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LIMITING OVERSELLING IN INTERNATIONAL EMISSIONS TRADING I:

Costs and Environmental Impacts of Alternative Proposals

By Erik Haites, Margaree Consultants Inc., and Fanny Missfeldt, UNEP Centre

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Foreword

We present in two volumes work undertaken in 2000/2001 on the analysis of rules to reduce the risk of overselling in the context of international emissions trading for greenhouse gases (GHG). GHG trading had been endorsed through its inclusion in the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997. The idea of international trade allowances to emit GHGs was relatively new in 1997, and there was virtually no experience with rules to ensure effective emissions trading at the international level.

The specific problem of emissions trading at the international level is that there is no supranational entity that can credibly enforce compliance. As Chayes and Chayes put it "sanctioning authority is rarely granted by treaty, rarely used when granted, and likely to be ineffective when used" (Chayes and Chayes, 1998). In the context of international GHG trading a country could, for example, maximize its gains by selling off its entire allocated quota, while free riding on the benefits of reduced climate change generated by other countries that reduce their emissions. In the context of the Kyoto Protocol, this quota is called assigned amount. In 2012 the assigned amount held by a country is to be compared with its actual emissions during the 2008-2012 the commitment period. If a country has sold too much of its quota (parts of its assigned amount), it may not be able to cover its actual GHG emissions. Thus a problem of overselling occurs.

While a number of experts and delegates to the climate meetings had identified the problem of overselling as early as summer 1998, the initial work in this area focused on the legal analysis of the problem. One of the first ideas was to introduce buyer or mixed liability to deter purchases from countries that engage in overselling. Since then the problem of overselling has been termed the 'liability problem' or 'liability issue'. By the end of 1999 a multitude of proposals were in circulation. This is when the authors of these reports decided that it might be worthwhile to test the performance of these proposals within the framework of an economic model.

In July 2001 the conference of the parties to the UNFCCC adopted one of these liability rules: the commitment period reserve. In this first volume we present the economic analysis of the numerous proposals under consideration at the time. The analysis identified the 'permanent reserve' as the proposal that best meets the criteria specified. In October 2000 the permanent reserve was modified to provide liquidity for buyer countries and was renamed the 'commitment period reserve'. In our second report we analyze alternative specifications of the commitment period reserve in terms of their effectiveness in constraining overselling, impact on compliance costs and liquidity in the emissions trading market. This analysis is performed at the country level for countries with emissions limitation commitments (Annex B Parties) under the Kyoto Protocol.

The authors gratefully acknowledge the generous cooperation and assistance provided by Prof. Denny Ellerman of MIT. In addition, helpful comments were provided by Christian Albrecht, Kyle Danish, Denny Ellerman, Robert Nordhaus, Andrea Pinna, Richard Rosenzweig, Tom Wilson, and ZhongXiang Zhang. Finally, the authors wish to

acknowledge financial support from EPRI. We would also like to thank the UNEP Centre and EPRI for enabling us to publish our work in full report size. Of course, we alone are responsible for the content and any remaining errors.

In the meantime we have published or submitted for publication part of the work presented here to make it available to a wider community in a more concise and problem-oriented format. Elements of our first reports are contained in the first issue of Climate Policy, published in early 2001 (Haites and Missfeldt, 2001a)), and in a more technical paper submitted to the Journal of Environmental Economics and Management (Haites and Missfeldt, 2001c). Further work derived from our second report has been submitted to Climate Policy (Missfeldt and Haites, 2001), and to the Journal of Financial Markets (Haites and Missfeldt, 2001b). Those interested in the details of our analysis and results produced are invited to read on.

Erik Haites, Toronto, and Fanny Missfeldt, Roskilde
June 2002

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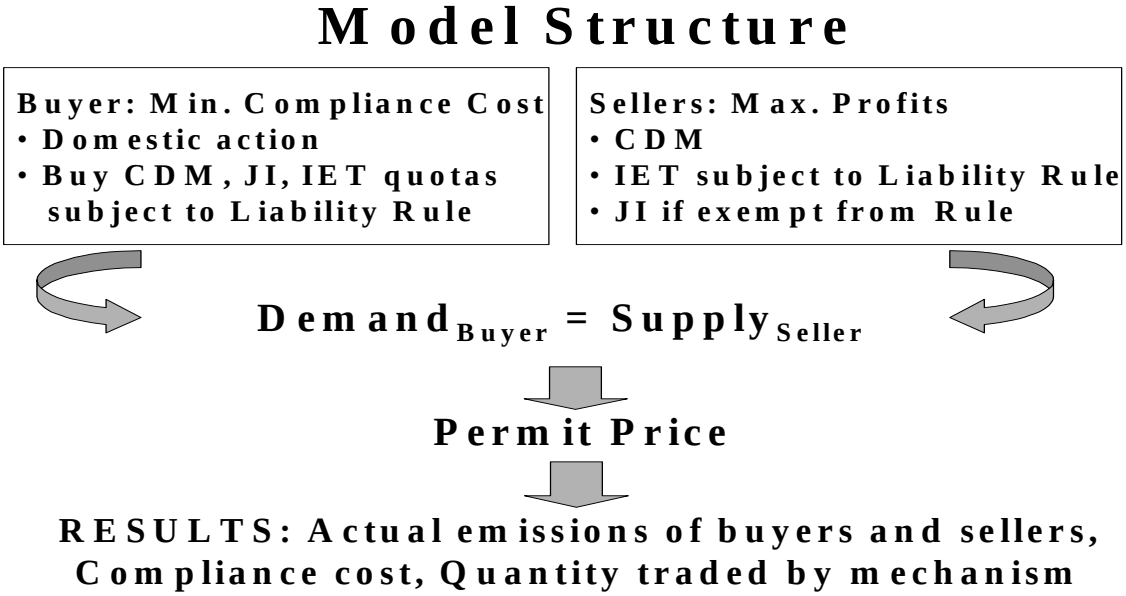
Executive Summary

Liability proposals seek to reduce non-compliance due to emissions trading by Annex B countries given weak penalties for non-compliance. This study develops and applies a model to assess the performance of different liability proposals.

A simple model based on the Emissions Projection and Policy Analysis (EPPA) model of the Massachusetts Institute of Technology is used for the analysis. As shown in Figure ES-1, the model includes a single Annex B buyer who seeks to minimize compliance costs, a single Annex B seller of AAUs and ERUs and a single non-Annex B seller of CDM credits both of whom seek to maximize their net income. The model is limited to the first commitment period, 2008-2012.

Figure ES-1



The analysis adopts a global perspective, so the buyer represents all Annex B buyers and the sellers represent all Annex B and non-Annex B sellers. As a result the compliance costs and excess emissions are the global totals rather than those for a single buyer or seller.

The buyer is assumed to be a firm located in an Annex B country that is likely to be a net importer of quotas (OECD countries) faced with domestic obligation to limit its emissions. It must demonstrate compliance with its domestic obligation annually and faces stringent domestic penalties for non-compliance. The firm can implement domestic reductions or purchase international quotas (AAUs, ERUs and CERs) to achieve compliance. However, the government is assumed to accept only AAUs that have no risk of being invalidated for compliance purposes.

The supply of CERs from CDM projects is determined by the cost of emission reduction actions in non-Annex B countries, taking into account transactions costs and adjusted for banked CERs from projects begun prior to 2008. The supply of ERUs from JI projects is limited to a share of the domestic reduction actions available to the Annex B seller taking into account transactions costs.

The supply of AAUs available is the total amount issued to the Annex B seller, unless constrained by the liability proposal, less the ERUs and AAUs sold. The Annex B seller implements no domestic reductions, other than JI projects, unless this increases the quantity of AAUs that can be sold under the liability proposal.

Supply and demand are equated by comparing the buyer's demand with the supply (domestic reductions by the buyer plus CERs, ERUs and AAUs) starting at the lowest price ($1/tC) and continuing in $1/tC increments until the supply is sufficient to meet the demand. Actual emissions for a given year are the "business-as-usual" emissions of the buyer or seller as projected by the model less any domestic emission reductions. Actual emissions of the sellers are only known with a two-year lag.

Compliance is assessed by comparing quota (CERs, ERUs and AAUs) holdings with actual emissions. Due to the stringent domestic penalties, the buyer is almost always in compliance. The Annex B seller faces no penalties for non-compliance unless those are part of the liability proposal.

The compliance cost for the buyer is the cost of domestic actions implemented plus the market price of the quotas (CERs, ERUs and AAUs) purchased plus any penalties for non-compliance less the value of any banked quotas at the end of the period. The net income of a seller is the revenue from the sale of quotas less the cost of domestic actions implemented less any penalties for non-compliance plus the value of any banked quotas at the end of the period. The compliance cost (net income) is expressed as the present value in 2008 of the costs (net income) during the period discounted at 5% net of inflation. All monetary values are 1995 US dollars.

The liability proposals are assessed by comparing them to a least-cost, full-compliance reference case. By comparing the liability proposals with the least-cost, full-compliance equilibrium, we focus on *relative*, rather than *absolute*, emissions and compliance costs.

Any analysis that uses a model is necessarily limited by the structure and assumptions of the model. The results presented should be interpreted with caution and should be only one input to the evaluation of the different liability proposals.

To be effective, liability provisions should deter deliberate efforts to benefit financially through non-compliance. Yet they should not increase costs to participants that meet their commitments and adhere to the rules. To assess the effectiveness of the liability proposals, we therefore assess their performance under "worst" case assumptions -- assumptions that lead to the highest excess emissions or the largest increase in compliance costs.

Many of the proposals have not been defined in operational terms. As part of the analysis alternative operational specifications of these liability proposals are tested. In some cases two alternative specifications yield good results. The operational specification(s) for each liability proposal that yields the highest level of compliance by the Annex B seller, assuming a competitive market, are listed in table ES-1.

The performance of the different proposals is assessed on the basis of:

- ***Excess emissions by the Annex B seller***. The purpose of a liability provision is to limit sales of AAUs to amounts surplus to the seller's compliance needs. Proposals that keep the seller's emissions within 2% of the least-cost full compliance level are preferred.

- ***Compliance cost for the Annex B buyer***. The Annex B buyer bears a net cost, while the sellers earn net income from their quota sales, so we focus on the buyer's compliance cost. Proposals that keep the buyer's compliance cost within 5% of the least-cost full compliance level are preferred.

- ***Sensitivity of the liability proposal to national circumstances***. The appropriate operational specification of a proposal may be sensitive to national circumstances and it may not be possible to determine the appropriate specification for each Annex B country accurately in advance. Thus, sensitivity of the liability proposal to national circumstances is not desirable.

- ***Sensitivity to seller behavior***. One or more of the Annex B sellers may be able to exercise market power by virtue of their share of the market for AAUs. A liability proposal that is not sensitive to market power is preferred.

- ***Temporal impacts***. A liability proposal may affect the date when trading of AAUs can begin or the quantity of AAUs available at different times during the commitment period. Proposals that allow trading to begin in 2008 and continue throughout the period are preferred.

- ***The distribution of net income across regions***. The mix of domestic action and quota purchases used by the buyer affects the distribution of net income for Annex B and non-Annex B sellers. The distribution of net income may affect the support for different liability proposals.

The performance of the liability proposals analyzed with respect to the first five criteria is summarized in Table ES-2.

Table ES-1
Operational Specifications of the Liability Proposals Analyzed

Issuer liability subject to sanctions for non-compliance
• The present value of the non-compliance sanctions must be substantially higher than $40/tC, probably higher than $98/tC, to be effective.
Issuer liability subject to eligibility requirements
• Eligibility established prior to 2008 but lost at the end of 2009. • Eligibility not established until the beginning of 2012.
Annual retirement of AAUs equal to actual emissions
• Annual retirement of AAUs equal to actual emissions when they are known (a two-year lag).
Limits on sales
• Sales of AAUs during a given year are limited to a maximum of 20% of the average assigned amount.
Sales prohibited until compliance established
• No sales of AAUs prior to 2014. • Surplus AAUs can be used for compliance in 2012.
Sales limited to AAUs surplus to a permanent reserve Sales are limited to AAUs surplus to a permanent reserve equivalent to projected emissions during the commitment period. Projected emissions are calculated as: • Five years of emissions calculated from the most recent data available adjusted for actual emissions as the data become available during the commitment period, i.e., 5 times the 2006 emissions in 2008 and 2009, 4 times 2006 emissions plus 2008 emissions when the latter become available in 2010. • The sum of projected emissions for the years 2008 through 2012 as estimated from a regression equation fitted to actual emissions for the years 2000 through 2006.
Swiss Proposal - Sales limited to AAUs surplus to the seller's compliance plan Sales are limited to AAUs surplus to a compliance plan defined by the seller. • Regular start - AAU sales begin in 2010 based on a comparison of actual emissions with the compliance plan for 2008. The compliance plan is defined as average assigned amount + 33% in 2008 declining to average assigned amount -33% in 2012. • Prompt start - AAU sales begin in 2008 based on a comparison of 2006 emissions with the compliance plan for 2008 and so on. The compliance plan is defined as average assigned amount for each year.
Sales limited to AAUs surplus to defined compliance plan Sales are limited to AAUs surplus to a defined compliance plan. • Regular start: AAU sales begin in 2010 based on a comparison of actual emissions with the compliance plan for 2008. The compliance plan for the years 2008 through 2012 is defined as: 2006*(1+Z/100)^2, 2008*(1+Z/100), 2009*(1+Z/100), 2010*(1+Z/100), 2011*(1+Z/100) with Z = -14%. • Prompt start: AAU sales begin in 2008 based on a comparison of 2006 emissions with the compliance plan for 2008 and so on. The compliance plan for the years 2008 through 2012 is defined as: 2006*(1+Z/100)^2, 2008*(1+2*Z/100), 2009*(1+3*Z/100), 2010*(1+2*Z/100), 2011*(1+Z/100) with Z = -7%.

Compliance reserve

With each sale of AAUs, the seller deposits a specified quantity of its remaining AAUs into a reserve that can be used only for the seller's compliance needs.

- Sales of AAUs are limited to the average assigned amount with a reserve requirement of 300%.
- Sales of AAUs are limited to the remaining assigned amount with a reserve requirement of 1600%

Compulsory insurance

- The Annex B seller pays a "premium" of one AAU for each AAU sold to the insurance company.
- The insurer purchases enough quota each year so that the Annex B seller's remaining assigned amount and the insurer's quota purchases are equal to the seller's projected emissions. To help achieve compliance, no emissions trading is allowed in 2012.

Escrow account

- Revenue from the initial sale of AAUs is deposited into an account where it is held until the issuer establishes compliance. If the seller does not achieve compliance, the funds are used to purchase the amount of quota need to bring the seller into compliance or the amount that can be purchased with the available funds, whichever is lower. The seller sets a minimum price of $20/tC for AAUs.

User liability

- The buyer purchases AAUs for compliance use at its risk. If the Annex B seller does not achieve compliance, some, or all, of the AAUs purchased are returned to the issuer. It is assumed that the buyer can only use the AAUs in 2012 after the seller has established compliance.

Shared liability

- If the Annex B issuer (seller) does not achieve compliance, part of the AAUs purchased are returned. Three alternatives are tested:
  1. LIFO invalidation with a user liability share of 50% and small penalty ($10/tC) for non-compliance by the issuer.
  2. The seller transfers AAUs equal to the amount purchased plus the 50% user liability share, i.e., the seller accepts the full risk since the penalties it faces for non-compliance are lower.
  3. Option 2 but with a small seller penalty on the seller ($10/tC) for non-compliance.

Double liability

- If the Annex B issuer (seller) does not achieve compliance, AAU sales are invalidated as necessary to bring the issuer into compliance in the same manner as under user liability. In addition, the seller is subject to penalties for non-compliance.

Traffic light

- Sales are made on an issuer liability basis until a specified a risk of non-compliance is reached. Thereafter, sales are on a user liability basis. The conditions that trigger the switch from issuer to user liability are:
  - AAU sales of 14% of assigned amount.
  - Cumulative actual emissions plus AAU sales > [(assigned amount/5) * years of data available + 2% of assigned amount/years of data available].

Table ES-2
Comparison of Selected Liability Proposals

Proposal	Excess Emissions by the Annex B Seller	Compliance Cost of the Annex B Buyer	Specification of the Proposal NOT Sensitive to National Circumstances[a]	Performance NOT Sensitive to Seller Market Power[b]	Trading can begin in 2008 and Continue through 2012
Sanctions >$40/tC	✔	✔			✔
Eligibility lost after 2009		✔	✔		
Eligibility starts in 2012	✔		✔		
Annual Retirement			✔		✔
Sales <20% of assigned amount	✔				✔
Sales Prohibited until 2014			✔		
Sales Prohibited until 2012			✔		
Permanent Reserve					
Option 1	✔	✔	✔	✔	✔
Option 3	✔	✔	✔	✔	✔
Swiss Proposal					
Regular Start	✔	✔			
Prompt Start	✔	✔			✔
Defined Compliance Plan					
Regular Start	✔	✔			
Prompt Start	✔	✔	✔		✔
Compliance Reserve					
Option 1, 300%	✔	✔			✔
Option 2, 1600%	✔	✔	✔		
Compulsory Insurance					
AAU premium			✔		✔
Insurer purchases			✔		✔
Escrow Account					
$20 Minimum Price	✔	✔			✔
User Liability	✔		✔		✔
Shared Liability					
50% with penalty	✔				✔
50% with adjustment	✔				✔
adjustment + penalty	✔				✔
Double Liability	✔		✔		✔
Traffic Light					
Limit of 14%					
Limit of 2%					

Notes: a Specification leads to excess emissions within ±2% of full compliance for all countries.
b Results when Annex B seller is able to exercise market power are within ±2% of those for the reference case.

The excess emissions are calculated as a percentage of the maximum possible non-compliance of 4,029.3 MtC. The compliance costs are expressed as a percentage of the reference case cost of $141.16 billion. To put the cost range into perspective, the transaction cost assumptions for JI and CDM can reduce the reference case cost by 5.4% or increase it 8.3%.

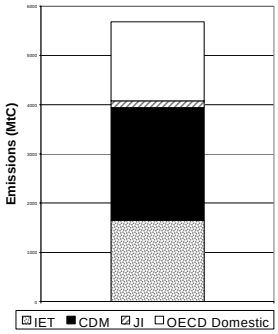
The compulsory insurance, escrow account, user liability, shared liability, double liability and traffic light proposals are difficult to analyze given the model structure, so those results should be interpreted with care.

The results confirm that sanctions lead to compliance if the penalties faced by the seller are higher than the market price and are enforced. The model suggests that the present value of the non-compliance sanctions must be substantially higher than $98/tC to be effective. The possibility that the sanctions for non-compliance faced by Parties under the Kyoto Protocol may be lower than required or may not be effectively enforced is the motivation for the other liability proposals.

While not sufficient to ensure compliance on their own, sanctions for non-compliance, eligibility requirements and annual retirement of AAUs equal to actual emissions, contribute to compliance at little or no cost. Hence these provisions could complement other liability proposals.

The permanent reserve proposal is the only one to meet all of the criteria.

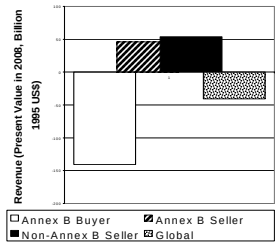
Figure ES-2
Mix of Actions Used to Achieve Compliance



The buyer needs to make domestic reductions and quota purchases totaling 5,680 MtC to achieve compliance. For liability proposals with excess emissions and compliance costs close to those of the reference case this is achieved through domestic reductions by the buyer (25% to 30%), purchases of CERs (about 40%), purchases of ERUs (1% to 5%), and purchases of AAUs (25% to 30%) as shown in Figure ES-2.

The distribution of compliance costs across regions is similar for liability proposals with excess emissions and compliance costs close to those of the reference case. The compliance costs by region for the reference case are shown in Figure ES-3. The compliance cost for the Annex B buyer is about $140 billion, while the Annex B seller and the non-Annex B seller each receive net income of about $50 billion, leaving a net cost of about $40 billion.

Figure ES-3
Compliance Cost by Region



The sensitivity of the results to various assumptions used in the model was tested with the following results:

- The assumptions on transactions costs for JI and the CDM can increase the compliance cost for the reference case by 8.3% or reduce it by 5.4%.

- The assumptions on the CDM supply from prior to 2008 can increase the compliance cost for the reference case by 11.7% or reduce it by 18.9%.

- The results for those proposals with a user liability component are not sensitive to risk aversion by the buyer, at least to the manner in which this was modeled.

- The discount rate does not have a significant impact on the relative performance of the different proposals.

Should ERUs be subject to the same liability provisions as AAUs? The model indicates that excess emissions associated with ERUs are in the range of 1% to 6% under several of the proposals. This suggests that if the quantity of ERUs awarded is decided through an independent international process, they should be valid once issued in the same way as CERs. On the other hand, if the decision on the quantity of ERUs awarded is left entirely to the host government, it can be argued that ERUs and AAUs are equivalent and that ERUs should be subject to the same liability provisions as AAUs.

Given the simple model structure and the other limitations of the analysis, the model results should be interpreted with care and be used as only one input to the evaluation of the liability proposals.

Future analyses can relax some of the model restrictions by allowing more regions and time periods. Future analyses could also incorporate uncertainty into the emissions of the participants during the commitment period. Such analyses can focus on a more limited set of liability proposals based on the results of this work. And they could integrate other proposed rules, such as supplementarity restrictions, into the analysis.

1. Introduction

Emissions trading allows a country with an emissions limitation commitment, an Annex B Party, to sell parts of its assigned amount (AAUs) to other Annex B Parties. If the seller subsequently does not have sufficient AAUs to cover its actual emissions it will be subject to the penalties for non-compliance.

The revenue from the sale of AAUs may exceed the sanctions for non-compliance if these penalties are weak or difficult to enforce.[1] Under these circumstances emissions trading enables a country to benefit financially through non-compliance. Liability proposals seek to ensure that non-compliance is not rewarded, by limiting sales of AAUs to amounts surplus to the seller's compliance needs.

