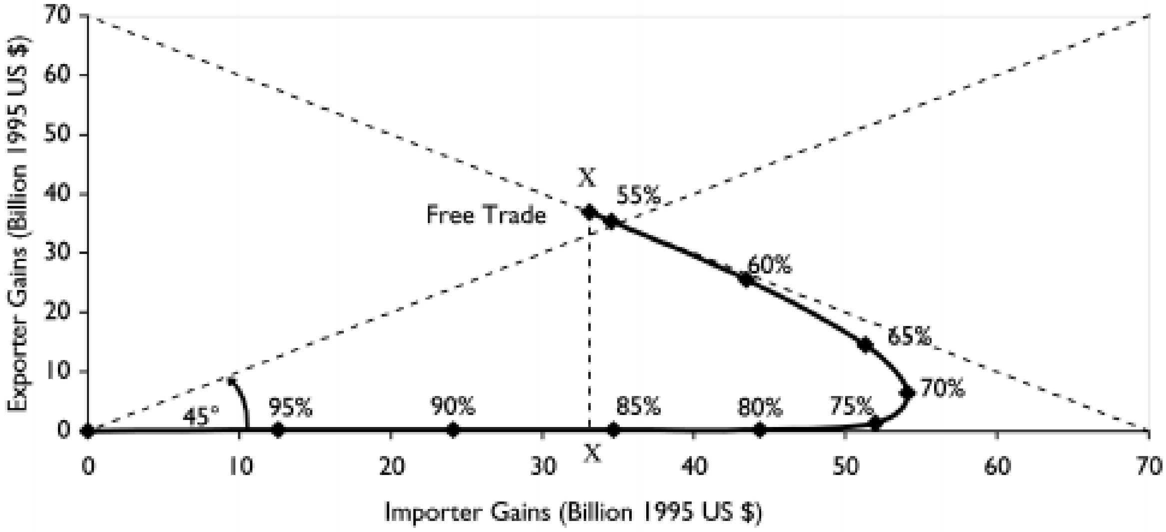


**Figure 5**. Effect of Restriction on Importer and Exporter Gains from Trade (EPPA Reference)

importers and exporters, which is used here to depict equity. Equity is of course a notoriously hard concept to quantify and we do not wish to suggest that an equal distribution of the gains from trade among importers and exporters is anything more than a heuristic concept of equity. Nevertheless, any more appropriate definition of equity would allocate the gains between importers and exporters in a manner that could be plotted in this space. Departures from this line would then provide a measure of the equity effects of the restriction.

The curve in Figure 5 indicates the effect of an increasingly more stringent, uniform import restriction on the aggregate gains from trade and the distribution of those gains between importers and exporters. The free trade point prevails for any uniform restriction mandating up to 53% domestic abatement. Restrictions of 55% and 60% domestic abatement result in little loss of efficiency, but the gains from trade are increasingly redistributed in favor of importers. The maximum gain for importers—and their least cost of complying with the Kyoto Protocol—will be achieved with a limit requiring 70% domestic abatement. Even tighter restrictions on importers move the locus of gains back towards the origin and eventually to the loss of all gains from emissions trading, which is the definition of autarky. The vertical line XX separates the curve into ranges for which importers gain (to the right) or lose (to the left) relative to free-trade. In this case, aggregate importer gains are possible over a wide range of restriction, from 53% to slightly over 85% required domestic abatement.

The specific results shown in Figures 4 and 5 reflect the particular forecast used and the allocation of AAUs in the Kyoto Protocol. Different forecasts and allocations would lead to a different free trade equilibrium point, which may be closer or farther from the origin and closer to one axis or the other than depicted in Figure 5. Also, depending on the forecast and the allocation, the point at which a concrete ceiling would bind would be higher or lower. What should be clear, however, is that, as soon as the import restriction binds, the monopsonistic effects shown in Figures 4 and 5 will appear. A restriction on imports can reduce the total costs for importers over a considerable interval of restriction because of the monopsonistic redistribution of the (reduced) gains of trade that is inherent in a restriction on demand.