Liability proposals complement, but do not replace, sanctions for non-compliance. Liability proposals focus on sales of AAUs, so they do not promote compliance by countries that are not net sellers of AAUs. Sanctions for non-compliance apply to all Annex B countries, regardless of whether they have engaged in emissions trading. If an Annex B seller does not comply with its commitment despite the liability proposal adopted, it is still subject to the non-compliance sanctions.

Over a dozen liability proposals have been suggested in the literature and international negotiations.[2] While many of these proposals have been subjected to critical review, there has been no quantitative analysis of the different proposals. Since the proposals are often complex and apply to all of the mechanisms in the international greenhouse gas quota market it is difficult to assess their performance without the aid of a model.[3]

The model developed for this study is designed to analyze the different liability proposals. It estimates market prices, compliance costs, and emissions in excess of the commitments of Annex B countries under the different liability proposals.

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[1] Abram and Antonia Chayes conclude that "sanctioning authority is rarely granted by treaty, rarely used when granted, and likely to be ineffective when used", *The New Sovereignty: Compliance with International Regulatory Agreements*, Harvard University Press, 1998, p. 32.

[2] Good reviews of the proposals are provided by R. Baron, "An Assessment of Liability Rules for International GHG Emissions Trading," International Energy Agency Information Paper, Paris, October 1999, and T. Hargrave, *et al.*, "Defining Kyoto Protocol Non-compliance Procedures and Mechanisms," Center for Clean Air Policy, Leiden International Emissions Trading Papers, Washington, D.C., October 1999. Proposals submitted by countries to the international negotiating process are described in United Nations Framework Convention on Climate Change (FCCC), "Mechanisms Pursuant to Articles 6, 12 and 17 of the Kyoto Protocol: Text for Further Negotiation on Principles, Modalities, Rules and Guidelines. Note by the Chairmen, FCCC/SB/2000/3, Bonn, April 12, 2000, para. 357, p. 127.

[3] The term "quota" is used to refer to any or all of AAUs, ERUs issued for emission reductions achieved by Joint Implementation projects and CERs issued for emission reductions achieved by Clean development Mechanism projects.

1.1 Approach

Liability proposals seek to reduce non-compliance due to emissions trading by Annex B countries given weak penalties for non-compliance. The performance of a liability proposal, then, should be assessed on the basis of its:

- Ability to keep an Annex B country seeking the maximum financial advantage from emissions trading in compliance by limiting sales to AAUs surplus to its compliance needs; and

- Impact on compliance costs of Annex B buyers. Excessively restrictive limits on sales can increase compliance costs for buyers.

To be effective, liability provisions should deter deliberate efforts to benefit financially through non-compliance. Yet they should not increase costs to participants that meet their commitments and adhere to the rules. To assess the effectiveness of the liability proposals, we therefore assess their performance under "worst" case assumptions:

- The seller tries to maximize its net income through international emissions trading. If the penalties for non-compliance are zero, the seller would be willing to sell its entire assigned amount without regard for the need to hold AAUs to cover its actual emissions at the end of the period.

- The buyer tries to minimize the cost of meeting its emissions limitation commitment. The assumptions used in the model, such as annual compliance by the buyer, increase compliance costs if AAU sales are restricted by the liability provision.

The liability proposals are compared to the least-cost, full-compliance equilibrium.[4] A liability proposal may increase costs by restricting sales of AAUs below the full compliance level and thereby causing the buyer to use more costly actions to meet its commitment. Alternatively, a liability proposal may allow some degree of non-compliance, leading to non-compliance and lower compliance costs.

We adopt a global perspective, rather than the perspective of an individual seller, to the analysis of the liability proposals. Thus, we focus on the extent to which the emissions of Annex B countries exceed their commitments and the impact on the compliance costs of Annex B countries for each proposal analyzed.

A global analysis of the liability proposals requires a global model that incorporates greenhouse gas emissions by region, emissions abatement costs by region, and international emissions trading. Several models with the necessary capabilities are available and have been

[4] Full compliance is assumed to be achieved voluntarily. This would be the case if the sanctions for non-compliance were judged to be serious by each Annex B country. Liability proposals are being considered, precisely because this assumption may not be valid.

used to estimate the costs of compliance with the emissions limitation commitments of Annex B countries.[5]

A simplified version of one of those models, the Emissions Projection and Policy Analysis (EPPA) model of the Massachusetts Institute of Technology, is used as the basis for the analysis. The EPPA model is used because it was relatively easy to develop a simplified version with the features needed to analyze the liability proposals. EPPA results tend to fall in the middle of the range for models that estimate the economic consequences of limiting greenhouse gas emissions.[6]

The simplified model used for our analysis includes a single Annex B buyer, a single Annex B seller and a single non-Annex B seller of CDM credits. The simplified model is also limited to the first commitment period, 2008-2012. These limitations facilitate the analysis of the liability proposals. But reality is obviously much more complex.

If the liability provision does not limit sales of AAUs, the Annex B buyer can comply with its emissions limitation commitment simply by purchasing AAUs. The EPPA model projects the buyer's total demand during 2008-2012 as 5,738.5 MtC, while the assigned amount of the selling countries is 6,410.5 MtC. Selling 5,738.5 MtC of IET quotas would leave the seller out of compliance by 4,566.0 MtC.[7]

The use of a model means that the results are sensitive to the structure and assumptions of that model. The results of our analysis reflect the "business-as-usual" emissions projection and the marginal abatement cost curves of the EPPA model. By comparing the liability proposals with the least-cost, full-compliance equilibrium, we focus on *relative*, rather than *absolute*, emissions and compliance costs.

Our analysis focuses on specific elements of the liability proposals, such as annual retirement of AAUs equal to actual emissions or a limit on the quantity of AAUs a country can sell. Some liability proposals include several elements that we analyze separately. Other proposals include subtleties that can not be accommodated fully, given the simple structure of the model.

Given the simple model structure and the other limitations of the analysis, the model results should be interpreted with care and be used as only one input to the evaluation of the liability proposals. Nevertheless, the model provides useful insights such as, whether any liability

[5] See J.P. Weyant and J.N. Hill, "Introduction and Overview," The Costs of the Kyoto Protocol: A Multi-model Evaluation, *The Energy Journal*, Special Issue, May 1999, pp. vii - xliv.

[6] See J.P. Weyant and J.N. Hill, *op cit.*

[7] The emissions of the Annex B Parties other than the OECD are projected at 5,238.0 MtC. Selling 5,738.5 of the 6,410.5 MtC of assigned amount would leave only 672.0 MtC available to offset the projected emissions. The result is a shortfall of 4,566.0 MtC, which is the maximum amount of non-compliance possible in the reference case.

proposals can work effectively, which proposals dominate others, guidance on operational specification of some proposals, and the sensitivity of the results to specific assumptions.

Future analyses can relax some of the model restrictions by allowing more regions and time periods. Future analyses could also incorporate uncertainty into the emissions of the participants during the commitment period. Such analyses can focus on a more limited set of liability proposals based on the results of this work. And they could integrate other proposed rules, such as supplementarity restrictions, into the analysis.

1.2 Measures of Performance

Annex B countries can meet their emissions limitation commitments by:

- Reducing domestic emissions;
- Purchasing AAUs from other Annex B countries through International Emissions Trading;
- Purchasing ERUs generated through Joint Implementation projects in other Annex B countries; and
- Purchasing CERs generated through Clean Development Mechanism projects in non-Annex B countries.

If some Annex B countries sell AAUs and then fail to meet their commitments, it increases the supply of AAUs on the market and so reduces the market price. If a liability provision reduces, but doesn't eliminate, overselling, the compliance cost for the buyer may be lower than the full-compliance reference case. If a liability provision restricts sales of AAUs that are surplus to the seller's compliance needs, it raises the compliance cost for the buyer relative to the reference case.

If some Annex B countries sell AAUs and then fail to meet their commitments, it changes the mix of actions used by the buyers to meet their emissions limits. The quantity of AAUs purchased rises, while domestic reductions and purchases of CDM quotas decline relative to the full compliance reference case.

Given these anticipated effects of a liability proposal, the performance of the different proposals is measured in terms of:

- ***Emissions by Annex B Parties in excess of their aggregate commitments***, i.e. emissions in excess of the AAUs, CERs and ERUs held. The purpose of a liability provision is to limit sales of AAUs to amounts surplus to the seller's compliance needs. Thus, the extent to which the emissions of Annex B sellers exceed their compliance needs is a key measure of the effectiveness. Since liability proposals focus on the Annex B seller, we assume the buyer behaves so that it is almost always in compliance. This means that non-compliance

by the Annex B seller is responsible for virtually all of the excess emissions by Annex B countries.

- ***Total compliance cost for Annex B Parties***. Liability proposals may restrict sales of AAUs and hence increase compliance costs. The Annex B buyer bears a net cost, while the Annex B and non-Annex B sellers generally earn net income from their sales of AAUs, CERs and ERUs. For this reason, we focus on the compliance cost to the Annex B buyer.

- ***Sensitivity of the liability proposal to national circumstances***. The appropriate operational specification of a proposal may be sensitive to national circumstances, such as the assigned amount surplus to "business-as-usual" emissions. It may not be possible to determine the appropriate specification for each Annex B country accurately in advance. Thus, sensitivity of the liability proposal to national circumstances is not desirable.

- ***Sensitivity to seller behavior***. One or more of the Annex B sellers may be able to exercise market power by virtue of their share of the market for AAUs. A liability proposal that is not sensitive to market power is preferred.

- ***The distribution of net income across regions***. The Annex B buyer meets its commitment through domestic emission reductions and purchases of IET, CDM and JI quotas. The mix of domestic action and quota purchases used by the buyer affects the distribution of net income for Annex B and non-Annex B sellers. The distribution of net income may affect the support for different liability proposals.

- ***Temporal impacts***. A liability proposal may affect the date when trading of AAUs can begin or the quantity of AAUs available at different times during the commitment period. The date at which trading can begin affects the development of the secondary market. Changes in the quantity of AAUs available from year to year may cause abrupt, undesirable shifts in the market price and the composition of demand.

  The model deals only with the "spot" market where quotas are traded at the current market price. A secondary market, where options, forward contracts and other instruments are traded, may also exist. A healthy spot market is a pre-requisite for development of the instruments traded in the secondary market. The impact of abrupt changes in prices can be mitigated through the use of options, but only if the spot market is well-established.

1.3 Structure of the Report

The next section provides an overview of the model developed to evaluate the liability proposals. Section 3 specifies how each liability proposal was modeled and presents the results of the analysis. Many of the proposals have not been defined in operational terms. We propose and test alternative operational definitions.

Conclusions are presented in section 4.

2. Model Structure

2.1 Overview

The model is a highly aggregated version of the Emissions Projection and Policy Analysis (EPPA) model of the Massachusetts Institute of Technology (MIT). The regions in the EPPA model are aggregated into three regions – one buyer and two sellers – as discussed below. The model structure is summarized in Figure 1. The buyer, represented by the OECD,[8] seeks the mix of domestic emission reduction actions and IET, CDM and JI quota purchases that minimizes its compliance cost. OECD has relatively high marginal emission reduction costs and is endowed with fewer AAUs than its "business as usual" (BAU) emissions during the 2008-2012 commitment period.

The sellers attempt to maximize their net income from the sale of quotas. CDM quotas (CERs) are sold by non-Annex B (NAB) countries. IET quotas (AAUs) and JI quotas (ERUs) are sold by the non-OECD Annex B – Rest of Annex B (RAB) – countries. The Rest of Annex B has relatively low emission reduction costs and is endowed with AAUs in excess of its "business as usual" (BAU) emissions during the 2008-2012 period.

The liability proposals apply to AAUs. Most proposals do not specify whether they apply to ERUs from the same countries. The model is used to test the implications of exempting ERUs from the liability provisions.

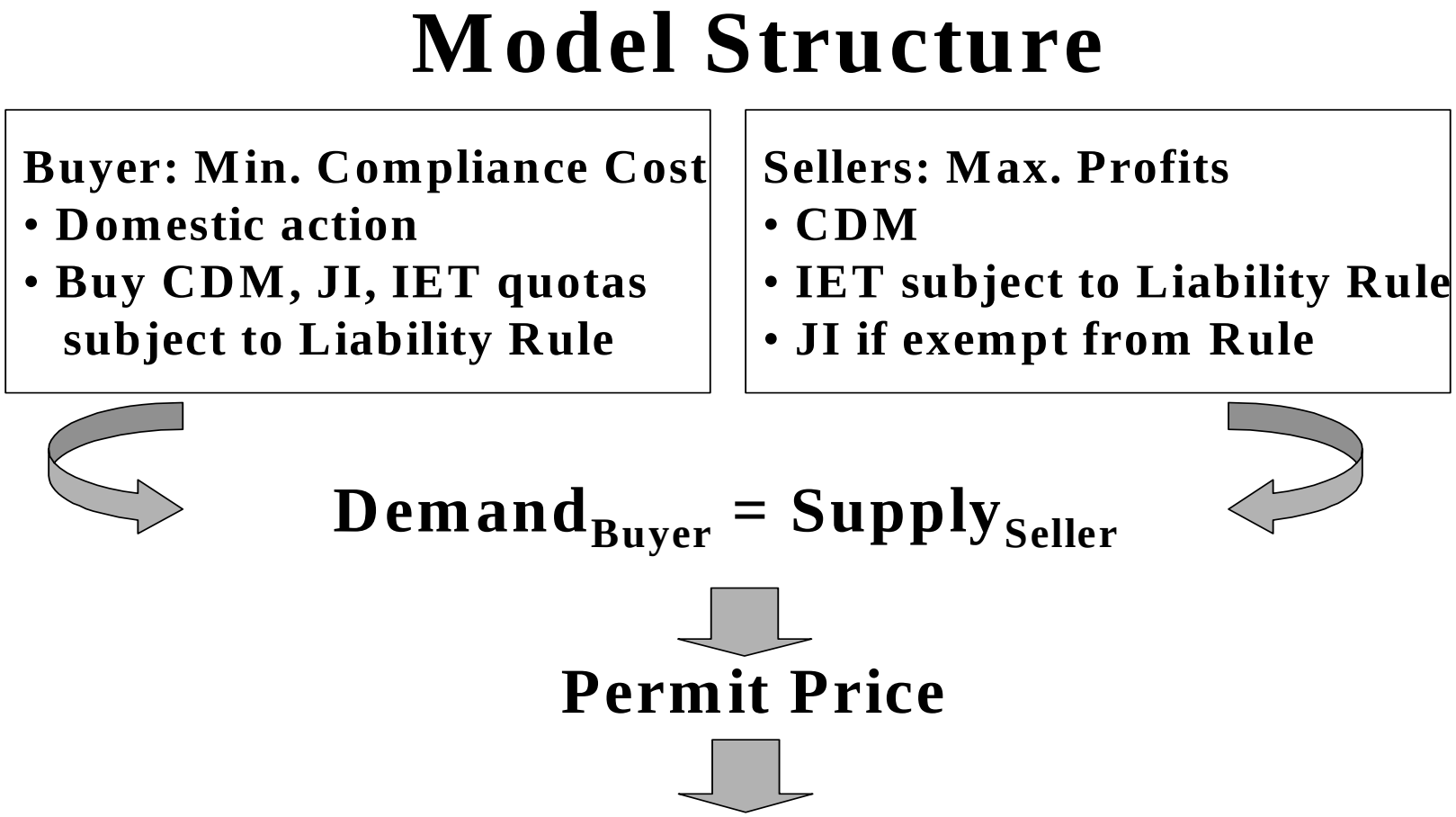
Supply and demand are matched to find the market price and the mix of quotas purchased by the buyer. Supply and demand are matched each year from 2008 through 2012. Then the total compliance cost and the total emissions of Annex B countries are calculated.

The marginal abatement cost curve for each region was derived from the EPPA model. The marginal abatement cost curves are based on energy-related CO_2 emissions only. Incorporating additional emissions sources and sinks into the analysis will reduce compliance costs.[9] Projected BAU emissions, emissions limitation commitments for the Annex B regions, and other data also come from the EPPA model.

[8] The composition of this region reflects the OECD membership in 1990. Membership of the OECD has subsequently expanded to include Poland, Hungary and the Czech Republic that are part of the "rest of Annex B" region as well as Korea and Mexico that are part of the "Non-Annex B" region.

[9] See J. Reilly, R. Prinn, J. Harnisch, J. Fitzmaurice, H. Jacoby, D. Klicklighter, J. Melillo, P. Stone, A. Sokolov and C. Wang. "Multi-gas Assessment of the Kyoto Protocol, *Nature*, 401, 7 October 1999, pp. 549-555.

Figure 1


Model Structure
Buyer: Min. Compliance Cost
• Domestic action
• Buy CDM, JI, IET quotas subject to Liability Rule
Sellers: Max. Profits
• CDM
• IET subject to Liability Rule
• JI if exempt from Rule
Demand Buyer = Supply Seller
Permit Price
RESULTS: Actual emissions of buyers and sellers, Compliance cost, Quantity traded by mechanism

2.2 The Buyer

The buyer is assumed to be a firm with a government-imposed obligation to limit its emissions located in an Annex B country that is likely to be a net importer of quotas (OECD countries). Governments of Annex B countries are responsible for meeting their emissions limitation commitments under the Kyoto Protocol. Thus, the buyer could be an Annex B government, or a firm with a government-imposed obligation to limit its emissions.

At least some Annex B countries are expected to devolve emission reduction obligations to firms. Assuming that the buyer is a firm leads to assumptions that raise compliance costs more if a liability proposal restricts sales of AAUs. Hence, the representative buyer is assumed to be a firm that needs AAUs for compliance with domestic policy obligations. The buyer is assumed to face stringent domestic penalties for non-compliance and consequently always seeks to achieve compliance.[10]

Participation by firms could lead to the following requirements, which could increase compliance costs under some liability proposals:

- Firms are assumed to be required to establish compliance (hold domestic permits and international quotas equal to their actual emissions) annually;[11] and

- Governments are assumed to accept only international AAUs that have no risk of being invalidated for compliance purposes.

Under some liability proposals a sale could be invalidated if the issuer (seller) is subsequently found not to be in compliance. Then some or all of the AAUs sold would be returned to the issuer to bring that country into compliance. A government is assumed not to accept AAUs subject to a risk of the sale being invalidated toward compliance with domestic obligations because the firm may no longer be in operation if the sale is invalidated. This creates a risk of non-compliance for the government that can be avoided by insisting on AAUs not subject to a risk of invalidation.[12]

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[10] The penalties for non-compliance, like those under the U.S. acid rain program, consist of the loss of quota in the next year equal to the excess emissions plus a financial penalty. The financial penalty is the higher of $100/tC (1995 US$) or three times the market price during the year the excess emissions occurred.

[11] Annual compliance is well established for environmental and other regulations. A longer compliance period increases enforcement problems due to turnover in the population of participating firms. A longer compliance period offers no advantages over annual compliance with banking, except for the possibility of borrowing within the period. Borrowing creates a risk of non-compliance by the government due to borrowing by sources that cease operation before the end of the period. With annual compliance, borrowing can be arranged through commercial transactions, which means the risk of non-compliance is borne by the participants rather than the government.

[12] This assumption has significant implications for the timing of transactions. It means that under user (buyer) liability proposals the purchased quotas can not be used until 2012 or later when the compliance status of the issuers is known. In practice governments might allow firms to use AAUs from specified "low

Thus the buyer implements domestic emission reduction actions and purchases international quotas to achieve compliance. The marginal abatement cost curve for domestic action, as given by the MIT EPPA model, is:[13]

(1) $C = 0.0064 * Q^{1.4883}$

The buyer purchases quotas (AAUs, ERUs and CERs) for compliance during the commitment period. Quotas purchased for compliance during the current year can not be subject to invalidation of the sale under the applicable liability rule. Where the liability provision creates a risk that purchased AAUs can subsequently be returned to the issuer, the buyer can only use those AAUs for compliance in 2012.[14]

The price paid for AAUs subject to a risk of invalidation is discounted to reflect the projected risk of invalidation. The buyer discounts the price in the current year by the projected risk of invalidation based on projections of the seller's emissions and quota sales during the commitment period.

The buyer finds the lowest price for which it can obtain the reduction from domestic action plus the quantity of AAUs, ERUs and CERs equal to the difference between its "business as usual" emissions and its emissions limitation commitment.

In summary, the buyer's decisions for each year from 2008 through 2012 are to:

- Implement domestic reductions and purchase the quantity of international quotas with no risk of being invalidated needed for compliance in the current year at the lowest cost.

- Purchase AAUs in anticipation of future compliance needs if the liability rule has a risk of invalidation.

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risk" seller, such as members of the same Article 4 "bubble". However, the model is used to test the performance of the liability proposals under the most restrictive conditions. Less restrictive assumptions will lead to results that lie between those reported and the reference case.

[13] C is the marginal cost in 1995US$ per metric ton of carbon equivalent, Q is the reduction in millions of metric tons of carbon equivalent, and "^" means "raised to the power".

[14] This assumes that the country that originally sold the AAUs can establish that it has complied with its emissions limitation commitment before the "grace period" available to the buyer to establish compliance expires. In practice, this is unlikely to be the case; compliance by Annex B countries (including the original seller of the AAUs) is likely to take at least two or three years, while domestic sources are likely to be allowed six months or less after the end of the year to achieve compliance. But since the model only covers the 2008-2012 commitment period, this is the only way to model such liability proposals. The possibility that AAUs can not be used for compliance purposes during the commitment period is also modeled.

2.3 The CDM Seller

The CDM seller is representative of all non-Annex B Parties. CDM quotas (CERs) are assumed to have no risk of being invalidated because they are certified through an agreed international process.