## 3. THE EU PROPOSAL ON SUPPLEMENTARITY

At the June 1999 meeting of the Subsidiary Bodies, the EU advanced a specific proposal to implement the supplemental provisions of the Kyoto Protocol.[11] This proposal is considerably more complicated than the single uniform limit used in the preceding section and in other analyses of supplementarity. Therefore, we quote it in full.

> "Net acquisitions by an Annex B Party for all three Kyoto mechanisms together must not exceed the higher of the following alternatives:
>
> - 5% of its baseline emissions multiplied by five and its assigned amount (over five years) divided by two, or
> - 50% of the difference between its annual actual emissions in any year of the period from 1994 to 2002, multiplied by five, and its assigned amount.
>
> "Net transfers by an Annex B Party for all three Kyoto mechanisms together must not exceed:
>
> - 5% of its baseline emissions multiplied by five and its assigned amount divided by two.
>
> "However, the ceiling on net acquisitions and on net transfers can be increased to the extent that an Annex B Party achieves emission reductions larger than the relevant ceiling in the commitment period through domestic action undertaken after 1993, if demonstrated by the Party in a verifiable manner and subject to the expert review process to be developed under Article 8 of the Kyoto Protocol."

There are three distinct components: a restriction on imports, a restriction on exports, and the however clause. The last two have a significant effect on the monopsonistic consequences of supplementarity.

The conventional import component of the EU proposal would limit a party's imports of tradable permits during the first commitment period to no more than the greater of the two formula quantities. These formulae may appear complicated, but they are a reasonable attempt to deal with an inherent problem in implementing an import restriction. Analysts typically model a restriction as a percent of the reduction required by the Kyoto Protocol, but the counterfactual emissions implicit in such a formulation are never observed. The EU proposal avoids this problem by referring to quantities already agreed upon or to emissions that will be observed before the proposed restriction becomes applicable. For any given forecast, such as the EPPA 3.0 reference case, the EU limits for both imports and exports can be readily calculated and converted to percentages of the required emission reduction in 2010, as shown in **Table 2**. The EU import limit would not be uniform among parties, as assumed in Figures 4 and 5, but would vary depending on growth of emissions since 1990. Using the EPPA 3.0 reference forecast, domestic abatement would be required for 72–77% of an importing party's reduction requirement, or equivalently, imports would be limited to 23% to 28% of the requirement.

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[11] Submission by Germany on Behalf of the European Community, its Member States, and Croatia, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia on Emissions Trading (Art. 17 KP); Principles, Modalities, Rules, and Guidelines for the Mechanisms Under Articles 6, 12, and 17 of the Kyoto Protocol, Note by the Secretariat, Addendum (FCCC/SB/1999/MISC.3/Add.3).

**Table 2**. Calculation of EU Supplementarity Limits in EPPA 3.0 Reference Case

| | USA | EEC | JPN | OOE | EET | FSU |
|---|---|---|---|---|---|---|
| 5% Formula Amount (MT) | 65 | 43 | 13 | 11 | 16 | 50 |
| 50% Formula Amount[a] (MT) | 169 | 75 | 27 | 24 | - | - |
| Greater of the two (MT) | 169 | 75 | 27 | 24 | - | - |
| Required emission reduction (MT) | 598 | 327 | 93 | 94 | - | - |
| % of required reduction | 28% | 23% | 28% | 26% | - | - |

*Note*: [a] Based on actual emissions through 1998 and interpolated amounts for later years.

The export component of the EU proposal would limit a party's permit exports to the first of the two formulae applying to imports, or to a total of 66 MT of carbon. Restricting permit exports as a means of implementing supplementarity is a novel interpretation of the Kyoto Protocol, but it does reflect a concern often expressed about the export of hot air. Moreover, it might be argued that an export limit provides an indirect way of implementing supplementarity since the higher market price associated with restricted exports of hot air reduces permit imports from what they would be otherwise.[12] The proposed export limit also effectively redefines the assigned amounts for would-be exporters in the Kyoto Protocol, at least to the extent that they or others anticipated trading hot air in the first commitment period in excess of the proposed limit.