The CDM supply curve is based on the marginal abatement cost curve for non-Annex B Parties. The marginal abatement cost curve for emission reductions in non-Annex B countries, as derived from the MIT EPPA model, is:

(2) $C = 0.0047 * Q^{1.5658}$

The quantity of CDM quota available during a given year at each price is calculated from the marginal abatement cost curve with adjustments for:

- The early start of CDM projects. CDM projects can begin to generate reductions in 2000, but those CERs can not be used until 2008. To reflect the inventory of CERs available in 2008, the annual supply at each price as calculated from the marginal abatement cost curve is multiplied by 1.8, with a sensitivity range of 1.5 to 2.4.[15] The costs of early CDM reductions are treated as a sunk cost for decisions during the commitment period.[16]

- Transactions costs. The price paid by the buyer must cover the costs of the international certification process, the levy for administrative expenses and assistance for adaptation by particularly vulnerable developing countries, as well as the cost of achieving the reductions. The transactions costs for international certification reduce the revenue to the seller by 25%, with a sensitivity range of 10% to 50%.[17]

[15] The inventory of CDM quota from early projects is assumed to be proportional to the CDM reductions during each year of the commitment period. This means that the size of the CDM inventory changes with each case. It also means that the inventory is distributed over the five years, rather than being available in full at the beginning of the period. It could be argued that the analyses of the different proposals are not strictly comparable because of the differences in the CERs inventory. On the other hand, if the liability proposal affects the mix of quotas used for compliance, this is likely to affect CDM activity prior to 2008 and the CERs inventory as well.

If the CDM generated the same quantity of emission reductions each year from 2000 through 2012, the inventory available at the beginning of 2008 would be 7 years' supply. When this inventory is spread over the 5 years from 2008 through 2012, the inventory represents 7/5 = 1.4 years' supply for each year. Thus to add the inventory to the supply created in a given year, the latter must be multiplied by 2.4. The rate at which CDM projects generate emission reductions is likely to increase over time, so the inventory adjustment is assumed to be less than 2.4.

[16] Specifically, the cost of the CERs generated prior to 2008 is assumed to be zero in the analysis.

[17] The precise form and size of the levy has not yet been established. Here the levy is assumed to be included in the transactions cost. If the levy takes the form of a share of the CERs issued for a project this still a realistic way to include it in the model. The return to the seller is reduced by the value of the CERs, which affects its behavior in the same way as a higher transactions cost. The CERs collected for the levy are sold on the international market so the impact on quota prices is as modeled.

2.4 The JI Seller

The JI seller is assumed to be representative of Annex B Parties likely to be net exporters of quotas (Annex B Parties other than OECD countries, or Rest of Annex B). One of the issues to be analyzed is whether AAUs and ERUs should be subject to the same liability provision. When both AAUs and ERUs are subject to the same liability provision, all quota sales by these countries are assumed to be AAUs and there is no JI seller. When only AAUs are subject to the liability provision, ERUs are assumed to have no risk of being invalidated.

The JI supply curve is based on the marginal abatement cost curve for Annex B Parties other than OECD countries. The marginal abatement cost curve for emission reductions in these Annex B countries, as derived from the MIT EPPA model, is:

(3) $C = 0.0413 * Q^{1.405}$

The quantity of JI quotas available during a given year at each price is calculated from the marginal abatement cost curve with adjustments for:

- Reductions that can be structured as JI projects. JI quotas must be linked to specific emission reduction actions, such as improvements to the efficiency of a district heating system, so only a fraction of the total reductions available in these countries at a given price will qualify. The remaining reductions are only available through broad policy measures such as a gasoline tax.[18] The fraction of reductions assumed to be available as JI quotas is 25%, with a sensitivity range of 10% to 75%.

- Transactions costs. The price paid by the buyer must cover the costs of the domestic or international process to certify the reductions achieved as well as the cost of achieving the reductions. The revenue to the seller of JI quotas will be reduced by 15% with a sensitivity range of 10% to 35%. The transactions costs for JI should be lower than those for CDM on the assumption that there will be less extensive review of JI projects and JI projects may not be subject to the levy for administrative expenses and adaptation assistance for particularly vulnerable developing countries.

2.5 The IET Seller

The IET seller is the same as the JI seller -- the Annex B Parties other than OECD countries (Rest of Annex B). IET quotas (AAUs) are part of the country's assigned amount.

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[18] When JI quotas are available they are always valid and so are at least as attractive to buyers as IET quotas. This will encourage the Annex B sellers to structure as much of the available emission reductions as JI projects. Thus, JI quotas could account for a relatively large share of the available emissions reductions.

The IET seller seeks to maximize its net income. It does this by selling as many AAUs as possible regardless of the price, since assigned amount has no cost to the seller. If the Annex B seller is subject to penalties for non-compliance, it will only sell AAUs surplus to its compliance needs at prices less than the penalty. Thus, if the penalty exceeds the market price the seller achieves compliance. But if the penalty is less than the market price, it will sell as much IET quota as possible and pay the penalty for non-compliance.

The IET supply curve is derived from the assigned amount for the Rest of Annex B Parties less the JI supply curve.[19]

- Several of the liability proposals limit the quantity of AAUs that can be sold during a given year. In these cases, the IET supply curve reflects the liability provision. Any unsold AAUs are added to the quantity available for the next year, where they may be allowed to be sold by the liability provision.

- Other liability proposals do not limit the quantity of AAUs that can be sold during a given year. In these cases, the total assigned amount for the commitment period is available for sale at the beginning of the period. The unsold portion, less any JI sales, is available for sale in the next year.

The IET seller can increase its net income under some options by implementing domestic reductions with a cost lower than the market price and then selling the additional AAUs. With a non-compliance penalty, the seller increases its revenue by implementing domestic reductions with a cost lower than the lesser of the penalty and the market price. The amount of domestic reduction possible at each price is determined from the marginal abatement cost curve for the Rest of Annex B Parties (see equation (3) above), less the amount developed as JI projects. Transactions costs for IET are assumed to be zero.

2.6 Calculation of Demand

At the beginning of each year, the buyer projects its demand for the year.[20] The demand for the current year is calculated as the buyer's projected emissions plus a compliance margin[21] less the domestic AAUs received and banked quotas.

The buyer is assumed to receive domestic AAUs equal to the annual assigned amount. Banked quotas from earlier years (if any) with no risk of invalidation are added to the

[19] The Kyoto Protocol defines the assigned amount as the allowable emissions for the 5-year commitment period. Article 3.11 requires that any ERUs transferred by a country be deducted from its assigned amount.

[20] As the MIT EPPA model only gives projections for the years 2005, 2010, and 2015, values for intermediate years are approximated through linear interpolation.

[21] As discussed in section 2.8 below, the model can be run in a deterministic or random mode. The compliance margin is zero when the model is run in the deterministic mode and is 5% of the "business-as-usual" emissions when the model is run in the random mode.

domestic AAUs. Any excess emissions by the buyer during the previous year, non-compliance, are added to the demand for the current year as part of the penalty imposed on the buyer.

The difference between the buyer's projected emissions plus the compliance margin less the domestic AAUs received and banked quotas becomes the buyer's demand for the current year. This demand must be met through domestic emission reduction actions and/or purchases of international quotas that are not subject to the risk of invalidation under the applicable liability provision.

Where the liability provision includes a risk of invalidation of the sale, the AAUs can only be used for compliance in 2012. When evaluating the purchase of such AAUs during earlier years, the buyer assumes its demand for 2012 will be equal to that during the current year. The price the buyer is willing to pay for AAUs that can be used in 2012 is the price during the current year reduced by the risk of invalidation. The two invalidation rules proposed, and the associated risk calculations are discussed in section 3.12.

2.7 Matching Supply and Demand

Supply and demand for the current year are matched by finding the lowest price at which the supply of domestic reductions, CERs, ERUs and AAUs available is sufficient to meet the buyer's demand. This is done by creating a supply schedule that includes the quantity of domestic reductions, CERs, ERUs and AAUs with no risk of invalidation available at each price under the liability proposal being analyzed. Then the buyer's demand is compared to the supply starting at the lowest price ($1/tC) and continuing in $1/tC increments until the supply is sufficient to meet the demand.

The market price is the lowest price at which the supply just exceeds the buyer's demand.[22] If the supply exceeds the buyer's demand at this price, supply is matched to demand by reducing the quantity of AAUs purchased appropriately. The quantities of domestic reductions, CERs and ERUs supplied satisfy the optimality condition for minimizing the cost of compliance, namely that the marginal abatement costs equal the market price.[23]

When there are no AAU sales, only CERs and ERUs can be traded. Then the buyer obtains the quantity of CERs and ERUs supplied at the market clearing price. These supplies will exceed the buyer's demand by a small amount because the model works in $1/tC price increments. This excess supply is banked for use during the following year.

[22] The market price is found through an iterative procedure using 1 US$ steps, so demand and supply cannot be matched precisely.

[23] For a formal proof of this property see, for example, W. Baumol and W. Oates (1975), *The Theory of Environmental Policy*, Cambridge University Press, Cambridge.

Liability proposals with a user liability component include a risk that some or all of the transactions will be invalidated. In these cases, the buyer purchases the lesser of its demand for 2012 and the buyer's projection of the issuer's surplus AAUs. The buyer's demand for 2012 is assumed to be equal to its demand for the current year. The buyer's estimate of the issuer's surplus AAUs is the issuer's total assigned amount less the issuer's projected emissions for 2008-2012 less the issuer's projected sales of JI and IET quota for 2008-2012. Projected emissions are the issuer's actual emissions during the period (subject to a two-year lag) plus a trend projection of emissions for the balance of the period.[24] JI and IET quota sales are projected on the basis of actual sales plus the assumption that sales remain constant for the balance of the period.[25].

Any AAUs purchased for 2012 are banked. When 2012 arrives, the AAUs reduce the buyer's demand for the current year. If the issuer is not in compliance at the end of 2012, AAUs are returned to the issuer and the buyer is subject to penalties for non-compliance.

2.8 Actual Emissions

Actual emissions of the buyer for a given year are its "business-as-usual" emissions as projected by the EPPA model less any domestic emission reductions. The EPPA model is run on 5-year steps for 2005, 2010 and 2015. The "business as usual" emissions for the intermediate years are linear interpolations. Actual emissions of the buyer are known in the current year -- the buyer needs to hold quotas for its actual 2008 emissions in 2008.[26]

The model may be run in a deterministic mode, where actual emissions are equal to the "business-as-usual" emissions, or a random mode, where the "business-as-usual" emissions are adjusted by a normally distributed random component. The random adjustment is implemented by generating a random number from a distribution with mean of zero and a standard deviation of one. One standard deviation is assumed to be equal to 2.5% of the "business-as-usual" emissions. Since over 95% of the values fall within two standard deviations, the random adjustments fall within a range of approximately ± 5%.[27]

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[24] Thus in 2008 the seller's emissions are projected for the years 2008 through 2012 based on actual emissions for the years 2000 through 2006. In 2011 the seller's emissions are its actual emissions for 2008 and 2009 plus projections for 2010 through 2012 based on actual emissions for the years 2000 through 2009.

[25] Thus in 2010 JI and IET quota sales for the period are projected as actual sales for 2008 and 2009 plus 2009 sales for 2010, 2011 and 2012.

[26] In practice firms will have some time, a "grace period" of say 3 to 6 months, after the end of the year to report their actual emissions and establish compliance. Firms are assumed to be required to hold quota valid for the year in which the emissions occurred, so this lag in establishing compliance can be ignored without affecting the analysis.

[27] Emissions of a single firm will fluctuate by much more than ± 5%. However, the fluctuations of different firms will offset each other (some rise while others fall) and the net effect on the emissions of Annex B buyers is likely to be less than ± 5%. Since it is total Annex B emissions and compliance costs that are of interest, the random fluctuation is limited to 5%.

Actual emissions of the Annex B seller for a given year are its "business-as-usual" emissions as projected by the EPPA model less a fraction of the ERUs sold. As part of the sensitivity analysis JI projects may be assumed to be subject to less stringent international review than CDM projects. If the quantity of ERUs issued is inflated relative to the reduction from "business-as-usual" emissions, the actual emissions of the Annex B seller should be "business-as-usual" emissions less a fraction of the ERUs sold.[28] A value of 1.0 (no inflation) will be assumed with a sensitivity range of 1.0 to 0.1 to be tested. Actual emissions of the Annex B seller are known with a two-year lag -- 2008 emissions are known in 2010.

Actual emissions of the non-Annex B seller for a given year are its "business-as-usual" emissions as projected by the EPPA model less the CDM quotas sold. Since CDM quotas are not likely to be subjected to the liability proposals, adding a random element to the emissions does not enhance the analysis.

2.9 Compliance

The buyer's compliance is assessed on an annual basis. At the end of each year the buyer's actual emissions are determined as described above. If the buyer's valid quota holdings exceed the actual emissions, its quota holdings are reduced by the amount of its actual emissions and the remaining quota is banked. The buyer's behavior is modeled so that it is almost always in compliance.

If actual emissions exceed the valid quota holdings, the quota holdings are reduced to zero. The deficiency is added to the buyer's demand for the next year and a financial penalty is applied. The financial penalty is the higher of $100/tC or three times the market price in the current year for each ton of excess emissions.[29]

The Annex B seller's compliance is assessed at the end of the commitment period. There are no penalties for non-compliance by the seller unless those are part of the liability proposal. The AAUs remaining at the end of 2012 are deducted from the Annex B seller's total emissions for 2008 through 2012 to determine compliance. Under many liability proposals the seller does not comply with its emissions limitation commitments.

[28] If there is no international review of JI projects as some Parties propose, the host government and the buyer conceivably could agree to provide 1 million tC of JI quota per year for symbolic actions such as planting a few trees. Other considerations not related to climate change mitigation may contribute to striking such deals.

[29] The domestic penalty does not change the buyer's behavior; it simply affects the compliance costs. The penalty justifies the inclusion of a 5% compliance margin in the buyer's demand. When the model is operated in the deterministic mode the buyer is always in compliance. When the model is operated in the random mode, the buyer may be out of compliance by a small amount due to the random adjustment incorporated into the actual emissions. The penalties are always small relative to the compliance costs.

The excess emissions by the Annex B seller are calculated and are used as a measure of the effectiveness of the liability proposal.

If the liability proposal includes the risk of invalidation and the Annex B seller does not achieve compliance, some or all of the AAUs sold are returned to the issuer (seller). The AAUs returned to the issuer are the lesser of the total quantity of AAUs sold and the quantity needed to bring the issuer into compliance. If returning AAUs to the issuer puts the buyer into non-compliance, it is subject to the non-compliance penalties.

2.10 Compliance Costs

The compliance cost for the OECD buyer is the cost of the domestic reductions plus the cost of the purchased quotas plus any non-compliance penalty (N). The compliance cost is reduced by the value of any quotas banked for use during the next commitment period (B).[30] The cost of the domestic reductions is equal to the area under the marginal abatement cost curve for the quantity reduced.

The cost of the purchased quotas is the market price (P) times the quantity purchased. For liability proposals with a risk of invalidation the purchases may also include early purchases at a discounted price (P') of AAUs for use in 2012. Thus the cost for the buyer is calculated as follows:

(4) $C = (0.0064/2.4883) * Q_{DOM}\text{^}2.4883 + P * (Q_{CDM} + Q_{JI} + Q_{IET}) + P' * (Q_{2012}) + N - B$

The compliance cost for the Annex B seller is the cost of domestic reductions and any non-compliance penalty (N) less the revenue from the sale of ERUs and AAUs less the value of any AAUs that can be banked for the next commitment period (B). Domestic reductions must be implemented to generate ERUs and may be undertaken to generate more AAUs where this yields a net financial return to the seller. Thus the cost is calculated as follows:

(5) $C = (0.0413/2.405) * (Q_{JI} + Q_{DOM\text{-}RAB})\text{^}2.405 + N - P * (Q_{JI} + Q_{IET}) - B$

Because the seller is assumed to maximize its net income, the revenue received will always exceed the cost of the domestic reductions. Under liability proposals that impose a non-compliance penalty, the seller incorporates the penalty into its profit-maximizing behavior. Thus the compliance cost is negative, meaning that the revenue exceeds the cost.

The compliance cost for the non-Annex B seller is the cost of the reductions to generate the CDM quota less the revenue from the sale of CDM quota. Thus the cost is calculated as follows:

[30] The value of AAUs banked for use during the subsequent commitment period is assumed to be 90% of the average price of AAUs over the period 2008 through 2012.

(6) $C = (0.0047/2.5658) * Q_{CDM}^{2.5658} - P * Q_{CDM}$

As a result of the seller's profit maximization behavior, the revenue received will always exceed the cost of the reductions to generate the CDM quota. Put differently, the compliance cost is always negative, meaning that the revenue is greater than the cost.

The compliance cost is calculated as the present value in 2008 of the compliance costs for 2008 through 2012. A discount rate of 5% is used for the calculation with sensitivity tests for discount rates from 2% through 10%. The present value of the compliance costs is another measure of the effectiveness of the liability proposals.

2.11 Sensitivity Tests

The model embodies a number of assumptions, and parameters with assumed values, that affect the results. To determine how sensitive the results are to these assumptions, we perform sensitivity tests on these assumptions and parameter values. The standard assumptions and the range of values tested are as follows:

- Transactions costs for CDM quota: 25% with a sensitivity range of 10% to 50% with CDM transactions costs always being higher than those for JI quota.

- Transactions costs for JI quota: 15% with a sensitivity range of 10% to 35%, with CDM transactions costs always being higher than those for JI quota.

- Adjustment for the inventory of CDM quota from projects started prior to 2008: the annual supply at each price is multiplied by 1.8, with a sensitivity range of 1.5 to 2.4.

- JI quotas as a share of the emissions reductions available in the Annex B seller countries: 25%, with a sensitivity range of 10% to 75%.

- The fraction of JI quota that corresponds to "real" emission reductions: 1.0, with a sensitivity range of 1.0 to 0.05.

- Annex B seller's surplus assigned amount: Annex B countries differ significantly in terms of the ratio of their assigned amount to their "business-as-usual" emissions. Changing the surplus emissions is a way to test how a liability proposal would affect different countries even though the model includes only a single seller. In the EPPA model the Annex B seller (the economies in transition) has assigned amount for 2010 of 1,282.1 MtC per year and "business-as-usual" emissions for 2010 of 1,047.6 MtC in 2010. The interpolated "business-as-usual" emissions for 2008 through 2012 are 5,194.86 MtC and the assigned amount for the five-year period is 6,410.5 MtC. The "business-as-usual" emissions (5,194.86 MtC) are given a value of 0 and the allocated assigned amount (6,410.5 MtC) is given a value of 1. Liability proposals are

analyzed for countries whose assigned amount relative to the "business-as-usual" emissions range from -0.4 (4,708.6 MtC) to 1.4 (6,896.8 MtC).

- Assumed seller behavior: The model assumes that all sellers are price takers in the quota market. It can be argued that the Annex B seller might behave as an oligopolist and seek to maximize its net income from sales of quotas by restricting the supply. In the model the income to the Annex B seller increases continuously as prices rise, so an arbitrary oligopolistic margin of $10/tC is assumed.

- Discount rate: 5% with sensitivity tests for 2% and 10%.

- The degree of risk aversion by the buyer: If the liability proposal involves a risk of invalidation of the sale, the buyer can be assumed to be risk neutral or risk averse. Under such rules, the buyer is able to purchase quotas for use in 2012 at a discount from the price in the current year. If the buyer is risk neutral, the discount reflects the buyer's estimate of the risk of invalidation based on its projection of the issuer's emissions and quota sales. If the buyer is risk averse, it applies a larger discount to the price. With risk aversion the estimate of the issuer's emissions used to calculate the discount is the trend projection plus one or two (depending upon the degree of risk aversion) standard deviations, rather than the trend projection.

2.12 Model Validation

The model is validated by replicating the EPPA results for global trading with full compliance. EPPA provides annual results on five-year time steps. EPPA does not include banking of quota or transactions costs. Our model operates in annual time steps, does not require compliance, allows banking and includes transactions costs.

To validate the model the EPPA results for 2010 are replicated by forcing compliance each year, setting transactions costs to zero, and setting the supply of CDM quota from reductions prior to 2008 to zero. The “business as usual” emissions for OECD and the rest of Annex B countries for the years 2008 through 2012 are assumed to:

- Remain constant at the 2010 values for the entire period; and

- Follow the interpolated values during the period, matching the EPPA value only in 2010.

Since the “business as usual” emissions and assigned amount for the OECD and the rest of Annex B (RAB) are specified and the model forces both groups to achieve full compliance each year, successful replication must be assessed on the basis of the market price and the compliance cost for each region for 2010. The market prices are shown in Table 1 and the annual compliance costs for 2010 are shown in Table 2.

Table 1
Market Prices
(1995US$/tC)

	2008	2009	2010	2011	2012
EPPA			$47.70		
Constant BAU emissions	$47.80	$47.80	$47.80	$47.80	$47.80
Interpolated BAU emissions	$35.00	$42.00	$47.80	$52.00	$57.00

In our model, prices are rounded up to the next dollar. For validation purposes only, price increments of $0.10 were introduced between $47.00 and $48.00. The EPPA price, which is between $47.70 and $47.71, is rounded up to $47.80 by our model. Thus our model produces the same market price as EPPA for each year where the demands are the same.

Table 2
Annual Compliance Costs 2010
(Billion 1995US$)

	OECD	Rest of Annex B	Non-Annex B	Total
EPPA	$43.3	-$15.4	-$10.5	$17.4
Constant BAU emissions	$43.41	-$15.38	-$10.57	$17.46
Interpolated BAU emissions	$43.41	-$15.38	-$10.57	$17.46
Note: Negative values mean a net revenue				

The model replicates the EPPA compliance costs to the second decimal point.

In conclusion, our model replicates the EPPA results accurately when the assumptions are the same.

2.13 Reference Case

The liability proposals are assessed by comparing them to a reference case that incorporates our standard assumptions. Specifically, the reference case assumes:

- Full compliance by the Annex B buyer and seller annually;
- Interpolated “business as usual” emissions;
- Transactions costs for JI and CDM;
- An inventory of CDM quota due to actions implemented prior to 2008;

- A portion of the potential emission reductions in the Rest of Annex B (RAB) countries can be implemented as JI projects; and

- No restrictions on international quota trade.

Detailed results for the reference case are presented in Table 3.[31]

The price rises from $26 in 2008 to $42/tC in 2012, which is substantially lower than under the price of $47.70/tC in 2010 under the EPPA assumptions. The reason for the lower prices is availability of early CDM quotas in our reference case. The reference case includes transactions costs on JI and CDM and limits on JI supply, which tend to increase prices. However, the inventory of CERs due to reductions prior to 2008 reduces prices by an even larger amount. So the net effect is lower prices in our reference case than in the EPPA global trading case.[32]

2.13.1 Reference Values to which Liability Proposals are Compared

As stated in section 1.3, the performance of each liability proposal is measured in terms of:

- Emissions by the Annex B seller in excess of its remaining assigned amount after trading. In the reference case the excess emissions of the Annex B seller are -38MtC, over-compliance of 38 MtC.[33]

  The excess emissions of the Rest of Annex B seller depend primarily on the quantity of AAUs sold. The actual emissions of the Rest of Annex B will not change significantly from one liability proposal to another. The liability proposal changes the amount of JI quota sold and the amount of domestic action undertaken in the Rest of Annex B. This affects the actual emissions in this region.[34] But the quantity of

[31] The meticulous reader will detect a small amount of over compliance on the part of the Rest of Annex B. The assigned amount remaining at the end of the period, 4,645 MtC, is 38 MtC larger than the actual emissions during the period of 4,607 MtC. Smaller amounts of over-compliance are evident for specific years. This is due to the fact that the model rounds prices up to the next dollar and accrues the corresponding reductions. The extra reduction is less than the reduction due to a change of $1.00 in the market price and so is within the resolution of the model.

[32] If the inventory of CDM quota is eliminated from the reference case, the prices rise from $39 to $61/tC. If all of the transactions costs are zero and all reductions in the non-OECD Annex B countries can generate JI quota, the prices range from $23 to $37/tC.

[33] The Rest of Annex B holds assigned amount of 4,645 MtC at the end of the period to cover actual emissions of 4,607 MtC during the 2008-2012 period.

[34] If all JI quota sales and all domestic reductions in the Rest of Annex B were reduced to zero, which is not the case under most liability proposals, the actual emissions would rise from 4,607 MtC to the BAU emissions of 5,195 MtC, an increase of 13%.

AAUs sold, and hence the quantity assigned amount remaining, has a much bigger impact on the Rest of Annex B excess emissions. The liability proposals affect the quantity of AAUs sold by the Rest of Annex B and hence directly affect its excess emissions.

Table 3
Reference Case
(million metric tons of carbon equivalent)

	2008	**2012**	**Total (2008-2012)**
OECD			
BAU Emissions	3,643	3,829	18,718
Domestic Reductions	266	367	1,612
Actual Emissions	3,377	3,462	17,106
CDM	384	521	2,302
JI	22	31	136
IET	364	302	1,629
Assigned Amount	2,608	2,608	13,038
Rest of Annex B			
BAU Emissions	989	1,077	5,195
Domestic Reductions	74	104	452
JI	22	31	136
Actual Emissions	894	942	4,607
Assigned Amount Issued	1,282	1,282	6,410
Assigned Amount Remaining	896	949	4,645
Non-Annex B			
BAU Emissions	2,629	2,879	13,747
CDM	384	521	2,302
Actual Emissions	2,246	2,358	11,327
Prices -- (US1995$/tC)			
	$26.00	$42.00	
Costs -- Present Value in 2008 (billion US1995$)			
OECD compliance	$21.71	$32.96	$141.16
Rest of Annex B compliance*	-$8.61	-$9.44	-$45.44
Non-Annex B compliance*	-$7.44	-$13.43	-$54.32
Total compliance	$5.66	$10.09	$41.40
Note: * Negative values indicate net revenue rather than a net cost.			

- Total compliance cost for the Annex B buyer. The total compliance cost for the Annex B buyer is $141.16 billion in the reference case. The total compliance cost of each liability proposal is expressed as a percentage change from this value.

- The mix of domestic action and quota purchases used by the Annex B buyer to achieve compliance and the associated distribution of costs. To achieve compliance the Annex B buyer creates a total demand of 5,680 MtC.

  Table 4 shows that in the reference case this demand is satisfied through domestic reductions by the buyer (28%), purchases of CERs (40%), purchases of ERUs (2.4%), and purchases of AAUs (28.7%). With non-compliance by the Rest of Annex B, the share of AAU purchases increases and the shares of all other options decline.

Table 4
Mix of Actions Used to Achieve Compliance
(Reference Case, 2008 through 2012)

Compliance Action by Annex B Buyer	**Quantity** (MtC)	**Percentage** (%)
Domestic reductions	1,612	28.4%
Purchases of CERs	2,302	40.5%
Purchases of ERUs	136	2.4%
Purchases of AAUs	1,629	28.7%
Total	5,679	100.0%

The mix of actions used by the Annex B buyer to achieve compliance affects the distribution of costs. As shown in Table 3, the total compliance cost for the buyer of $141.16 billion involves transfers of about $100 billion to the Rest of Annex B seller ($45 billion) and the Non-Annex B seller ($54 billion). With higher sales of AAUs (and non-compliance) by the Annex B seller the share of the revenue that goes to the Rest of Annex B rises, while the share that goes to the Non-Annex B seller falls.

- Impact on market prices over time due to restrictions on the AAUs sold. In the reference case the market price rises steadily from $26.00/tC in 2008 to $42.00/tC in 2012.

  Some liability proposals can cause sharp increases or decreases in the market price by restricting, or increasing, supplies of AAUs from one year to the next. Large price fluctuations are undesirable, so this is another indicator of the performance of a liability option.

  The model deals only with the "spot" market where quotas are traded at the current market price. A secondary market, where options, forward contracts and other instruments are traded, may also exist. A healthy spot market is a pre-requisite for development of the instruments traded in the secondary market. Thus, if a spot market is well established, the impact of abrupt changes in prices can be mitigated through the use of options.

It can be argued that a spot market for CERs will exist because of the CDM projects started prior to 2008, so that options should be available from the beginning of the commitment period. While CERs will be available prior to 2008, the supply of AAUs available will have a significant impact on the market price for quotas. Therefore, firms may be unwilling to enter into option contracts until some experience with AAUs is available as a basis for assessing the risks.

2.13.2 Random Fluctuations

The buyer's decision for some liability proposals depends on its projection of the issuer's future emissions. The analysis is straightforward if the buyer can project the issuer's future emissions with perfect accuracy. However, this is unlikely to be the case in practice. To more closely approximate the reality, the historical emissions used for the projection include some random fluctuation.

Random adjustments are applied to the "business-as-usual" emissions of the OECD and the Rest of Annex B as interpolated from the EPPA model. The random adjustment is implemented by generating a random number from a distribution with mean of zero and a standard deviation of one. One standard deviation is assumed to be equal to 2.5% of the "business-as-usual" emissions. Since over 95% of the values fall within two standard deviations, the random adjustments fall within a range of approximately ± 5%. The interpolated and adjusted emissions for the two regions are shown in Figure 2.

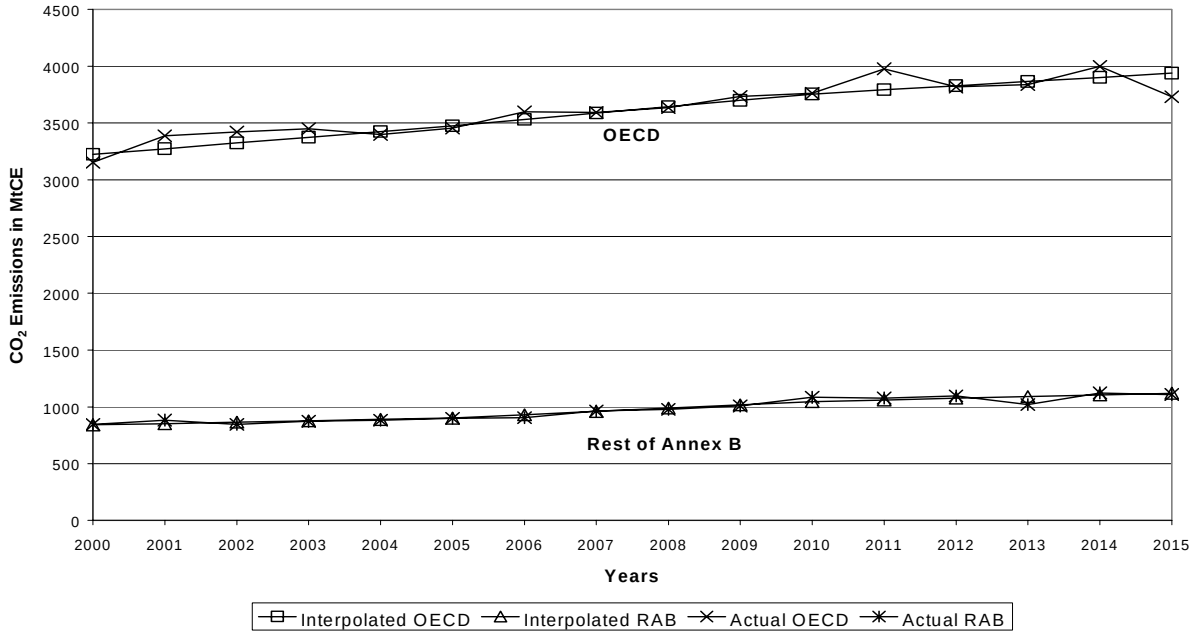
The randomly adjusted emissions are the same for all runs where they are used. Otherwise differences in costs between runs could be due to differences in the random adjustments to the historical emissions.

2.13.3 Random Reference Case

The model can be run in a deterministic mode or a random mode. In the deterministic mode, the buyer knows what its future emissions will be and so does not include a compliance margin in its demand. In the deterministic mode, the future emissions of the buyer and seller are not known and vary from the trend projection. Given the severe domestic penalties the buyer faces, it includes a compliance margin in its demand.

Adding a compliance margin to the buyer's demand increases costs and means that the buyer holds banked quotas at the end of the period. Table 5 compares the random reference case to the deterministic reference case summarized in Table 3. The compliance cost for the OECD buyer, at $221.54 billion, is 57% higher. Most of this increase is due to the bank of quotas held by the buyer as a result of including a compliance margin in its demand. The bank amounts to 780 MtC which are purchased at prices of up to $70/tC. At $70/tC the bank has a value of $54.6 billion, which is equivalent to 68% of the increased cost of $80.4 billion.

Figure 2
Interpolated and Adjusted Emissions for the OECD and Rest of Annex B Regions



The banked quotas resulting from the compliance margin are a significant component of total demand and total compliance cost. In our judgement this distorts the compliance action needed during the 2008-2012 period and the associated costs. Therefore, the liability proposals are analyzed using the deterministic mode for which the reference case is summarized in Table 3.

Table 5
Comparison of the Random and Deterministic Reference Cases
(million metric tons of carbon equivalent)

	Random Reference Case	Deterministic Reference Case	Increase from Deterministic Case
OECD			
BAU Emissions	18,927	18,718	1%
Domestic Reductions	1,903	1,612	18%
Actual Emissions	17,024	17,106	-1%
CDM Quota Purchases	2,694	2,302	17%
JI Quota Purchases	163	136	20%
IET Quota Purchases	1,701	1,629	4%
Assigned Amount Issued	13,038	13,038	0%
Banked Quota in 2012	780	0	
Rest of Annex B			
BAU Emissions	5,250	5,195	1%
Domestic Reductions	539	451	20%
Actual Emissions	4,711	4,744	-1%
Banked Quota in 2012	-36**	38	
Non-Annex B			
BAU Emissions	13,747	13,747	0%
CDM Quotas Sold	2,694	2,301	17%
Actual Emissions	11,053	11,327	-2%
Costs -- Present Value in 2008 (billion US$1995)			
OECD Compliance	$221.54	$141.16	57%
Rest of Annex B Compliance	-$60.79*	-$45.44*	34%
Non-Annex B Compliance	-$84.90*	-$54.32*	56%
Total Compliance	$75.85	$41.40	83%

Note: * Negative values indicate net revenue rather than a net cost.
** Negative value means excess emissions (non-compliance).

3. Analysis of Liability Proposals

Over a dozen liability proposals have been suggested in the literature and the international negotiations. The proposals reflect several different strategies for limiting sales of AAUs to amounts surplus to the seller's compliance needs. These strategies include:

- Issuer liability
  - Issuer liability subject to sanctions for non-compliance
  - Issuer liability subject to eligibility requirements

- Limits on sales
  - Annual retirement of AAUs equal to actual emissions
  - Limits on sales

- Trading limited to surplus quota
  - Sales prohibited until compliance established
  - Sales limited to AAUs surplus to a permanent reserve
  - Sales limited to AAUs surplus to the seller's compliance plan
  - Sales limited to AAUs surplus to defined compliance plan

- Restoration of default
  - Compliance reserve
  - Compulsory insurance
  - Escrow account

- User liability
  - User liability
  - Shared liability
  - Double liability

- Progressive response to probability of default
  - Traffic light

Other proposals include combinations of two or more of the above proposals. Those more complex proposals have not been evaluated.

Many of the proposals have not been defined in operational terms. The compliance reserve proposal does not specify the size of the contribution to the reserve. This could range from 10% to over 2000% of IET quota sold. This analysis evaluates alternative operational specifications of the liability proposals analyzed.

There are likely to be several Annex B countries that are net sellers of AAUs and ERUs, rather than the single seller included in the model. Applying a liability proposal in the

model assumes, in effect, that it would apply equally to all Annex B sellers. Some proposals probably would not affect all Annex B sellers equally. For example, it is unlikely that all of the Annex B sellers would gain or lose their eligibility simultaneously.

Analyzing the impacts when only some of the Annex B sellers are affected could be incorporated into the evaluation of the relevant proposals by assuming only a fractional change in the sales of AAUs. However there is no analytical basis for choosing this fraction and it could change from year to year, so this feature has not been included in the analysis. Rather the results for those proposals need to be interpreted as indicating the worst possible outcome.

The remainder of this section describes how each liability proposal has been modeled and the results of the analysis.

3.1 Issuer Liability Subject to Sanctions for Non-compliance

The procedures for determining non-compliance and the consequences for non-compliance with the emissions limitation commitments by Annex B Parties are not yet defined. Article 18 of the Protocol states that the consequences should reflect the "cause, type, degree and frequency of non-compliance." Proposed penalties include reduction of the Party's assigned amount for the subsequent commitment period by an amount at least equal to the excess emissions.[35] Various restrictions on the ability of a non-compliant Party to sell AAUs and/or ERUs during the subsequent commitment period have also been proposed. But since participation in the Kyoto Protocol is voluntary the penalties can not be too onerous or the offending Party may simply withdraw from the Protocol.

The model is limited to the first commitment period, so measures that apply during the subsequent commitment period can not be modeled explicitly. To analyze the effect of sanctions for non-compliance, we model a range of monetary penalties representing the expected value to the Annex B seller of the sanctions imposed. All AAUs sold are valid for use by the buyer during the year they are purchased.

The Annex B seller adjusts its behavior in response to the penalty. If the penalty is below the market price, the penalty becomes the minimum price at which AAUs and ERUs are sold. If the penalty is above the market price, the Annex B seller calculates the quantity needed for compliance and sells only AAUs and ERUs in excess of this amount. Thus, a penalty above the market price leads to full compliance.

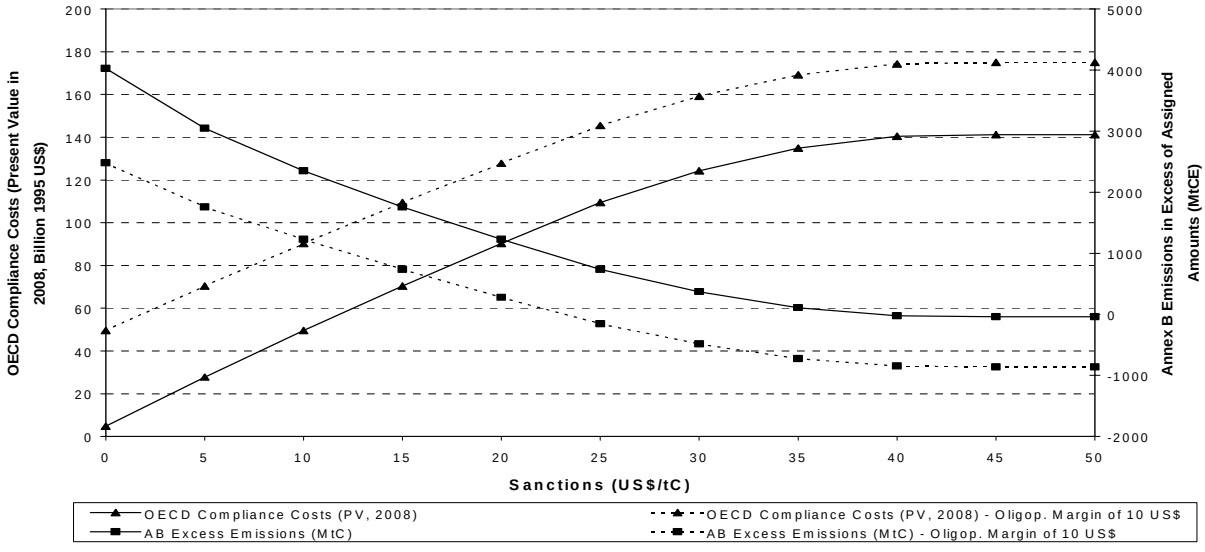
[35] The assigned amount for the next commitment period could be reduced by (100 + X%) where X% (say 5 to 50%) represents a penalty for non-compliance. This requires that the commitments for the subsequent period are negotiated well in advance of the end of the current period. Otherwise a Party that expects that it might be subject to such a penalty could seek to negotiate a higher commitment to reduce the impact of the anticipated penalty. Article 3.9 of the Protocol specifies that consideration of commitments for the second commitment period will begin no later than 2005, so it is possible that agreement on the commitments for the subsequent period could be reached prior to the start of the first commitment period.

The model results for penalties ranging from $0 to $50 per tC are summarized in Figure 3. If the Annex B seller is a price taker, it sells as many AAUs as the OECD needs for compliance when the penalty is zero, resulting in excess emissions of over 4,000 MtC. If the Annex B seller is able to command a premium of $10/tC due to its market power, the excess emissions are reduced to about 2,500 MtC with a zero penalty. The premium price demanded by the Annex B seller, not surprisingly, increases compliance costs for the OECD buyer significantly.

If the Annex B seller is a price taker, compliance is not achieved until the penalty reaches $39/tC, which is almost equal to the market price of $42/tC in 2012.[36] A penalty higher than $39/tC doesn't increase compliance costs or reduce emissions. The Annex B Parties comply with their commitments for all penalties above $39/tC and the compliance costs never exceed the costs in the full compliance reference case.

If the Annex B seller is able to exercise market power, it withholds AAUs from the market to raise the price. This leads to a higher level of compliance regardless of the level of the penalty as shown in Figure 3. If the Annex B seller is able to command a premium of $10/tC, compliance is achieved with a penalty of $24/tC.[37] For penalties between $24 and $39/tC the Annex B seller banks AAUs leading to lower emissions and higher compliance costs for the buyer.

Figure 3
OECD Compliance Costs and Annex B Excess Emissions as a Function of the Level of the Penalty



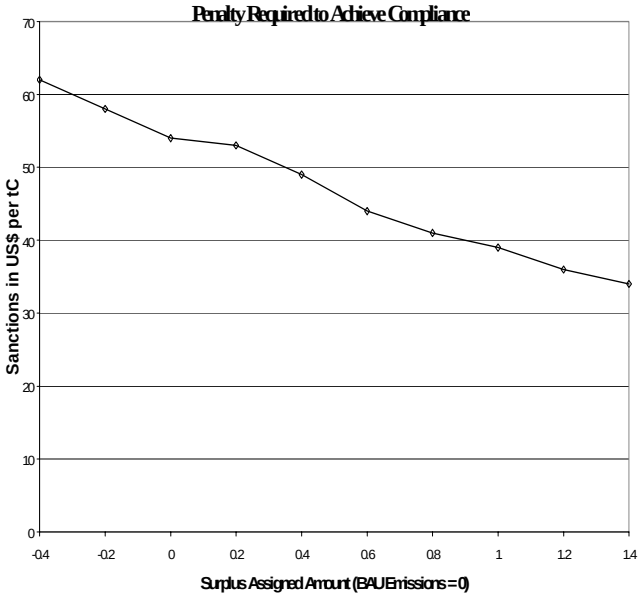
[36] Figure 3 shows over-compliance of 38 MtC for penalties in excess of $42/tC. This is simply the over-compliance associated with rounding prices upward to the next dollar.

[37] If the Annex B seller is able to command a premium of $35/tC compliance is achieved with a zero penalty. This premium is equivalent to the average price ($26 to $42/tC) over the period.

In summary, if the Annex B sellers are price takers, the penalty for non-compliance should be set well above the market price. But if the Annex B sellers are expected to exercise market power, the penalty should be set below the market price to minimize compliance costs. As compliance costs remain constant after full compliance has been achieved, choosing the appropriate penalty is straightforward. The penalty has to be higher than any expected market price to be an effective deterrent under all circumstances.

Figure 4 indicates that the minimum penalty needed to achieve compliance by the Annex B seller(s), assuming they are price takers, declines as their total assigned amount rises relative to their "business-as-usual" emissions. The minimum penalty falls from $62/tC to $34/tC over the range of countries considered.

Figure 4



If the Annex B sellers are price takers, setting the penalty above the market price imposes no additional costs. But a penalty whose present value for the seller is below the market price leads to non-compliance. Thus, the penalty should be set so that the present value to every seller under any market conditions still exceeds the market price. The combination of assumptions that produces the highest price, yields a penalty of $98/tC in 2012.[38]

A higher penalty is probably needed because an Annex B seller may have a much higher discount rate than the 5% assumed for the analysis, thus requiring a higher penalty to reach a given level of compliance.

No penalty is able to guarantee compliance because an Annex B seller could plan to drop out of the Protocol for the next commitment period. This would effectively reduce the present value of any end of period penalty to zero.

Setting an appropriate penalty for a competitive market will increase compliance costs if some Annex B sellers are able to exercise market power. Creating a competitive market

[38] These assumptions are assigned amount of 4,708.6 MtC relative to "business-as-usual" emissions of 5,194.86 MtC, high transactions costs for JI and the CDM, and no CERs from actions prior to 2008. The price is in 1995 U.S. dollars. This penalty is about three times the expected average price of $34/tC. Specifying that the penalty will be three times the market price is one way to ensure that it will always exceed the cost of compliance.

is perhaps the best way to avoid this situation. A large flow of CDM projects beginning as soon as possible will reduce the market power of Annex B sellers. Rules that restrict free trade in any of the Kyoto mechanisms will tend to enhance the market power of the Annex B sellers.