The however clause raises the proposed ceilings on both imports and exports to the extent that an Annex B party undertakes verifiable domestic abatement. An importing party can exceed the formula quantities to the extent it can demonstrate domestic abatement greater than that amount. Thus, the clause effectively raises the import ceiling, and reduces the domestic abatement requirement, to 50% of the emission reduction requirement. By implication, a party importing more than the formula amount but meeting less than 50% of its requirement by domestic abatement would receive credit for imports equal only to the level of domestic abatement. For instance, a party otherwise in compliance that had imported permits to cover emissions 60 MT over the Kyoto limit but that could demonstrate only 40 MT of domestic abatement, would presumably be judged 20 MT short of its commitment.

On the export side, the however clause operates in a similar manner. Annex B parties could export more than the formula amount if verifiable domestic abatement by the exporting party can be demonstrated. Assuming that hot air can be distinguished from real abatement, unconstrained parties would be limited to exporting only the formula amount of hot air, but they would not otherwise be restricted. Constrained parties (those with no hot air), which might export due to low marginal cost, would be protected up to the formula amount from challenges based on additionality, but for exports in excess of the formula amount, verifiable abatement would need to be shown.

[12] Although the export limit will result in greater Annex B abatement during the first commitment period, the provision leads to no greater cumulative abatement given the ability of any party to bank unused assigned amounts against presumed reduction requirements in later commitment periods by Article 3.13 (See Manne and Richels, 1998, for an analysis of the relative benefit of banking versus selling in the first commitment period.)

The loosening effect of the however clause is entirely dependent on the possibility of proving that abatement is real. If verifiable abatement could be demonstrated with relatively little cost, the however clause would operate as intended: to relax the otherwise very restrictive formula limits on emissions trading. Such is its effect in the first-best world of model simulations in which all abatement is real and trading is frictionless; however, in a less perfect world—where the counterfactual emissions required to establish verifiable reductions can never be definitively proven—the added test invites mischief that would frustrate the intent of the clause. Importers who would use the clause will find themselves embroiled with their challengers in an ultimately irresolvable duel of competing model projections concerning what domestic emissions would have been had no domestic actions been undertaken to comply with the Kyoto Protocol. Exporters who would take advantage of the however clause will find themselves in the same dilemma for the distinction between hot air and real abatement depends similarly on establishing what exporter emissions would have been without any abatement in response to the Kyoto Protocol. At best, the added test needlessly increases transaction costs; at worst, it will prove the however clause's promise of relief to be illusory.

The several components of the EU proposal have a large effect on the efficiency and equity aspects of the distribution of the gains from emissions trading. Four points on **Figure 6** can be used to illustrate the effects of the import and export limits alone and of the however clause. The two points labeled "w/o however clause" indicate the division of the gains between exporters and importers when either the import or export limit is applied. The import limit diminishes the global gains from trade by about 20% relative to the unfettered market equilibrium, but the income transfer is such that, from the standpoint of the importers, a nearly optimal monopsonistic restriction is achieved. The export limit without the however clause

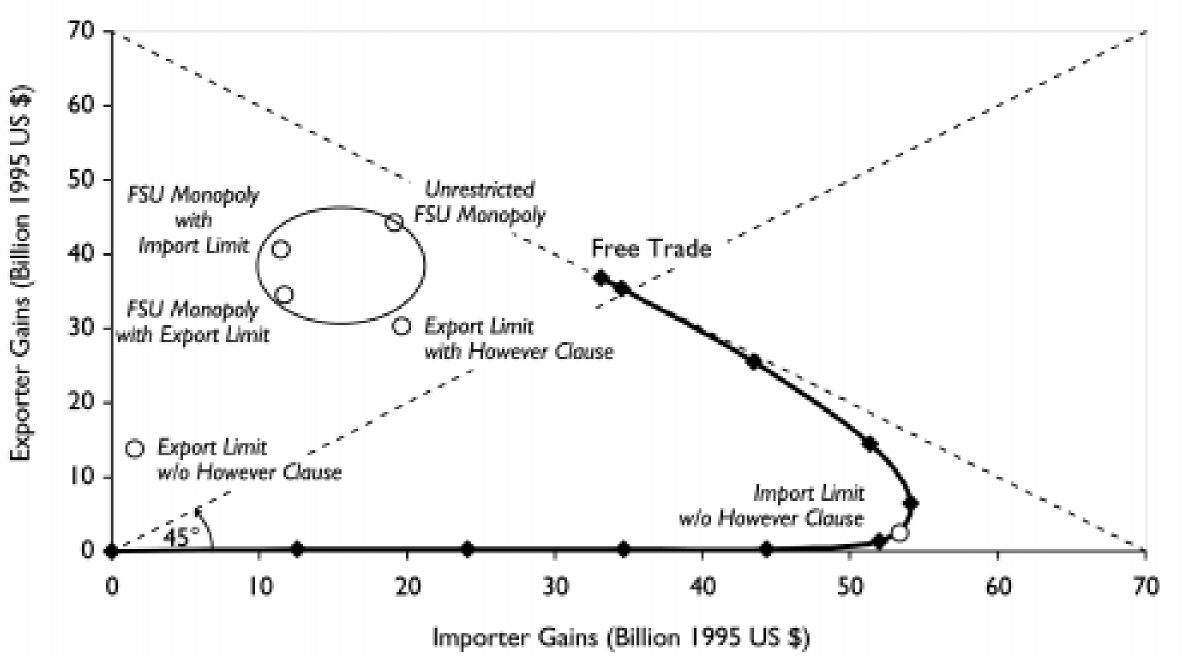


**Figure 6**. Importer and Exporter Gains From Trade with EU Limits (EPPA Reference)

would restrict the supply of cheap abatement from the non-constrained Annex B parties to 66 MT, but that small amount is sold at a very high price: high enough in this case to cause two of the constrained Annex B regions to become small exporters. The two non-constrained regions, the FSU and eastern Europe, are better off than with the import limit, but the importers are much worse off, and nearly all the potential gains from emissions trading have been given up.

When the however clause is present and operating as intended, it moves both of these points toward the free trade equilibrium. In the EPPA 3.0 reference case with the import limit, no importing party would be restricted when the however clause operates since all constrained parties would abate at least 50% of their emission reduction requirements domestically. As a result, the point representing the import limit with the however clause is the same as that for the free trade equilibrium. When the export limit applies, the however clause allows exporting parties to sell as much real abatement as importers are willing to buy. All parties gain from the relaxation of the export limit, as shown by the point labeled "export limit with however clause." In fact, this point represents the efficiency and equity implications of the full EU proposal (both limits with however clause operating) when it is applied in an Annex B market. In this instance, only the export limit is binding since the clearing price is high enough to cause all importing regions to abate more than 50% of their emission reduction requirement domestically. Compared to free trade, the proposal reduces total surplus by about 28% to $50 billion, roughly 60% of which would accrue to exporters.

The four outcomes illustrated by Figure 6 depend greatly in magnitude and exact location upon the BAU emissions prediction, but the relative positions shown here will hold for all reasonably plausible forecasts of Annex B emissions during the first commitment period. For instance, in the IEO99 forecast, some parties import more than 50% of the reduction requirement with free trade so that the import limit with the however clause would not coincide with the free trade equilibrium using this forecast. In general, when the EU import limit binds, the locus of gains is moved to the southeast into the region showing monopsonistic effects, and when the EU export limit binds, the locus is moved mostly toward the origin. For both limits, the however clause operates to place these points nearer, or even at, the free trade equilibrium.