The results confirm what is widely accepted -- that sanctions lead to compliance if the penalties faced by the seller are higher than the market price and are enforced. The model suggests that the present value of the non-compliance sanctions must be clearly higher than $98/tC to be effective for all countries. The possibility that the sanctions for non-compliance faced by Parties under the Kyoto Protocol may be lower than required or may not be effectively enforced is the motivation for seeking other mechanisms to limit non-compliance due to trading -- the various liability proposals.

For the comparison with other liability proposals, penalties of $0/tC, $15/tC and $40/tC will be used because they span the range of possible penalties up to full compliance. A penalty of $15/tC results in an OECD compliance cost roughly half that of the full-compliance reference case.

3.2 Issuer Liability Subject to Eligibility Requirements

This proposal requires the Annex B seller to meet various eligibility requirements before being allowed to sell AAUs and ERUs. Proposed eligibility requirements include:

- Compliance with Article 5, maintaining an acceptable national emissions inventory;
- Compliance with Article 7, reporting actual emissions and other information;
- Being Party to a compliance regime adopted under Article 18, being subject to penalties for non-compliance; and
- Maintaining a registry to track AAUs and ERUs that meets specified standards.

Even if eligibility is established prior to the start of the commitment period, eligibility could be lost during the period.[39] However, there may be a time lag between the event that triggers loss of eligibility and the date when participation in emissions trading is restricted.

Since the proposed eligibility conditions relate, at least in part, to the adequacy of the emissions inventory we assume that this can only be assessed with a two-year lag. Thus the cases tested are as follows:

[39] Article 5.1 requires that each Annex B Party have a satisfactory national emissions inventory system in place at least one year prior to the start of the commitment period. Thus, compliance with the eligibility requirements could be established prior to the start of the commitment period.

1. Eligibility is demonstrated prior to 2008, but lost due to non-performance. Three cases are examined: sales of AAUs cease in 2010, 2011 or 2012 due to loss of eligibility.

2. Eligibility must be demonstrated before sales are allowed. Three cases are examined: sales of AAUs can not begin until eligibility is established in 2010, 2011, or 2012.

While the seller is eligible, sales of AAUs and ERUs are not restricted. If the seller is not eligible to engage in international emissions trading, sales of ERUs can continue. All AAUs sold are valid for use by the buyer during the year they are purchased.

Figure 5 shows the impact of eligibility on the market price. If the Annex B seller is a price taker, the price is low ($1/tC) when the seller is eligible to trade. The price rises sharply (to over $60/tC) when the Annex B seller is ineligible to trade because the buyer must then rely on domestic action, CERs, and ERUs to achieve compliance. If the Annex B seller is able to command a price premium of $10/tC the price becomes $11/tC when the seller is eligible to trade. But the price increase is generally less than $10/tC when the Annex B seller is ineligible to trade and the buyer must rely on other other quotas and domestic reductions to achieve compliance.

Figure 5
Impact of Eligibility on Market Prices

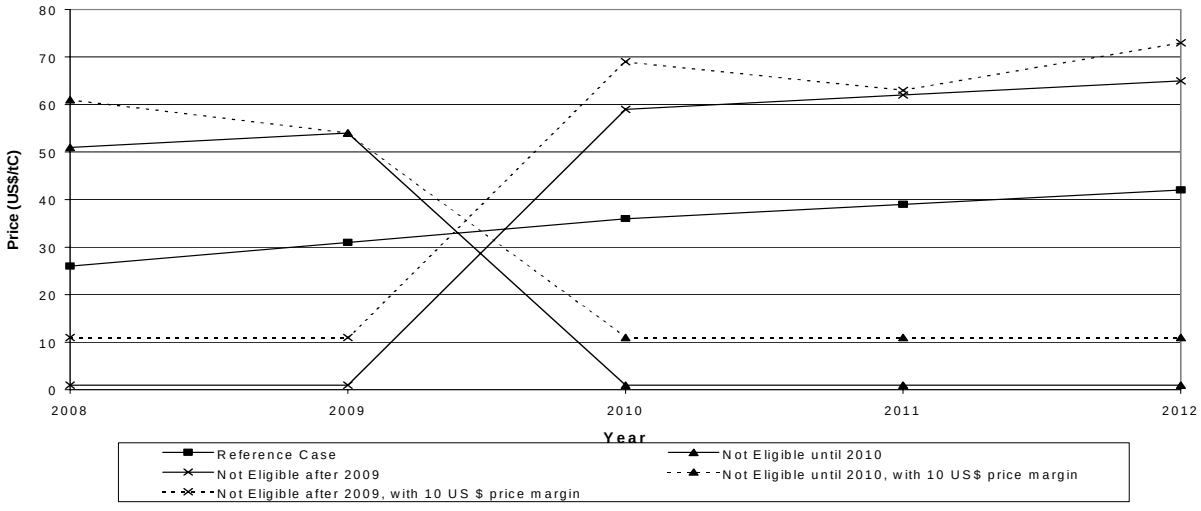
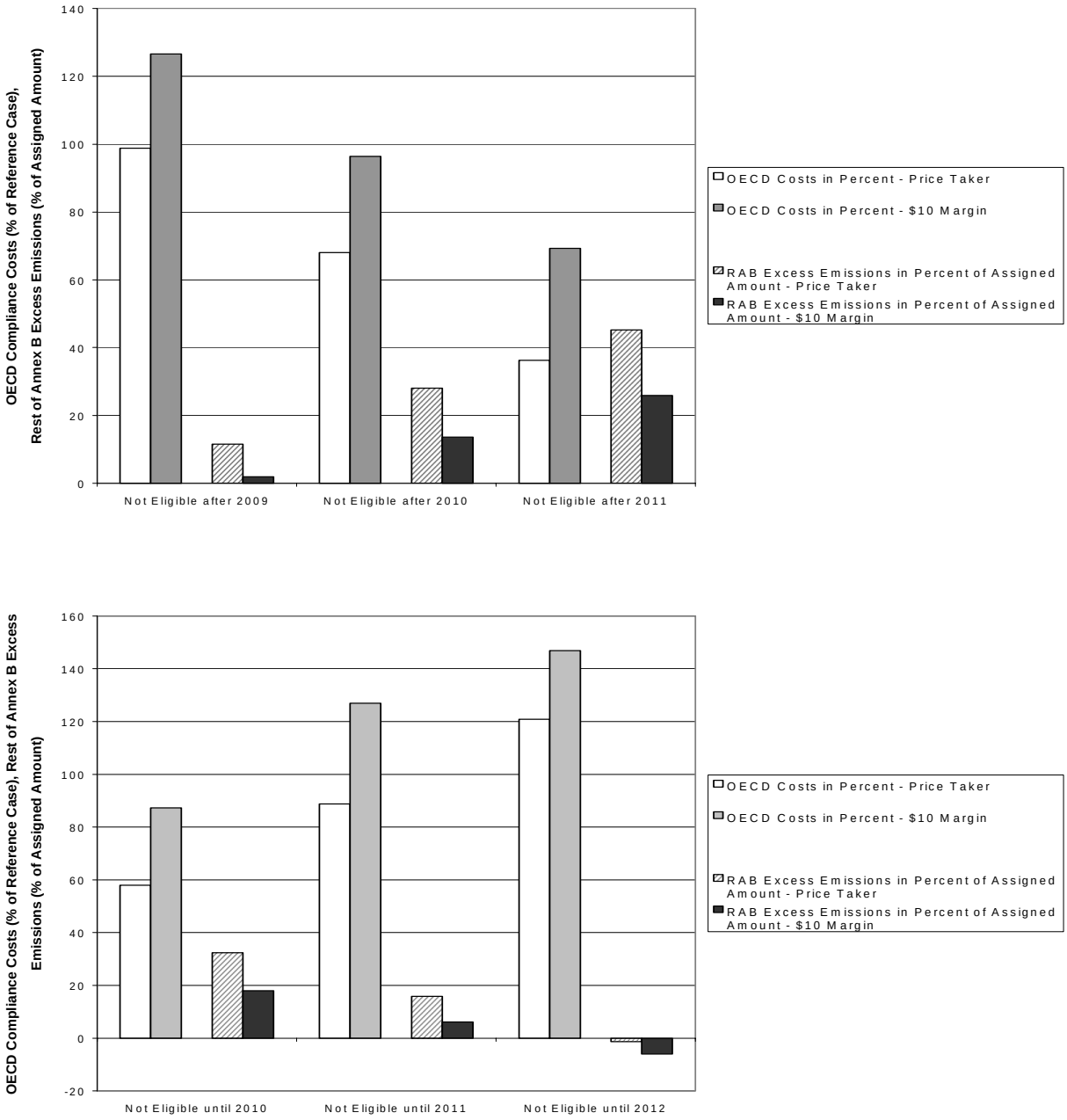


Figure 6 shows the OECD compliance costs and excess emissions by the Annex B seller for the different cases. The longer the Annex B seller is eligible to engage in emissions trading -- the earlier eligibility is established or the later it is lost -- the higher the excess emissions and the lower the OECD compliance costs. This is true whether the Annex B seller is a price taker or is able to exercise some market power.

The only case in which the Annex B seller achieves compliance is when its eligibility to trade is limited to one year; eligibility to trade is not established until 2012. Annex B seller compliance is achieved because the demand during a single year is not sufficient to sell all of the surplus AAUs. This increases the compliance costs for the OECD by 20% to 45% from those in the reference case.

Figure 6

Impact of Eligibility on OECD Compliance Costs and RAB Excess Emissions



The model results overstate the impact of loss of eligibility because there is only one seller. In practice there would be several sellers and it is unlikely that all of them would lose (or gain) their eligibility at the same time. However, the finding that eligibility requirements alone are not sufficient to ensure that Annex B participants in IET trading do not oversell AAUs is robust.

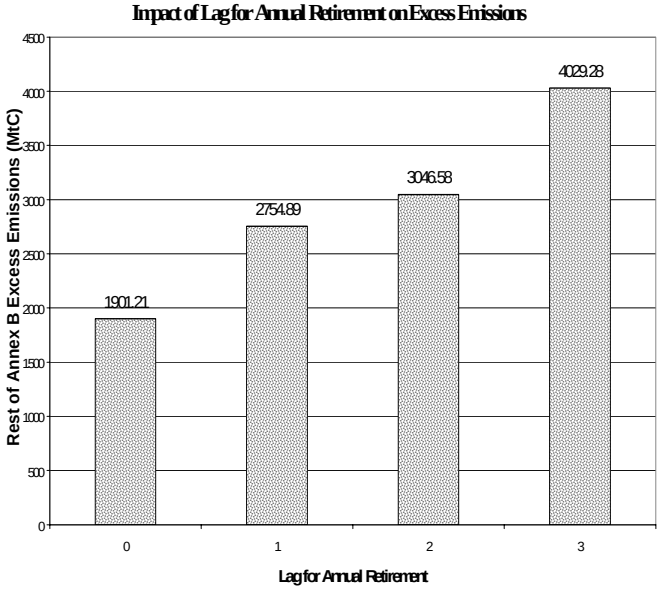
In summary, various eligibility requirements -- such as an accurate inventory, timely reporting, a suitable registry and participation in the compliance regime -- may be essential conditions for participation in emissions trading, but they are not sufficient to ensure that Annex B participants only sell AAUs surplus to their compliance needs.

To compare this liability proposal with the other liability proposals; loss of eligibility at the end of 2009 and eligibility not established until the beginning of 2012 will be used.

3.3 Annual Retirement of AAUs Equal to Actual Emissions

Under this proposal, the quantity of IET quota available for sale is the seller's total assigned amount for the commitment period less cumulative emissions and cumulative sales of AAUs and ERUs. Since the seller's actual emissions are only known with a two-year lag, the entire assigned amount is available for sale until 2010. All AAUs sold are valid for use by the buyer during the year they are purchased.

Figure 7



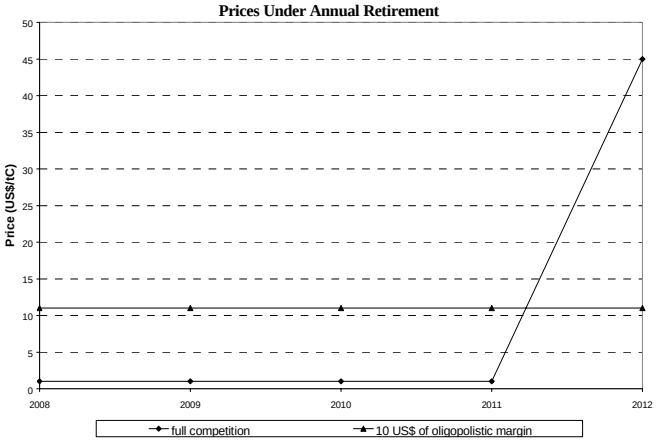
This proposal is not effective in limiting sales of AAUs to the amount surplus to the seller's compliance needs. This is due to a combination of two factors. First, the quantity of AAUs available for sale (the seller's assigned amount) is more than five times the seller's annual emissions. This means that several years of emissions and quota sales must be deducted from the total before sales are limited.

Second, actual emissions are only known with a lag of two years, which allows more sales to occur before the available supply is restricted. The result is that annual retirement does not limit the quantity that can be sold until 2012, by which time the seller has already sold a substantial quantity of the AAUs it will need for compliance. Figure 7 shows that the excess emissions rise as the lag for reporting annual inventories grows longer. Even

with no lag in reporting actual emissions, annual retirement does not prevent excess emissions.

If the Annex B seller is a price taker, the price is low ($1/tC) as long as AAUs remain available. In 2012 when the supply is restricted due to the annual retirements, the price rises to $45/tC. If the Annex B seller is able to exercise sufficient market power to command a $10/tC premium, the price remains constant at $11/tC throughout the period. This is shown in Figure 8.

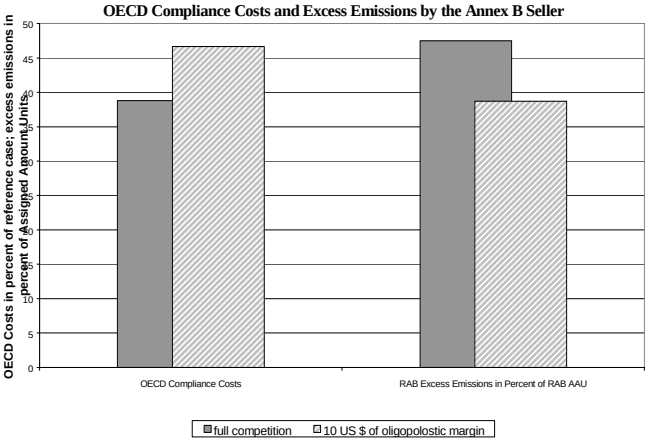
Figure 8
Prices Under Annual Retirement



Since annual retirement does not restrict sales until possibly 2012, the excess emissions by the Annex B seller are large. If the Annex B seller is a price taker the excess emissions are a little over 3,000 MtC (about 75% of the maximum degree of non-compliance), while if it is able to exercise market power the excess emissions are almost 2,500 MtC. This is shown in Figure 9.

The low prices also mean low compliance costs for the buyer. As shown in Figure 9, if the Annex B seller is a price taker, the compliance cost for the OECD is roughly 40% of the cost in the full-compliance reference case. If the Annex B seller is able to exercise market power, the compliance cost for the OECD rises to 45% of the full-compliance reference case.

Figure 9
OECD Compliance Costs and Excess Emissions by the Annex B Seller



Modifying this proposal to require the seller to maintain a reserve sufficient to enable annual retirement of actual emissions makes this proposal essentially the same as the permanent reserve proposal discussed in section 3.6 below.

In conclusion, annual retirement of AAUs (or ERUs or CERs) equal to actual emissions is not effective in limiting sales to amounts surplus to the seller's compliance needs. If the Annex B seller is able to exercise market power, the degree of non-compliance is reduced. Since annual retirement does not increase compliance costs, Annex B countries could be required to follow this practice.

Annual retirement with a two-year lag will be compared with the other liability proposals.

3.4 Limits on Sales of AAUs

This proposal specifies a formula that determines the maximum quantity of AAUs that can be sold each year. Two formulae have been proposed:

1. Sales of AAUs during a given year are limited to a maximum of X% of the total assigned amount divided by 5. Possible values of X range from 2% to 50%.

2. Sales of AAUs during a given year are limited to a maximum of:
   5% of [1990 base year emissions + (assigned amount/5)]/2[40]

All IET quota sold is valid for use by the buyer during the year it is purchased.

Analysis of this proposal indicates that it can be effective in limiting sales of AAUs to amounts surplus to the seller's compliance needs. However, the appropriate percentage is different for each country due to differences in the emissions limitation commitment, business as usual emissions, and marginal abatement costs.

Figure 10 shows the revenue and excess emissions under different limits (values of X) for the Annex B seller. The seller's revenue is maximized by an emissions limit of zero -- no emissions trading -- with a lower peak when the limit is 33%.[41] With this limit the Annex B seller has excess emissions of over 865 MtC and OECD compliance costs are about 15% lower than for the full-compliance reference case. Figure 10 also shows that any limit up to 19% keeps the Annex B seller in compliance.

Figure 11 shows how the limit would vary for different countries. Countries are characterized by the percentage of surplus assigned amount they have been allocated. The "business-as-usual" emissions of the Annex B seller in the model is defined as zero (no surplus AAUs), while the assigned amount allocated to the Annex B seller in the model is defined as 1. Recall from Figure 10 that the maximum limit which leads to no excess emissions is 19% and the peak revenue with trading occurs with a limit of 33%, resulting in excess emissions of 865 MtC. These are the values for the Annex B seller with surplus assigned amount equal to 1 in Figure 11.

The limit that maximizes the seller's net income with trading declines steadily from about 45% to about 30% as the amount of surplus assigned amount increases. Those limits always lead to non-compliance by the Annex B seller. The excess emissions range from 500 MtC to 2,500 MtC and rise as the amount of surplus assigned amount decreases.

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[40] This is the European Union proposal to limit transfers under the supplementarity clause. In our model this limit will be similar to that under the first formula with X = 5%.

[41] It seems paradoxical that no trade maximizes the seller's net income, but this leads to more JI quota sales and higher market prices, which increase the value of the 1,215 MtC of AAUs banked. The OECD compliance cost is over 50% higher than for the reference case.

In contrast, the emissions limit that achieves full compliance by the Annex B seller rises steadily with the country's surplus assigned amount from 5% for a country with surplus assigned amount of 0.2 to 25% for a country with surplus assigned amount of 1.4. The limit on sales proposed by the European Union, option 2, leads to compliance for all countries with surplus assigned amount greater than 0.2. The amount banked under this limit rises steadily to almost 1,500 MtC for a country with surplus assigned amount of 1.4.

Figure 10

Annex B Seller's Excess Emissions and Net Income for Different Limits

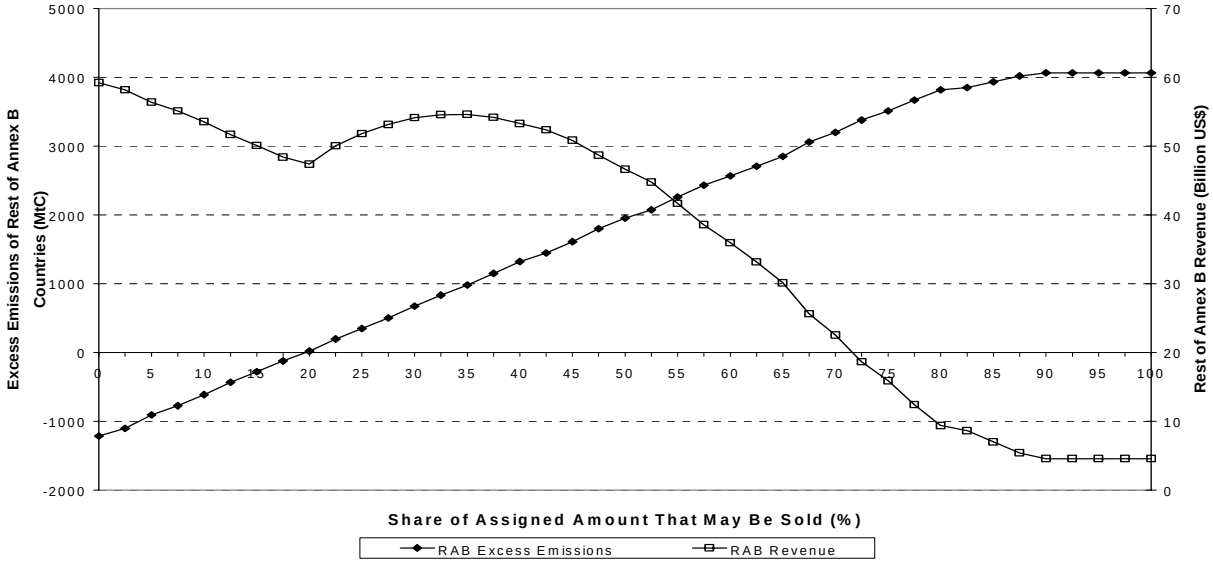
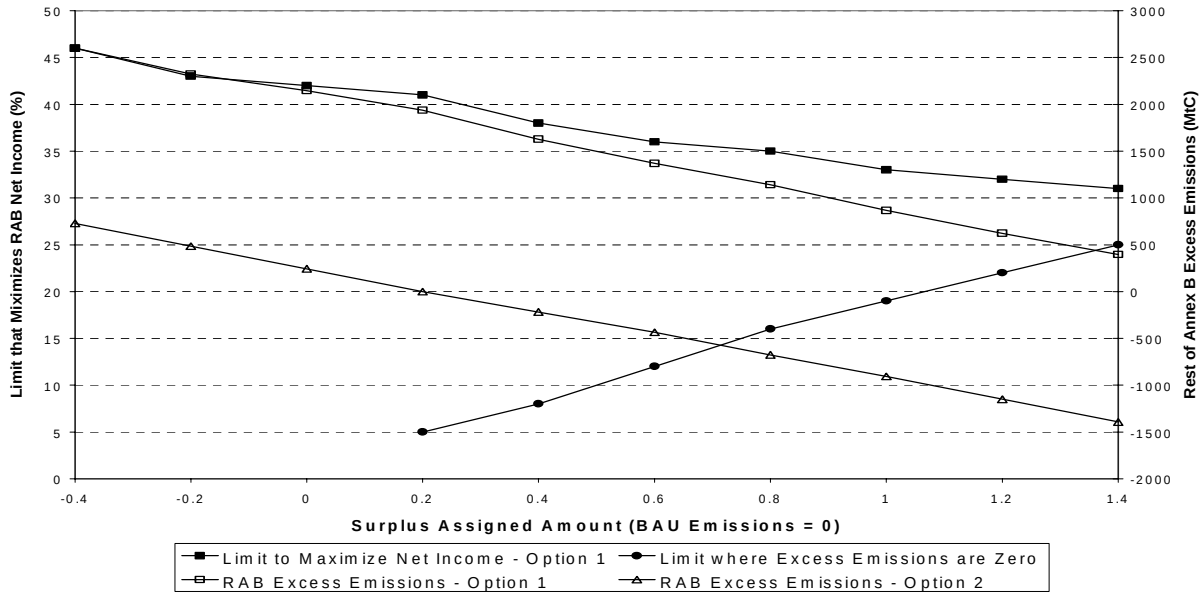


Figure 11

Excess Emissions for the Limit that Maximizes the Annex B Seller's Net Income and the Limit that Just Achieves Compliance for the Annex B Seller



Unfortunately, it is not possible to determine in advance the limit that would keep each Annex B seller in compliance. The Annex B seller has an incentive to argue for a higher limit to maximize its net income.