The point representing the full EU proposal (export limit with however clause) can be usefully compared to the three points within the oval on Figure 6, which represent solutions in which the FSU is assumed no longer to be a price taker but to exercise its potential for monopoly power. Each dot within the oval reflects a different assumption about importer behavior: no restriction, the EU limit on imports without the however clause, and the EU limit on exports with the however clause.[13] The exercise of monopoly power by the largest supplier always entails a loss of efficiency, but the principal effect is to redistribute the gains from buyers to sellers, as can be seen by comparing each point to the corresponding position where the FSU is assumed to be a

[13] The import limit with the however clause is that same as being unrestricted in this forecast, and the export limit without the however clause removes all exporter discretion.

price taker.[14] Although suppliers can always gain by exploiting market power, if they are unable to do so, the proposed EU export limit approximates the result by providing the requisite mechanism for restricting supply. By so doing, the EU export limit succeeds in transforming the unwelcome invitation to monopsony into a self-abnegating invitation to monopoly, at least in an Annex B market.[15] But this monopolistic result depends critically on whether the however clause works as intended. If it does not the export limit will still be the binding constraint, and whether the FSU is a price taker or monopolist will be a moot point, for any exports beyond this limit will be open to question based on exporters' counterfactual emissions. In this case, the outcome will be the point closest to the origin where there is little trading, and little gain for anyone.

## 4. CONCLUSION

The title to this paper indicates the conclusion. The supplementarity condition in the Kyoto Protocol is an invitation to the exercise of monopsonistic power, whether intended or not. Monopsonistic effects require only that demand be restricted, not that the restriction be optimal in any sense. Also, these effects occur with price-taking behavior by both buyers and sellers so long as an effective coordinating or restraining mechanism is in place. A concrete ceiling on permit imports provides such a mechanism, and with it, all buyers will be better off over some range of restriction, although most assuredly there is a point beyond which further restriction results in higher costs for importers than under free trade. Thus, the unexpected results noted by many analysts are not accidental features of import restriction, but unavoidable consequences.

The EU proposal avoids the monopsonistic effects that are addressed in this paper, but it does so only by calling into question the basic elements of the agreement among the parties at Kyoto. Emissions trading and hot air were included in the Kyoto Protocol to lower the costs of the emissions reductions sufficiently to gain agreement and encourage parties to take the first steps toward averting the threat of dangerous climate change. Supplementarity was also included, raising the question—at least implicitly—of what was agreed upon. This provision can be interpreted as stating the obvious about the necessarily supplemental nature of imported permits in any serious implementation of Kyoto. Unfortunately, and as if to illustrate the proposition that seemingly innocuous provisions are rarely such, the EU proposal goes well beyond the simple, relatively non-binding restriction that might have been imagined. The export limit effectively vitiates whatever role the excess AAUs were intended to have. And setting aside hot air, the beneficial effects of emissions trading for both importers and exporters depend entirely on the workability of the however clause, which hinges on yet another seemingly innocuous provision, that verifiable abatement be shown. One might understandably question whether there was any agreement on emissions trading and hot air at Kyoto.

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[14] Conversely, the dots within the oval indicate the effect of the proposed EU limits if monopolistic behavior is assumed from the beginning. Neither restriction improves importer gains.

[15] The import limit would not be redundant in a global market because of the abundant low-cost supplies from non-Annex B exporters. In this market, the export limit mitigates the impact of monopsonistic effects on non-Annex B suppliers.

The EU proposal on supplementarity is a well-intentioned and in many ways clever interpretation of this worryingly vague provision of the Kyoto Protocol, but it is also illustrates how good intentions and bad assumptions can make things worse. The good intention is the very goal of the Kyoto Protocol: that parties undertake real abatement. The bad assumption is that emissions trading could lead a party to avoid undertaking any real abatement at all. It is hard to imagine how this latter circumstance could occur, other than by permits that are fraudulent, in which case the problem is fundamental and more severe than can be addressed by restrictions on emissions trading. In the end, the appropriate distribution of emissions reductions achieved domestically versus abroad and now versus later (*e.g.*, hot air) is a decidedly secondary concern to the more important issue of creating the monitoring and accounting mechanisms to ensure that all traded permits are excess to the issuing country's needs. In focusing on such concerns, and in introducing equally worrisome distinctions, the EU proposal threatens to become a distracting side-show from the main event, which is to build a workable and effective international structure to encourage parties to undertake actions to reduce emissions of greenhouse gases.

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## APPENDIX

In region $j$ the domestic supply price $p_j$ of a quantity of abatement $a_j$ is determined by its marginal abatement curve $f_j(a_j)$. We assume that each function $f$ passes through the origin, is invertible, strictly increasing in abatement, and possesses a non-negative second derivative. Every region faces an emissions reduction commitment $k_j$ and may be endowed with surplus permits $h_j$ representing hot air.

**A1.** ***Import restrictions generate a fall in the permit price in the presence of competitive supply:***

With emissions trading, $j$'s net imports of emissions-reduction credits $m_j$ are defined by the market clearance condition

$$m_j = k_j - h_j - a_j = k_j - h_j - f_j^{-1}(p_j) \tag{2}$$

and the aggregate excess demand for permits by

$$\textstyle\sum_j m_j = \sum_j (k_j - h_j) - \sum_j f_j^{-1}(p_j). \tag{3}$$

Let the set of $j$ regions in the market be partitioned into $i$ importers and $e$ exporters. Assuming constancy of parties' commitments and endowments of hot air, we can split equation (3) into an aggregate demand function

$$\textstyle\sum_i m_i = \sum_i \left(\bar{k}_i - f_i^{-1}(p_i)\right) \tag{4}$$

and an aggregate supply function

$$\textstyle\sum_e m_e = \sum_e \left(\bar{k}_e - \bar{h}_e - f_e^{-1}(p_e)\right). \tag{5}$$

Import restrictions imply that $dm_i < 0$. We assume that sellers adjust their output for the market to clear. Using the sign convention that $m_i < 0$ and $m_e > 0$, this implies

$$\textstyle\sum_e dm_e = -\sum_i dm_i > 0.$$

With restricted trade, let $p^{RT}$ be the price at which the marginal cost of abatement is equalized across exporters, such that the market clears. Linear additivity of abatement allows us to define a function $A_e$ of the price, so that we can rewrite equation (5) as

$$\textstyle\sum_e m_e = \sum_e (\bar{k}_e - \bar{h}_e) - A_e(p^{RT})$$

implying that

$$\textstyle\sum_e dm_e = -A_e' \, dp^{RT}.$$

The fact that the functions $f_e^{-1}$ are strictly increasing means that $A_e' > 0$, implying that $dp^{RT} < 0$.

**A2.** ***Unrestricted ("fringe") importers diminish lead monopsonists' price-setting capability:***

From equation (1), the first-order condition of the optimal restriction for a restricted importer $r$ is given by

$$f_r(a_r) = p - m_r \frac{dp}{da_r}.$$

The derivative in this expression is a total derivative that takes into account the reaction of both exporters $e$ and unrestricted importers $u$ to $r$'s restriction. For simplicity, consider a market in which agents in each of these three classes of parties can be aggregated into representative individuals. Under the assumption that the price is determined by the change in abatement of the exporter

$$\frac{dp}{da_r} = f_e' \frac{da_e}{da_r}.$$

Market clearing requires that

$$da_e = -(da_r + da_u)$$

which may be written equivalently as

$$\frac{da_e}{da_r} = -\left(1 + \frac{da_u}{da_r}\right).$$

The solution turns on the fact that the derivative within parentheses can be stated as

$$\frac{da_u}{da_r} = 1/f_u' \frac{dp}{da_r}.$$

Combining these formulae then yields

$$\left.\frac{dp}{da_r}\right|_u = -f_e'\left(1 + 1/f_u'\right) = \frac{-f_e'f_u'}{f_u' + f_e'} \tag{6}$$

which is negative with strictly increasing marginal abatement curves ($f' > 0$).