In summary, while this proposal can be effective, it requires a different limit for each Annex B seller. The limit that keeps the Annex B seller in compliance differs significantly from the one that maximizes the seller's revenue. Since each country's surplus assigned amount can not be known accurately in advance and since each country has a financial incentive to argue for a different limit, it is unlikely that a set of country-specific limits that would achieve compliance for all Annex B Parties could be negotiated.

For purposes of comparison with other liability proposals, Option 1 with limits of 5%, 20% and 35% of annual assigned amount will be used.

3.5 Sales Prohibited until Compliance Established

Sales of AAUs are prohibited until compliance is established and then are restricted to surplus quota. Since actual emissions are only known with a two year lag, the Annex B seller will not establish compliance and determine the quantity of AAUs available until 2014.

Two alternatives are modeled:

1. No sales of IET quota prior to 2014. Buyers can only use domestic reductions, CDM quota and JI quota, if it is not subject to this liability provision, for compliance during the 2008-2012 commitment period.

2. Surplus IET quota can be used in 2012. This alternative assumes that compliance is established relatively quickly and that the buyer has a relatively long grace period to achieve compliance thus enabling the surplus IET quota to be used for compliance in 2012.

The first variant assumes no sales of AAUs prior to 2014. This reflects the model assumption that the seller reports actual emissions and establishes compliance with a two-year lag. In this case the buyer can only use domestic reductions, CERs and ERUs for compliance during the 2008-2012 commitment period. As a consequence, market prices are substantially higher ($51 to $65/tC) than the reference case and compliance costs are over 50% higher than the reference case. None of the assigned amount surplus to the Annex B seller's compliance needs can not be sold, so it is forced to bank over 1,200 MtC of AAUs.

The second variant assumes that surplus AAUs can be used for compliance by the buyer in 2012. This could occur if compliance can be established quickly by the seller and the buyer has a relatively long grace period to purchase the quota needed for compliance.

The results for the 2008 through 2011 are identical, but in 2012 the buyer relies entirely on purchased AAUs because the surplus is sufficient to meet the buyer's compliance needs.

If the Annex B seller is a price taker, the price drops to $1/tC in 2012 but the OECD compliance cost is still about 20% higher than in the full-compliance reference case due to the higher prices during the first four years of the commitment period. If the Annex B seller is able to exercise market power, the price in 2012 is $11/tC and the OECD compliance cost is increased to over 45% above the full-compliance reference case.

In short, this proposal leads to over-compliance, but at a substantial increase in cost. Both variants are compared with the other liability proposals.

3.6 Sales Limited to AAUs Surplus to a Permanent Reserve

The permanent reserve proposal requires the Annex B seller to maintain a compliance reserve equal to 5 years of projected/actual emissions. AAU sales are limited to the difference between the country's total assigned amount and the permanent reserve.

The proponents of this proposal have not specified how to calculate the size of the reserve using the emissions data likely to be available. Three cases are modeled:

1. The permanent reserve is equal to 5 times the 2006 emissions initially. The size of the reserve is adjusted on the basis of actual emissions during the commitment period as the data become available -- e.g., 4 times 2006 emissions plus 2008 emissions when the latter become available in 2010.

2. The permanent reserve is equal to the actual emissions for the years for which the data are available together with a multiple of the latest actual emissions to make 5 years -- e.g., 5 times 2006 emissions for 2008, 5 times 2007 emissions for 2009, 5 times 2008 emissions for 2010, 2008 emissions plus 4 times 2009 emissions for 2011, and 2008 plus 2009 emissions plus 3 times 2010 emissions for 2012.

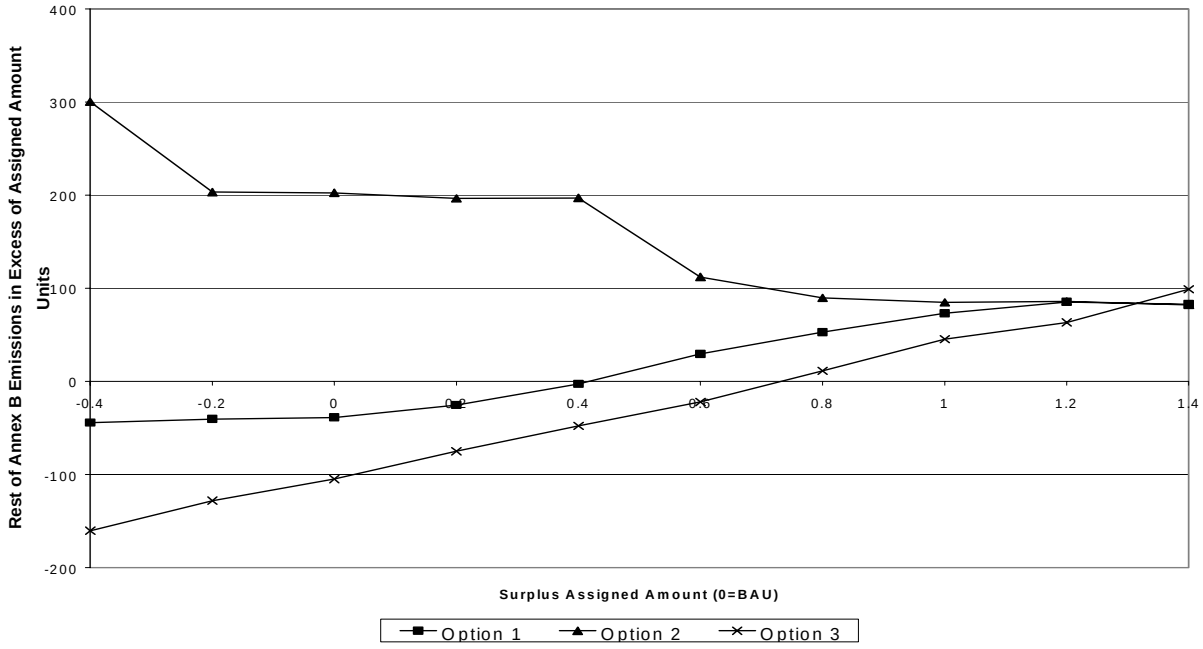
3. The permanent reserve is the sum of the projected emissions for the years 2008 through 2012 as estimated from a regression equation fitted to actual emissions for the years 2000 through 2006.[42]

All AAUs sold are valid for use by the buyer during the year they are purchased. The AAUs in the permanent reserve can only be used by the Annex B seller for compliance purposes. Any surplus can only be banked for use during the subsequent commitment period.

[42] A regression equation is fitted to the randomly adjusted actual emissions of the Annex B seller for the years 2000 through 2006 and used to project the values for 2008 through 2012.

This proposal is effective at limiting sales of AAUs to amounts surplus to the seller's compliance needs. Figure 12 shows the excess emissions under the three options for different countries. Option 1 keeps all countries within ±100 MtC of compliance.[43] Option 3 is more conservative, keeping more countries in over-compliance, while limiting excess emissions to 100 MtC.[44] Option 2, on the other hand, leads to excess emissions of 100 to 300 MtC for all countries. The rest of the discussion considers only Options 1 and 3.

Figure 12
Excess Emissions for Different Countries Under the Three Options for Calculating the Permanent Reserve



Virtually all of the surplus AAUs for the entire period are available at the beginning of 2008, which leads to low prices ($1 and $8-$9/tC) during the first two years if the Annex B seller is a price taker. As shown in Figure 13, this leads to higher prices ($59 to $65/tC) for the remaining years. If the Annex B seller is able to exercise market power, it keeps the price at $11/tC during the first two years higher, leading to lower prices in 2010 and slightly higher prices ($63 to $68/tC) during the balance of the period.

[43] Since "business-as-usual" emissions by the Annex B seller are 5,194.9 MtC over the commitment period, 100 MtC represents excess emissions of slightly less than 2%.

[44] Option 3 depends on the regression line fitted to the randomized historic data for 2000 through 2006. A different random history could change the results. If the projected emissions are lower by two standard deviations, Option 3 leads to excess emissions about 150 MtC higher than those shown in Figure 12 for each country; excess emissions in all cases rising from about zero to 250 MtC for country 1.4. If the projected emissions are higher by two standard deviations, Option 3 leads to additional banking of about 150 MtC in all cases, thus leading to over-compliance for all countries.

Figure 13

Prices Under Different Options for Calculating the Size of the Permanent Reserve

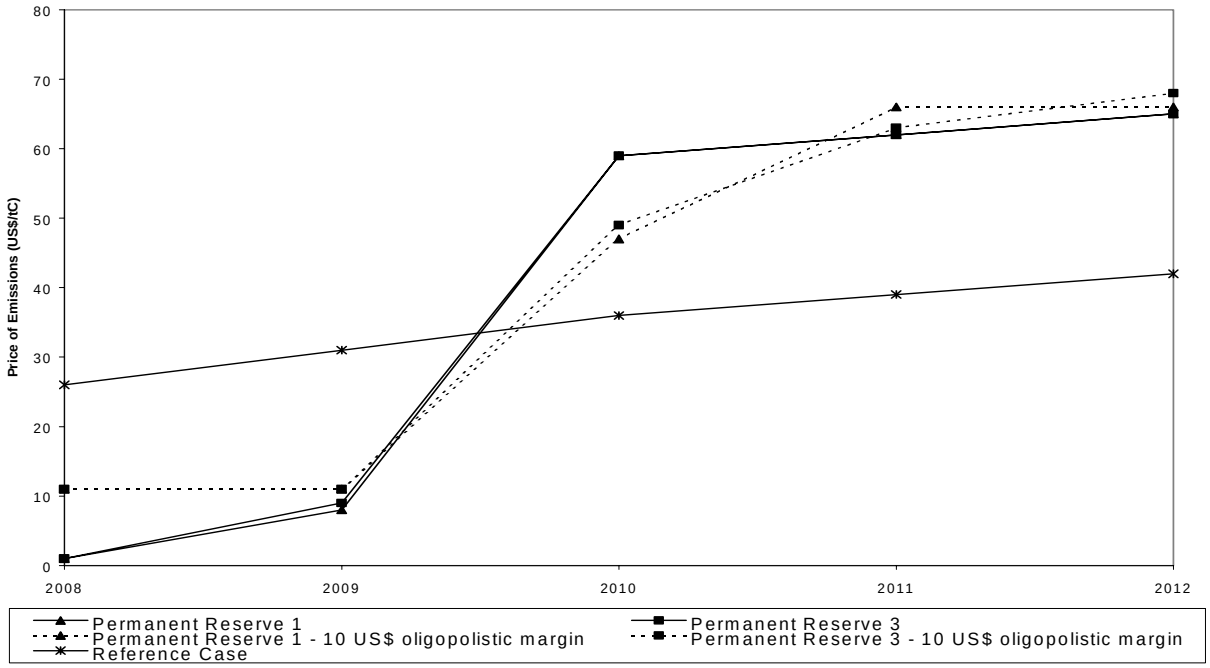
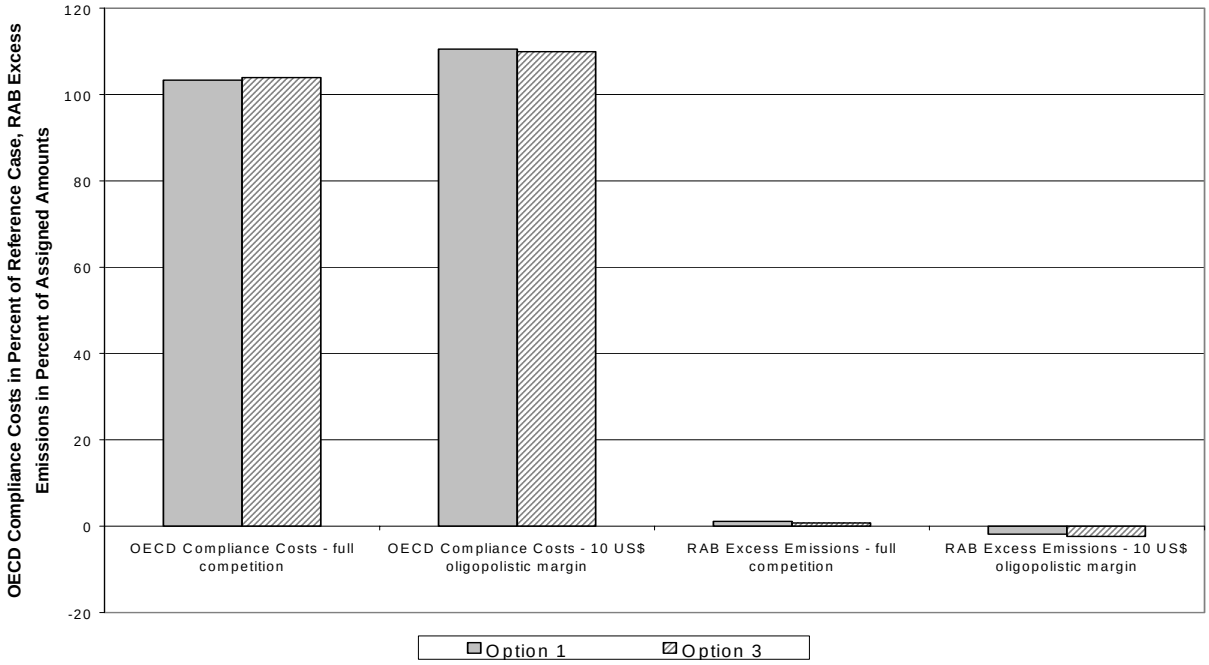


Figure 14

OECD Compliance Costs and Rest of Annex B Excess Emissions for Different Permanent Reserve Options



The OECD compliance costs and excess emissions for the Annex B seller are shown in Figure 14. It is clear that the two options are very similar, but as noted earlier, Option 3 is slightly more conservative. If the Annex B seller is a price taker, the OECD compliance costs are a little over 3% higher than the full-compliance reference case for Option 1 and just under 4% higher then the reference case for Option 3. If the Annex B seller is able to exercise market power, the OECD compliance cost is about 10% higher than the reference case for both options.

If the Annex B seller is a price taker, both options result in excess emissions of about 1%. If the Annex B seller is able to exercise market power, both options lead to over-compliance of about 2%. Option 3 provides slightly more environmental protection than Option 1 in both cases.

It is striking how insensitive the results are to the ability of the Annex B seller to exercise market power, compared to the other liability proposals. This is because the seller's behavior does not materially affect the total quantity of AAUs available for sale. The seller's actions to increase prices, are at least partially offset by lower prices in other years.

In summary, the permanent reserve proposal can be effective in limiting sales of AAUs to amounts surplus to the seller's compliance needs at a small increase in compliance costs and a small risk to the environment. The difference in performance for Options 1 and 3 as methods of calculating the permanent reserve is marginal, with Option 3 providing slightly more environmental protection for a small cost premium. The formula for calculating the size of the permanent reserve is not sensitive to national circumstances. And the results are very similar regardless of the market power of the Annex B seller.

Both Option 1 and Option 3 are compared with the other liability proposals.

3.7 Swiss Proposal - Sales Limited to AAUs Surplus to the Seller's Compliance Plan

Under this proposal, developed by Switzerland, countries that wish to sell AAUs must submit a compliance plan to the Climate Change Secretariat before the start of the commitment period. The compliance plan specifies how the country's assigned amount is to be allocated over the five years of the commitment period.[45] When the country's actual emissions for a given year are submitted to the Secretariat they are verified. If the compliance plan exceeds the verified actual emissions on a cumulative basis, the difference can be sold.[46]

[45] Countries are allowed to change their compliance plan during the course of the commitment period subject to the restriction that the compliance plan can not be less than the actual emissions plus IET and JI quota sales prior to the revision.

[46] In 2010 when actual emissions for 2008 are known they are compared with the compliance plan for 2008. Any surplus AAUs can be sold. In 2011 emissions for 2008 plus 2009 are compared with the compliance plan for 2008 and 2009. If under the cumulative compliance plan emissions exceed the

The Annex B seller's actual emissions are only known with a two-year lag. Thus AAU sales can only begin in 2010 under this proposal. To enable AAU trading to take place during the entire commitment period, the compliance plan can be compared to actual emissions two years earlier -- the compliance plan for 2008 is compared to the actual emissions for 2006 and so on. We call this the prompt start option.

The model is used to test various compliance plans with a two-year lag in the start of trading and with a prompt start to trading, specifically:

1. Regular start - AAU sales begin in 2010 based on a comparison of 2008 emissions with the compliance plan for 2008 and so on.

2. Prompt start - AAU sales begin in 2008 based on a comparison of 2006 emissions with the compliance plan for 2008 and so on.

The compliance plan has the following structure for the years 2008 through 2012:

(7) AA/5 + Y%, AA/5 + (Y/2)%, AA/5, AA/5 - (Y/2)%, and AA/5 - Y%,

where AA is the country's assigned amount for the commitment period and Y is a deviation from the average assigned amount. Although Switzerland has suggested a range of ±20%, values ranging from -25% to +25% are tested. A value of Y = 0 means the assigned amount is allocated equally over the five years. Positive values of Y allow relatively high AAU sales during the early part of the commitment period, but increase compliance costs during the latter part of the commitment period. Negative values of Y mean a lower emissions limit and lower AAU sales during the early part of the commitment period.

All AAUs sold are valid for use by the buyer during the year they are purchased. This proposal does not guarantee compliance by the seller. The actual emissions may be less than the compliance plan during the initial year(s) allowing the surplus to be sold. During subsequent years the actual emissions may exceed the compliance plan. Further sales would not be allowed, but the seller would exceed its emissions limitation commitment.

Figure 15 shows that the Annex B seller remains in compliance for all values of Y tested with the regular start option. The seller's net income falls as the value of Y rises, while the amount of over-compliance declines as Y rises. Since each seller specifies its compliance plan, we focus on the compliance plan (value of Y) that maximizes the net income of the Annex B seller, namely Y = -25%.

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cumulative emissions, any AAUs sold during 2008 are subtracted to get the AAUs available for sale in 2009. And so on.

If the Annex B seller is a price taker, it would bank over 1,000 MtC of AAUs under that compliance plan, raising OECD compliance costs by about 28% relative to the reference case. If the Annex B seller is able to exercise market power, it would bank over 1,450 MtC of AAUs at that compliance plan, increasing its net income by about $10 billion and increasing the compliance costs for the OECD by over $30 billion.