This result may be compared to the equilibrium condition that obtains when there are no unrestricted importers in the market ($\neg u$). In this case

$$\frac{da_e}{da_r} = -1 \quad \text{and} \quad \left.\frac{dp}{da_r}\right|_{\neg u} = -f_e'.$$

The presence of unrestricted importers therefore attenuates the response of the market clearing price to import restrictions:

$$\left.\frac{dp}{da_r}\right|_{\neg u} > \left.\frac{dp}{da_r}\right|_u.$$

This result embodies the intuition that attempts by unrestricted importers to expand imports to take advantage of the fall in the permit price feed back negatively on the price reduction that can be achieved in the market.

**A3.** ***With restricted trade, internal deadweight loss increases with domestic abatement, savings from permit imports achieve a maximum, and total abatement costs achieve a minimum:***

With reference to Figure 2, a restricted party $r$ suffers a deadweight loss $ABC$ given by

$$DWL_r = \int_{a^{FT}}^{a_r} f_r(\omega)d\omega - p^{FT}(a_r - a^{FT}) \tag{7}$$

where $p^{FT}$ and $a^{FT}$ are, respectively, the permit price and level of domestic abatement under free trade. This increment to cost is offset by the gross savings on permit imports $CDEF$ given by

$$S_r = \left(p^{FT} - p(a_r)\right)(k_r - a_r). \tag{8}$$

Differentiating these expressions yields first-order conditions

$$\hat{a}_r = f_r^{-1}(p^{FT})$$

and

$$\tilde{a}_r = k_r - \left(p - p^{FT}\right)\frac{1}{p'}.$$

The interpretation of these formulae is straightforward. First, the internal deadweight loss $DWL_r$ is minimized at the free-trade level of imports $\hat{a}_r = a^{FT}$. To see this, note that the second derivative of (7) is

$$\frac{d^2 DWL_r}{da_r^{\ 2}} = f_r' > 0.$$

Combined with the fact the derivative of $DWL_r$ is $f_r - p^{FT} > 0$, this condition implies the that deadweight loss is increasing and convex in $a_r$. This is shown by the thin solid line in Figure 3. Second, the gross savings on imports $S_r$ are maximized at a level of restriction $\tilde{a}_r$. By equation (6) $p' < 0$, implying that $\tilde{a}_r \in (a^{FT}, k_r)$. Sufficient conditions for savings to be maximized can be found from the second derivative of (8):

$$\frac{d^2 S_r}{da_r^{\ 2}} = 2p' - (k_r - a_r)p''$$

where $p''$ is simply the derivative of equation (6). A negative value of this expression indicates that $S_r$ achieves a maximum. From A2 we know that

$$p' = \begin{cases} \dfrac{-f_e' f_u'}{f_u' + f_e'} < 0 & \text{if } u \text{ exists} \\ -f_e' < 0 & \text{if } u \text{ does not exist.} \end{cases}$$

Therefore, all that is required is to determine the sign of $p''$. When there are no unrestricted parties

$$\frac{d^2p}{da_r^{\,2}} = -f_e'\frac{da_e}{da_r} = f_e'' > 0.$$

When there are unrestricted parties the solution is more complicated

$$\frac{d^2p}{da_r^{\,2}} = \frac{-1}{(f_e' + f_u')^2}\left[\frac{da_e}{da_r} f_u'^{\,2} f_e'' + \frac{da_u}{da_r} f_e'^{\,2} f_u''\right].$$

Again, A2 facilitates substitution for $\frac{da_e}{da_r}$ and $\frac{da_u}{da_r}$ to give

$$\frac{d^2p}{da_r^{\,2}} = \frac{f_e'' f_u'^{\,2}\left(f_e' + f_u'\right) + f_u'' f_e'^{\,3}}{(f_e' + f_u')^3} > 0$$

from which the second-order condition for maximum savings is met. The result is shown by the dashed line in Figure 3.

The difference between (7) and (8) gives the net increment to the total cost of compliance under import restrictions:

$$ITC_r = DWL_r - S_r.$$

The first order condition for this expression gives the optimal ceiling

$$a_r^* = k_r + (f_r - p)\frac{1}{p'}.$$

The second derivative is

$$\frac{d^2 ITC_r}{da_r^{\,2}} = f_r' - 2p' + (k_r - a_r)p''$$

which, since $p' < 0$ and $p'' > 0$, implies that net incremental costs achieve a minimum. This is shown by the heavy line in Figure 3.

**A4. *The existence and computation of equilibrium in a market for tradable permits*:**

At the positive free-trade permit price $p^{FT}$ the sum of net imports is zero, so that equation (3) becomes

$$\textstyle\sum_j (k_j - h_j) - \sum_j f_j^{-1}(p^{FT}) = 0.$$

Linear additivity of regions' emissions reductions allows us to express aggregate abatement as a single function $A$ of the price

$$\textstyle\sum_j f_j^{-1}(p^{FT}) = A(p^{FT}).$$

From the definition of $f_j$, the functions $f_j^{-1}$ exist and are strictly increasing, so that $A(0) = 0$ and $A' > 0$. If $A$ is invertible, a closed-form solution exists for the market-clearing price as a strictly increasing function of the commitments of all regions, net of the aggregate endowment of hot air

$$p^{FT} = A^{-1}\left[\sum_j \left(k_j - h_j\right)\right].$$

$A(\cdot)$ one-one is then sufficient for a unique solution.

In general, an analytic expression for $A^{-1}$ does not exist. In the paper we compute prices and quantities in market equilibrium by finding $p^*$ such that

$$\sum_j (k_j - h_j) - A(p^*) = 0.$$

This is equivalent to solving

$$\min_{p>0} \left|\sum_j \left(k_j - h_j\right) - A(p)\right|$$

by iterating over prices $p$. $A$ strictly increasing implies that the maximand possesses the single-crossing property that guarantees that if a solution exists, it will be unique. It is then straightforward to solve for the distorted equilibrium with supplementarity limits $l_j$ as a constrained minimization:

$$\min_{p>0} \left|\sum_j \left(k_j - h_j\right) - A(p)\right| \text{ s.t. } f_j^{-1}(p) \geq l_j.$$

A similar framework may be used to solve for the market equilibrium in the presence of a price-setting monopolistic exporter. For any exporting region $e$, the profit $\pi_e$ it receives will be given by revenues from permits sales net of the costs of actual abatement.

$$\pi_e = \left(a_e + h_e\right) \cdot p_e - \int_0^{a_e} f_e(\omega) d\omega$$

We assume that when a region $\hat{e}$ acts as a monopolist it manipulates the price $p_e$ across *all* exporters to maximize its own profit

$$\pi_{\hat{e}}(p_e) = \left[a_{\hat{e}}(p_e) + h_{\hat{e}}\right] \cdot p_e - \int_0^{a_{\hat{e}}(p_e)} f_{\hat{e}}(\omega) d\omega$$

subject to the permit market clearing on quantity. Importers $i$ are assumed to be acquiescent and to respond as if competitive market conditions prevailed, equalizing their marginal costs of abatement at a common buyer price $p_i$ that is determined by the aggregate quantity of exported permits. The monopolistic equilibrium may then be found by solving for prices $p_e$ and $p_i$ that simultaneously maximize $\hat{e}$'s profits while clearing the market, which is the simple maximization problem

$$\max_{p_e, p_i > 0} \pi_{\hat{e}} \text{ s.t. } \sum_i \left[k_i - f_i^{-1}(p_i)\right] - \sum_e \left[f_e^{-1}(p_e) + h_e\right] = 0.$$