Figure 15

Net Income and Excess Emissions of the Annex B Seller with No Trading Until 2010

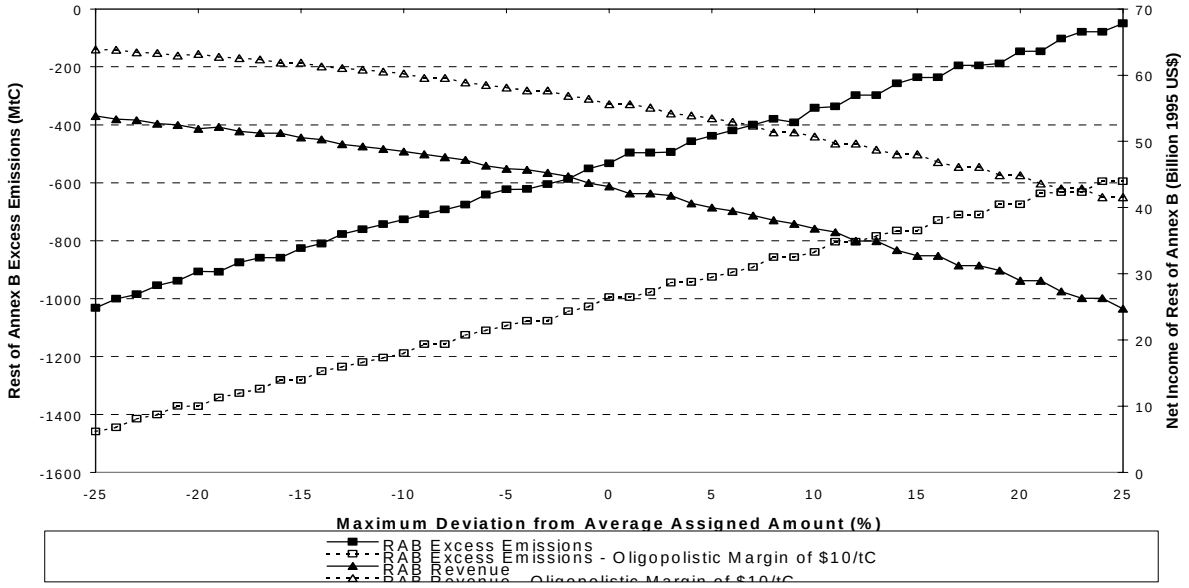


Figure 16

Net Income and Excess Emissions of the Annex B Seller with Trading Starting in 2008

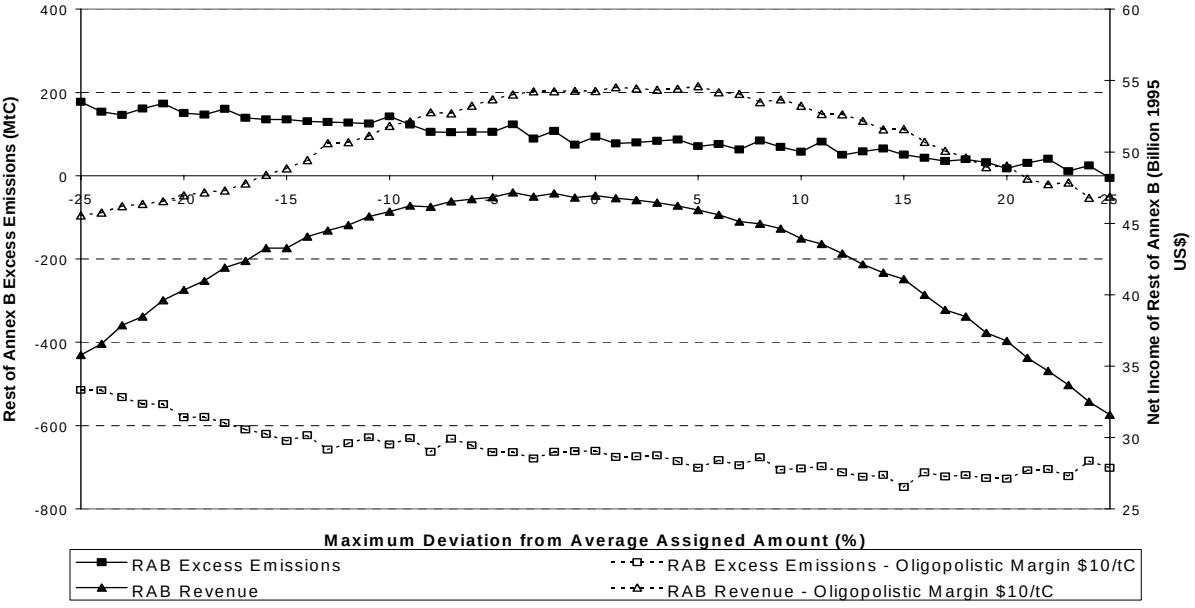


Figure 16 illustrates the situation for the prompt start option. Compliance improves as the value of Y increases. If the Annex B seller is a price taker, this option results in excess emissions (non-compliance) for all values of Y less than +25%. However, for values of Y greater than zero, the excess emissions are less than 100 MtC. If the Annex B seller is able to exercise market power, it always remains in compliance, banking between 500 and 700 MtC.

The net income received by the Annex B seller is maximized with a value of Y = -4% if it is a price taker and for Y = +5% if it is able to exercise market power. Regardless of the extent of the seller's market power, all values in the range -5% to +5% yield roughly the same net income. Taking Y = 0% as an approximation of the Annex B seller's preferred compliance plan, leads to excess emissions of approximately 50 MtC if it is a price taker and over-compliance of about 650 MtC if it is able to exercise market power.

The sensitivity of the Annex B seller's behavior to its market power is noteworthy. With a regular start, the ability to exercise market power induces additional over-compliance of 450 to 550 MtC. With a prompt start, the ability to exercise market power changes the result from non-compliance to substantial over-compliance, a shift of 650 to 700 MtC.

A prompt start reduces compliance costs for the OECD buyer. This is because it allows sales of more AAUs and spreads the sales over the entire period. A comparison of Figures 15 and 16 indicates that for any given compliance plan, a prompt start leads to less over-compliance and hence sale of more AAUs. Delaying AAU sales until actual emissions are known forces the buyer to rely on domestic reductions, CERs and ERUs during the first two years of the period. This leads to high prices in 2008 and 2009 followed by a sharp drop in 2010 when AAUs become available. In contrast, a prompt start results in a continuous increase in prices over the period.

Figure 17 shows how this proposal would work in different countries. The results are similar to those described above for the Annex B seller in the model. With the proposed start in 2010, the compliance plan that maximizes the seller's net income is defined by Y = - 25% for most countries. These compliance plans lead to substantial over-compliance regardless of whether the seller is a price taker or is able to exercise market power. The extent of the over-compliance increases as the seller's surplus rises and if the seller is able to exercise market power. The compliance plan that just keeps the Annex B seller in compliance differs significantly from the compliance plan that maximizes the seller's net income.

Figure 18 shows how the prompt start version would work in different countries. Again the results are very similar to those presented above for the Annex B seller in the model. If the Annex B seller is a price taker, the compliance plan that maximizes its net income leads to excess emissions of the order of 100 MtC, or about 2% of "business-as-usual" emissions. If the Annex B seller is able to exercise market power, the compliance plan that maximizes its net income leads to over-compliance of 400 to 700 MtC.

In summary, the regular start version of this liability proposal leads to a significant amount of banking by the Annex B seller, which increases compliance costs for the OECD buyer. The prompt start version of this proposal leads to excess emissions of the order of 100 MtC, or about 2%, if the Annex B seller is a price taker. If the Annex B seller is able to exercise market power, it maximizes its net income by banking 400 to 700 MtC under either version of the proposal. The prompt start leads to more stable prices and slightly lower compliance costs than the regular start.

For comparison with other liability proposals, the Annex B seller is assumed to adopt a compliance plan with Y = -25% or +33% for the regular start and with Y = 0% or -4% for the prompt start version.

Figure 17
Compliance Plans for Different Countries with No Trading Until 2010

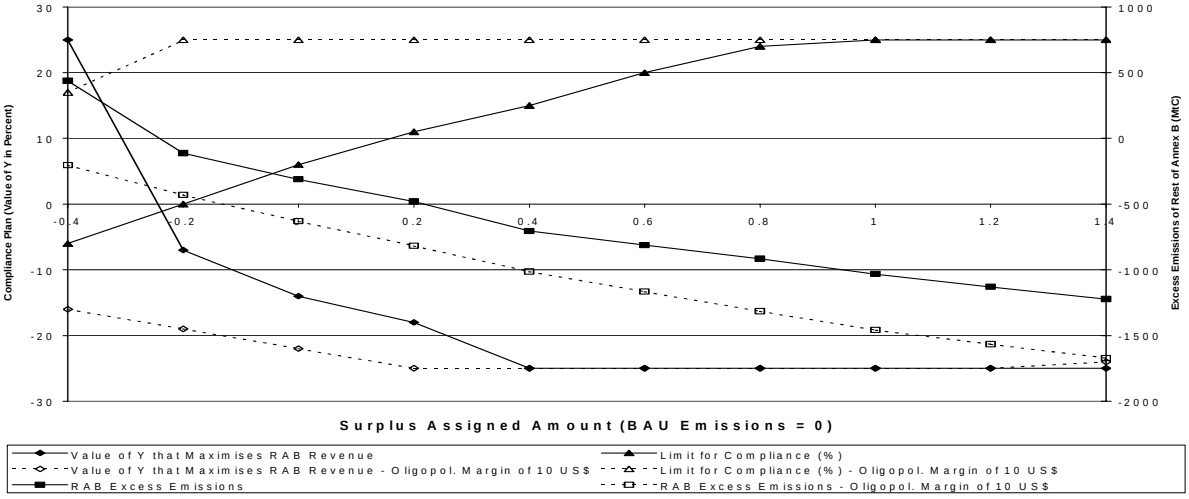
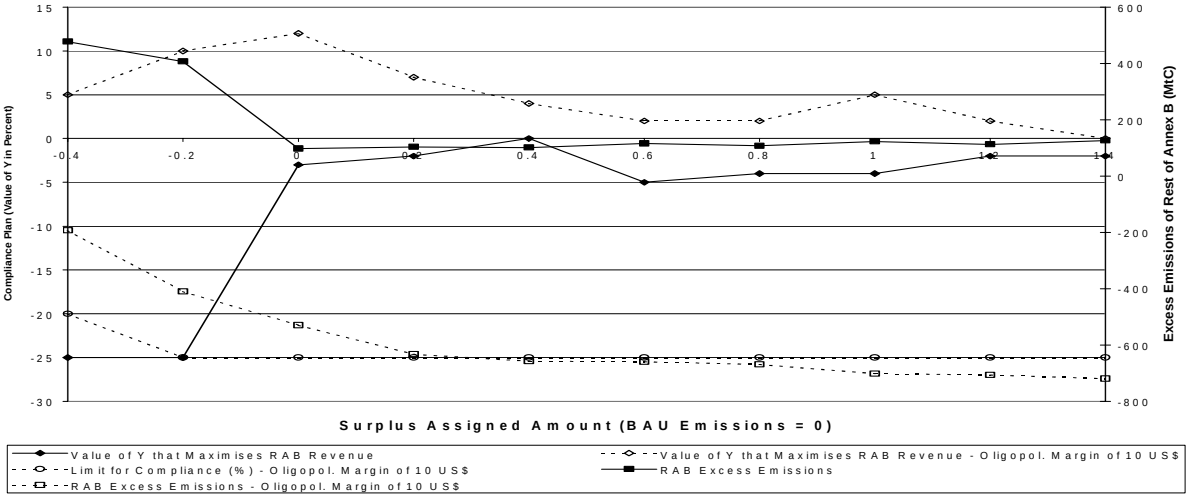


Figure 18
Compliance Plans for Different Countries with Trading Starting in 2008



3.8 Sales Limited to AAUs Surplus to Defined Compliance Plan

This proposal is similar to the previous one, except that the compliance plan is defined by the rules rather than chosen by the Annex B seller. The compliance plan consists of an emissions profile that is tied to actual emissions and is scaled to equal the seller's total assigned amount. Only AAUs surplus to the compliance plan on a cumulative basis can be sold.

The issue of when trading can begin also arises for this proposal due to the two year lag in determining actual emissions.

The model is used to test three different emissions profiles with a two-year lag in the start of trading - regular start - and with no lag in the start of trading - prompt start. The three emissions profiles for the years 2008 through 2012 are as follows:

1. Option 1: 2006*(1+Z/100)^2, 2008*(1+Z/100), 2009*(1+Z/100), 2010*(1+Z/100), 2011*(1+Z/100);

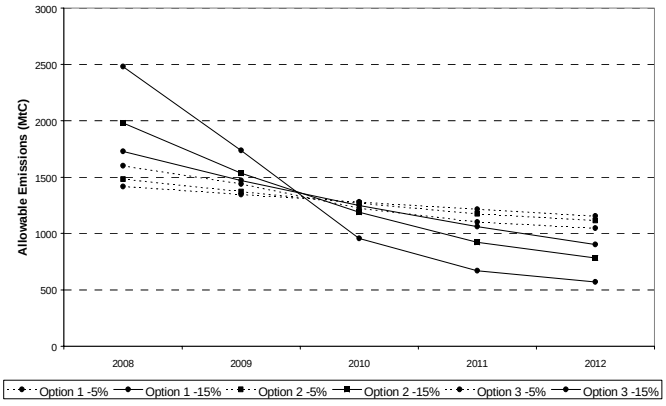
2. Option 2: 2006*(1+Z/100)^2, 2008*(1+1.5*Z/100), 2009*(1+1.5*Z/100), 2010*(1+1.5*Z/100), 2011*(1+Z/100);

3. Option 3: 2006*(1+Z/100)^2, 2008*(1+2*Z/100), 2009*(1+3*Z/100), 2010*(1+2*Z/100), 2011*(1+Z/100);

where Z is a variable that defines the emissions profile. These initial values are scaled so that their sum equals the seller's total assigned amount for the commitment period. After examining values ranging from -25% to +25% we focus the discussion on plans defined by values of Z ranging from -20% to 0% because they provide the best compliance results.

All AAUs sold are valid for use by the buyer during the year they are purchased.

Figure 19
Illustrative Compliance Plans



Profiles for the three options with Z= -15% and Z= -5% are shown in Figure 19. A negative value of Z produces a compliance plan with higher emissions at the beginning of the period than at the end of the period. The larger the value of Z, the steeper the decline in allowable emissions over the commitment period. For any given value of Z, Option 1 produces the compliance plan with the flattest slope while Option 3 yields the compliance plan with the steepest slope. All three options lead to equal annual emissions when Z = 0.

Figure 20 shows the net income to, and the excess emissions of, the Annex B seller for the three options assuming trading starts in 2010. If it is a price taker, low values of Z (-20%) lead to excess emissions under all three options. At values of Z ranging between -15% and -5% all three options move into compliance. And with Z = 0 all three options result in over-compliance of over 500 MtC. Option 1 always produces the highest level of compliance. Option 1 also produces the highest net income for the Annex B seller in all cases. If the Annex B seller is able to exercise market power, it reduces sales by 450 to 650 MtC from the competitive market result. Thus, all three options lead to over-compliance ranging from 200 MtC to 1,000 MtC. Option 1 produces the most over-compliance.

Figure 20
Net Income and Excess Emissions of the Annex B Seller with No Trading Until 2010

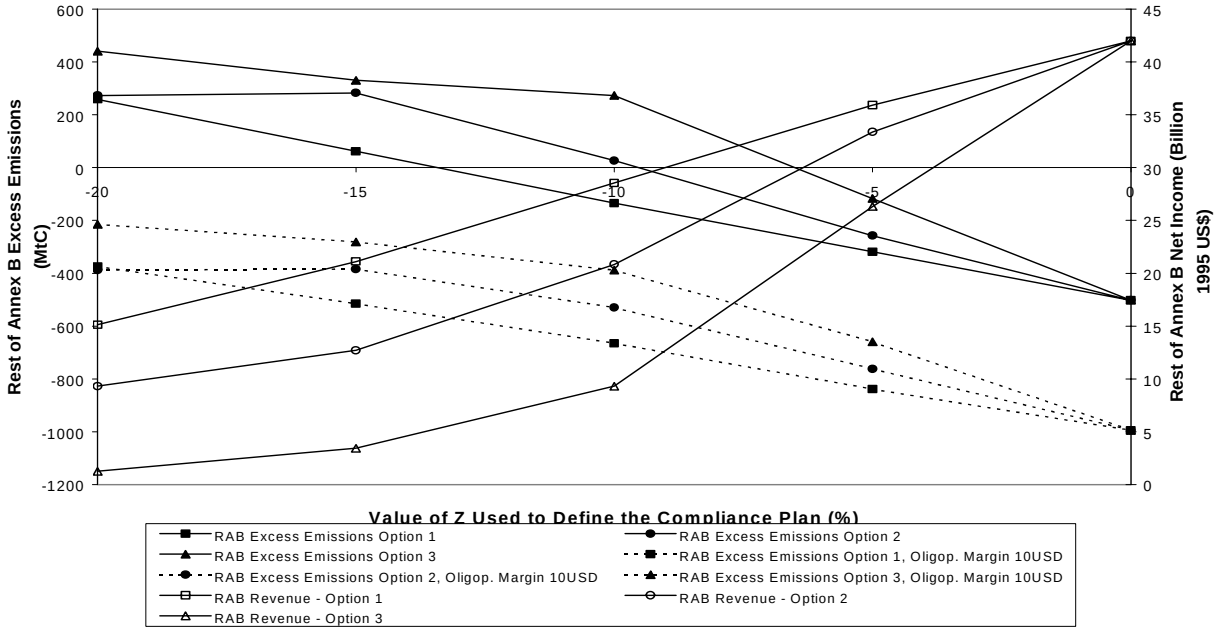
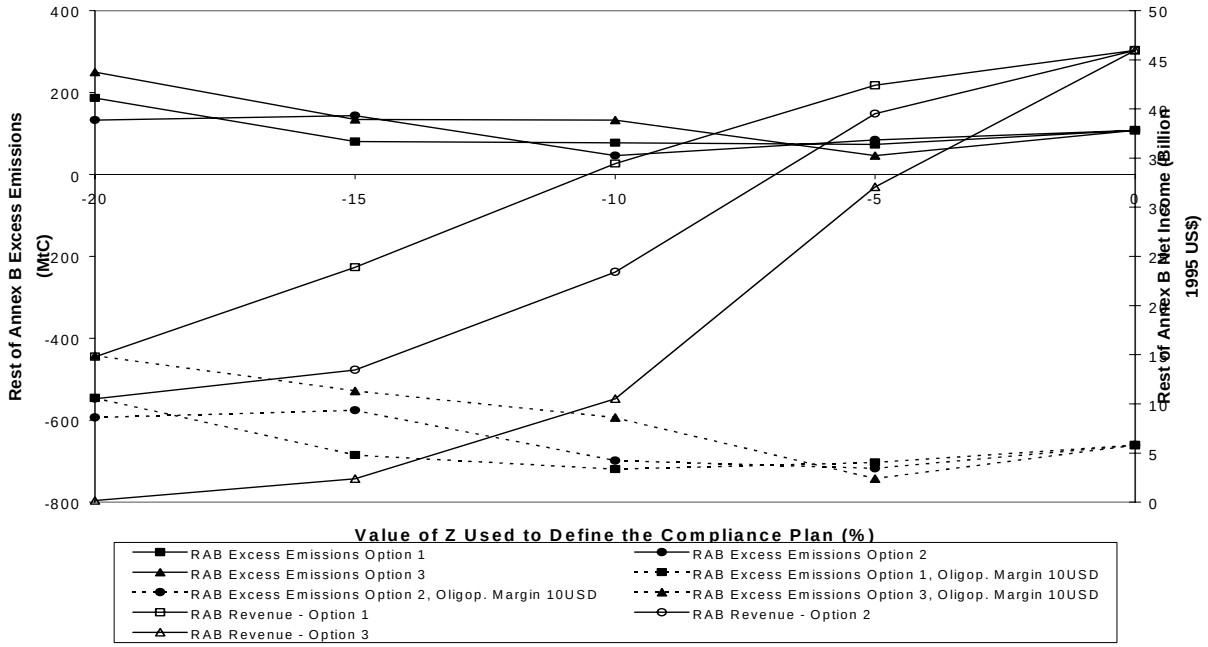


Figure 21 shows the results for the three options assuming a prompt start. If the Annex B seller is a price taker, all of the options lead to excess emissions. The excess emissions are minimized for values of Z between -15% and -5% depending upon the option. In almost all cases the excess emissions are less than 100 MtC. While none of the options is clearly superior in environmental terms, Option 1 always yields larger net income for the Annex B seller. If the Annex B seller is able to exercise market power, sales of AAUs are reduced by 600 to 750 MtC, leading to over-compliance in all cases. Option 1 produces the most over-compliance.

Figure 21
Net Income and Excess Emissions of the Annex B Seller with Trading Starting in 2008



Option 1 appears to be superior to the others if the Annex B seller is a price taker. Option 1 provides the best compliance performance with a regular start, and results similar to those for the other options with a prompt start. The revenue to the Annex B seller is always higher under Option 1. And, although, not shown in the figures, the OECD compliance cost is lowest for Option 1 with an early start. If the Annex B seller is able to exercise market power, Option 3 leads to the least amount of over-compliance and hence lower OECD compliance costs. Option 3 also yields the lowest OECD compliance costs with a regular start if the Annex B seller is a price taker.

Figure 22 assesses the performance of Options 1 and 3 for different Annex B sellers with a regular start. The figure shows the minimum value of Z that achieves compliance for a given country and option if the Annex B seller is a price taker.[47] The figure also shows the excess emissions with that compliance plan if the Annex B seller is able to exercise market power. Clearly, the value of Z needed to define the appropriate compliance plan differs by country under both options. As well, the results will vary significantly depending upon the market power the Annex B seller is able to exercise.

Figure 23 assesses the performance of Options 1 and 3 for different Annex B sellers with a prompt start. The figure shows the value of Z that achieves compliance or minimizes the level of excess emissions. Compliance is achieved only for countries with relatively

[47] A value of -5% means that values of Z from 0 to -4% lead to over-compliance while values from -6% to -20% lead to excess emissions.

large surplus assigned amount in the case of a prompt start. However, the level of non-compliance is small, generally less than 50 MtC (about 1%). Option 3 leads to compliance in more cases than Option 1. Again the value of Z needed to define the appropriate compliance plan differs by country under both options and the results will vary significantly depending upon the market power the Annex B seller is able to exercise.

Figure 22

Performance of Options 1 and 3 for Different Countries with no Trading Until 2010

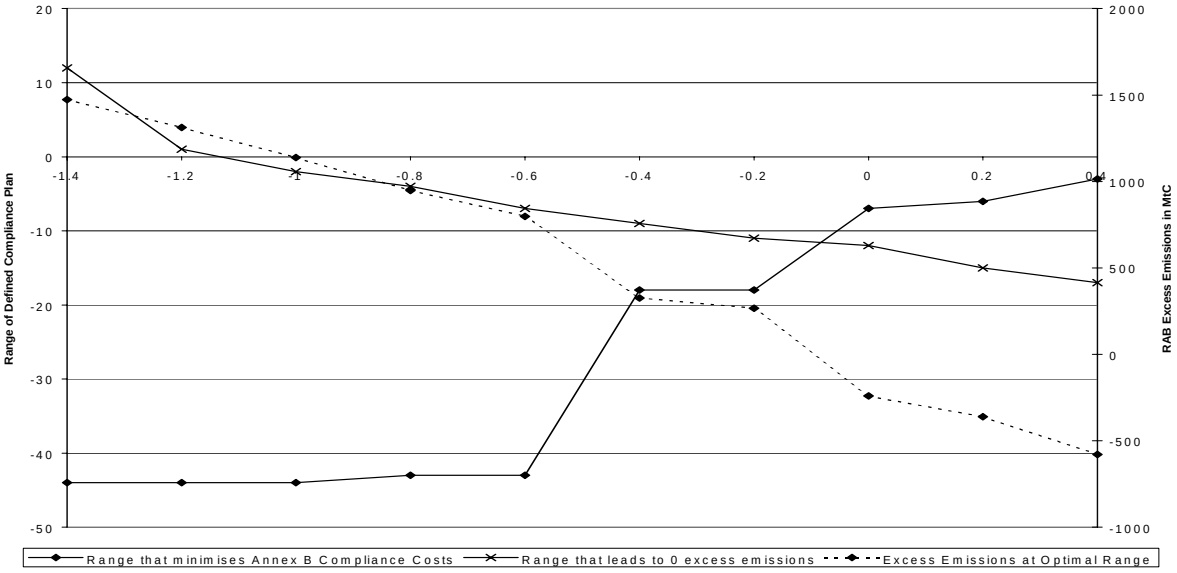
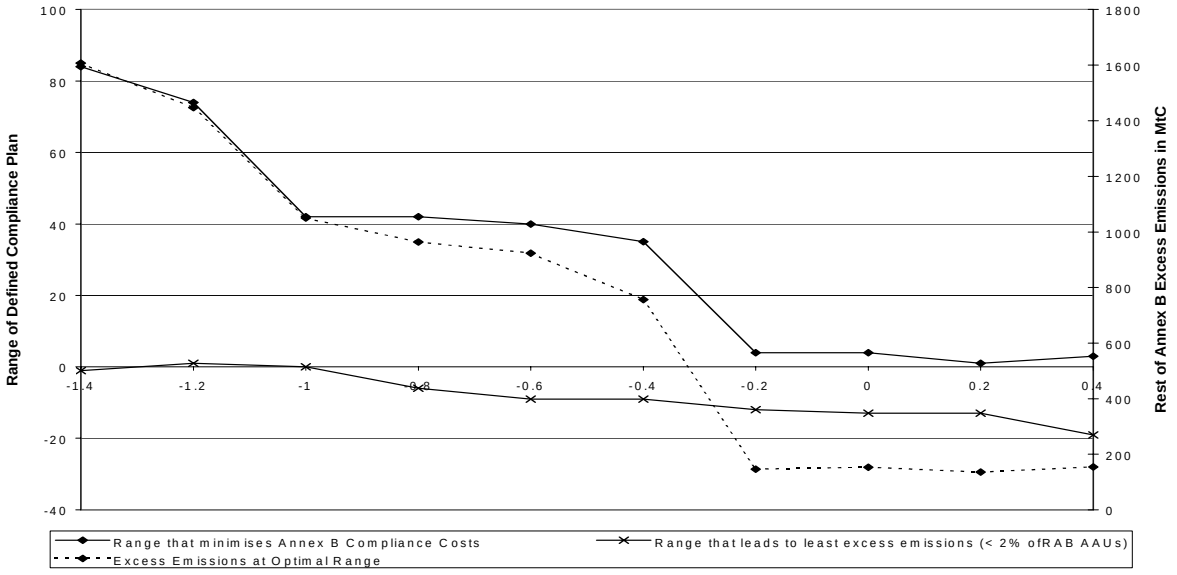


Figure 23

Performance of Options 1 and 3 for Different Countries with Trading Starting in 2008



In summary, this proposal is very similar to the previous proposal. The regular start version can do a good job of achieving compliance with no cost premium if the Annex B seller is a price taker. The prompt start version leads to excess emissions of 50 MtC or less for almost all countries, with Option 3 leading to compliance for more countries. A prompt start leads to more stable prices and slightly lower compliance costs than the regular start. Both versions of this proposal are quite sensitive to the market power of the Annex B seller, it can change the amount of AAUs sold by 200 to 900 MtC.

For comparison with other liability proposals, the defined compliance plan is assumed to be Option 1 with Z = -14% with a regular start and Option 3 with Z = -7% with a prompt start.

3.9 Compliance Reserve

The compliance reserve proposal requires the Annex B seller to deposit AAUs equal to a multiple of the quantity sold into a compliance reserve. Only the difference between the country's total assigned amount and the compliance reserve can be sold.

The quantity of AAUs available for sale during a given year can be calculated in either of the following ways:

- Option 1: Sales of AAUs are limited to:
  [assigned amount (divided by 5)]/[1 + W/100]; or

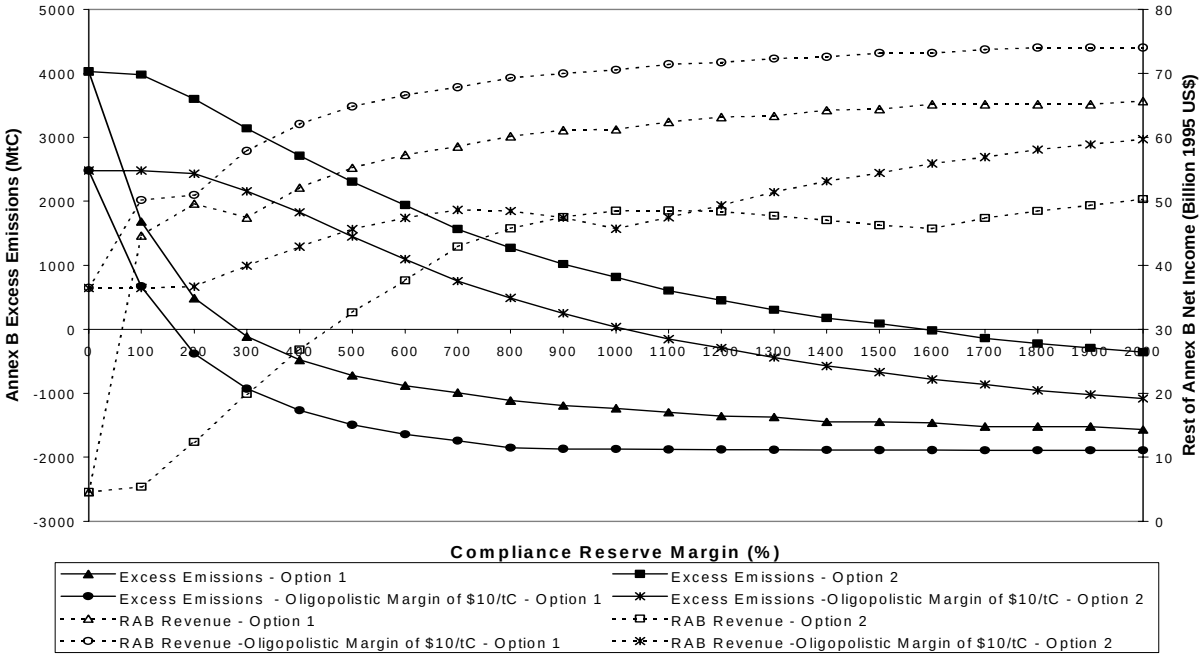
- Option 2: Sales of AAUs are limited to:
  [remaining assigned amount]/[1 + W/100],

where W is the reserve contribution expressed as a percentage. The proponents of this proposal have not specified the reserve percentage, so values ranging from 10% to 2,000% are modeled.

The AAUs in the compliance reserve can only be used by the Annex B seller for compliance purposes. Any surplus can only be banked for use during the subsequent commitment period. All AAUs sold are valid for use by the buyer during the year they are purchased.

The net income and excess emissions of the Annex B seller for different reserve percentages (values of W) under both options are shown in Figure 24. The reserve percentage that keeps the Annex B seller in compliance is 300% under Option 1 and 1,600% under Option 2. Higher percentages lead to over-compliance by the seller and lower percentages lead to excess emissions. Option 1 is much more sensitive to the percentage with excess emissions rising rapidly for lower percentages.

Figure 24
Net Income and Excess Emissions of the Annex B Seller for Different Compliance Reserve Margins

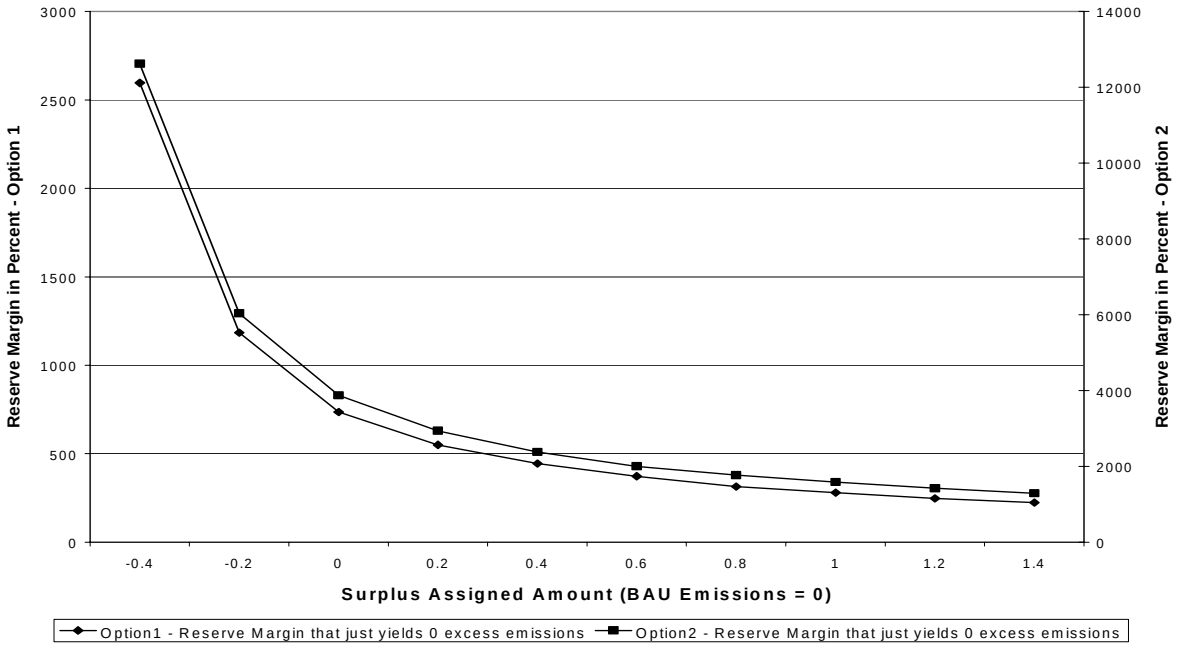


If the Annex B seller is a price taker, as assumed in Figure 24, the seller's net income is always higher under Option 1. The reason is that Option 1 sets annual limits that affect prices each year, while Option 2 sets a cumulative limit that affects prices only during the latter part of the commitment period. As a result the seller receives higher prices for its AAUs under Option 1.

If the Annex B seller is able to exercise market power, the results are similar to those in Figure 24 except that fewer AAUs are sold for any given compliance reserve margin. Withholding some of the AAUs from the market enables the seller to command the assumed premium of $10/tC. Naturally, the seller's net income is higher than if it is a price taker. Compliance occurs at a lower reserve margin (150% for Option 1 and 1000% for Option 2) and substantial over-compliance occurs at the reserve margin that achieves compliance in a competitive market (about 900 MtC for Option 1 and 800 MtC for Option 2).

The reserve percentage that keeps a seller in compliance is sensitive to the country's national circumstances. This is shown in Figure 25. Under Option 1, the required compliance reserve margin declines from 2600% to 225% as the country's surplus assigned amount rises. Under 2, the required compliance reserve margin declines from 12,600% to 1,290% as the seller's surplus assigned amount increases. In every case, this reserve margin leads to substantial over-compliance (400 to 900 MtC) if the Annex B seller is able to exercise market power.

Figure 25
Reserve Margin to Achieve Compliance for Different National Circumstances



The main weakness of this proposal is that it is very difficult to determine the compliance reserve percentage that keeps each Annex B seller in compliance *ex ante*. The proposal's effectiveness depends on specification of the correct reserve percentage for each seller and the excess emissions, especially under Option 1, are very sensitive to this percentage. The seller does not have an incentive to cooperate in finding the correct reserve percentage because a higher percentage will increase its revenue.

In summary, while this proposal can be effective, it requires a different reserve requirement for each Annex B seller. There is no way to determine the optimal reserve requirement for each seller in advance. Annex B sellers have an incentive to argue for a requirement that is higher than the level needed to ensure compliance because this raises their net income. If the requirement is too high sales of AAUs that are surplus to the seller's compliance needs are restricted and compliance costs are increased. Setting the compliance reserve too low leads to excess emissions.

The comparison with other liability proposals will use Option 1 with reserve percentages of 150% and 300% and Option 2 with reserve percentages of 1000% and 1600%.

3.10 Compulsory Insurance

Under the compulsory insurance proposal the buyer purchases AAUs at its risk, but is required to purchase insurance that replaces some or all of the AAUs purchased if the

Annex B seller does not achieve compliance.[48] The insurance premium should reflect the risk of non-compliance by the seller.[49] The seller would bear the cost of the insurance coverage.[50] The seller can reduce the insurance premiums for sales of its AAUs, and hence increase its revenue, by implementing policies to reduce the risk of non-compliance. One such policy is to limit sales of AAUs to quantities surplus to its compliance needs.

All insured IET quota sold is valid for use by the buyer during the year it is purchased.

Compulsory insurance is difficult to analyze given the structure of the model. Ideally, the model would include an insurer as a separate entity. The insurer would set premiums based on the estimated risk of non-compliance and purchase quotas with the premium revenue to correct any non-compliance.

Since the model does not include a separate insurer, we analyze the following three cases as different approximations of the impact of compulsory insurance:

- Requiring the Annex B seller to pay a "premium" in the form of AAUs to the insurance company. The premium is one AAU for each AAU sold. Then if the seller fails to comply, the insurer holds enough quotas to replace all of the AAUs sold. This is equivalent to a reserve of 100% under Option 1 of the compliance reserve.

- The insurer purchases enough quotas each year so that the Annex B seller's remaining assigned amount and the insurer's quota purchases are equal to the seller's projected emissions.[51] The insurer's demand for quotas is added to that of the buyer. To ensure that approximate compliance is achieved, no emissions trading is allowed in 2012.

- The insurer determines the likely extent of non-compliance by the Annex B seller at the end of 2011 and purchases the quotas needed to restore compliance in 2012. Emissions trading is not allowed in 2012.

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[48] See E. Haites, 1998: International emissions trading and compliance with GHG limitation commitments, Working Paper W70, International Academy of the Environment, for a discussion of this proposal.

[49] This is feasible only if a LIFO approach is used to invalidate transactions in the case of non-compliance. This allows the insurer to assess the risk of non-compliance at the time of the sale. Proportional invalidation of sales would mean that subsequent sales would affect the risk of invalidation of the current sale so it is not possible to establish a premium for the insurance coverage. On the other hand, a LIFO approach means that the risk of invalidation of the current sale is not affected by subsequent sales.

[50] Buyers are able to purchase CERs and ERUs with no risk of invalidation. Hence the buyer will only pay the equivalent price for fully insured AAUs. This means that the price received by the seller is reduced by the cost of the insurance coverage regardless of whether the insurance is actually purchased by the buyer or the seller.

[51] The seller's projected emissions are calculated using the formula for Option 1 under the permanent reserve.

The results for these three cases are summarized in Table 6.

A premium of 1 AAU for each AAU sold does not lead to compliance. Since there is no penalty for non-compliance, the cost of the premium to the seller is zero. This means that a premium in the form of AAUs has no deterrent effect. Therefore, the only way such a premium could induce compliance is through limiting sales by reducing the quantity available for sale. A premium of 1 AAU for each AAU sold does not limit sales enough to keep the seller in compliance. When the Annex B seller is able to exercise market power, the price rises to reflect the seller's oligopolistic margin of $10/tC, the level of non-compliance is reduced substantially (by over 1,000 MtC), and the compliance cost rises although only to 80% of the reference case compliance cost.

Annual purchases of quotas by the insurer to compensate for the projected shortfall of the Annex B seller still leads to excess emissions of 376 MtC if the seller is a price taker. This is mainly due to differences between the seller's projected emissions and its actual emissions as a result of the two-year lag in reporting actual emissions. This proposal is modeled by assuming that the insurance company buys the required AAUs in the market. This affects the overall compliance cost, but does not affect the behavior of the seller.

Hence, if the Annex B seller is a price taker, the price remains at $1/tC until 2012, when it rises sharply to $183/tC. The high price in 2012 raises the OECD compliance cost to almost 90% above that of the full-compliance reference case. If the Annex B seller exercises market power, the level of compliance is higher, the price increase in 2012 is smaller, and the OECD compliance cost is lower, although still 75% above that of the full-compliance reference case.

Purchasing quotas in 2012 to cover the seller's the anticipated shortfall achieves full compliance but is very costly. If the Annex B seller is a price taker, the price shoots up from $1/tC in 2011 to $545/tC in 2012. If the Annex B seller exercises market power, the prices during the earlier years are increased by the $10/tC oligopolistic margin and the price in 2012 rises to $355/tC. The OECD compliance cost is about 5 times as high as in the full-compliance reference case. This option is far more expensive than any other liability proposal analyzed.

To sum up, the model is not well suited to analysis of the compulsory insurance proposal. If the purpose of the insurance coverage is to protect the buyer by replacing quota if sales are subsequently invalidated, this does not create sufficient incentive for sellers to limit their AAUs sales to quantities surplus to their compliance needs. As modeled, the annual and end-of-period purchase options do not affect the seller's behavior, so the improved compliance leads to large increases in compliance costs.

The first two options, a premium of 1 AAU for each AAU sold and annual purchases by the insurance company are compared with other liability proposals.

Table 6
Summary Results for Compulsory Insurance Options

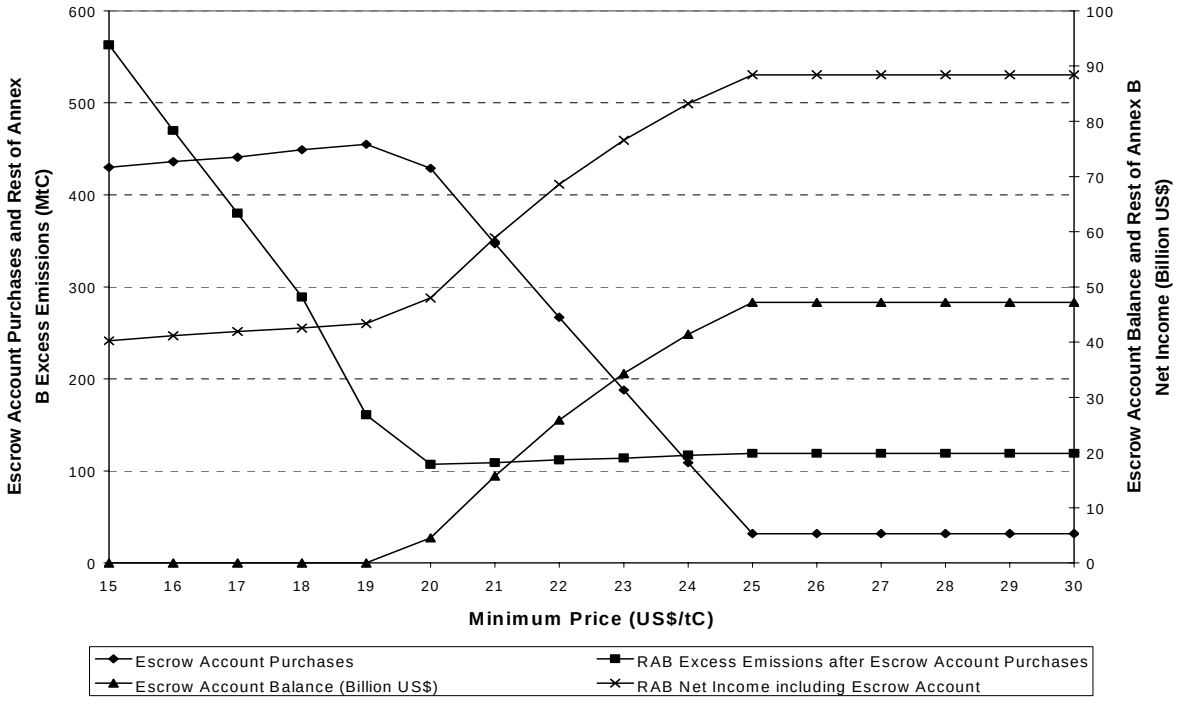
	Quotas as Premium		Annual Purchases by Insurer		End of Period Purchases by Insurer	
	Seller is Price Taker	Seller has Market Power	Seller is Price Taker	Seller has Market Power	Seller is Price Taker	Seller has Market Power
Excess emissions by Annex B Seller (MtC)	1,683	669	376	298	0	0
OECD Compliance Cost Relative to Reference Case (%)	52.1%	79.6%	188.2%	174.5%	884.6%	497.4%
Market Price in 2008 ($/tC)	$12	$22	$1	$11	$1	$11
Market Price in 2009 ($/tC)	$15	$25	$1	$11	$1	$11
Market Price in 2010 ($/tC)	$17	$27	$1	$11	$1	$11
Market Price in 2011 ($/tC)	$19	$29	$1	$11	$1	$11
Market Price in 2012 ($/tC)	$21	$31	$183	$158	$545	$355
Quantity of Quotas Purchased (Received) by the Insurer (MtC)	3,167	2,260	2,521	1,360	3,328	2,088
Cost of Quotas Purchased by the Insurer (billion 1995$US)			$170.94	$112.68		
Cost of Insurer Purchases Relative to OECD Compliance Cost (%)			67.81%	45.74%		

3.11 Escrow Account

The escrow account proposal requires that the revenue from the initial sale of AAUs be deposited into an account where they are held until the issuer establishes compliance.[52] Interest is earned by the funds in the account. If the issuer achieves compliance at the end of the commitment period, it receives the funds in the account. If the seller does not achieve compliance, the funds are used to purchase the amount of quota needed to bring the seller into compliance or the amount that can be purchased with the available funds, whichever is lower. Any remaining funds are paid to the seller. All AAUs sold are valid for use by the buyer during the year they are purchased.

Figure 26 illustrates how the escrow account is modeled. The Annex B seller sets a minimum price below which it will not sell AAUs. When the price is low ($15/tC), the buyer meets its commitment primarily by purchasing AAUs. All the funds in the escrow account are used to purchase CERs and ERUs to try to bring the seller into compliance. Despite these purchases the seller has excess emissions of 563 MtC. When the minimum price is $20/tC, some funds are left after the required purchases and these are included in the Annex B seller's net income. Due to the assumed two-year lag in reporting actual emissions, the model bases escrow account purchases on projections of the seller's behavior in 2012. This leads to insufficient purchases when the minimum price is $25/tC resulting in non-compliance of 119 MtC.

Figure 26
Performance of the Escrow Account for Different Minimum Prices

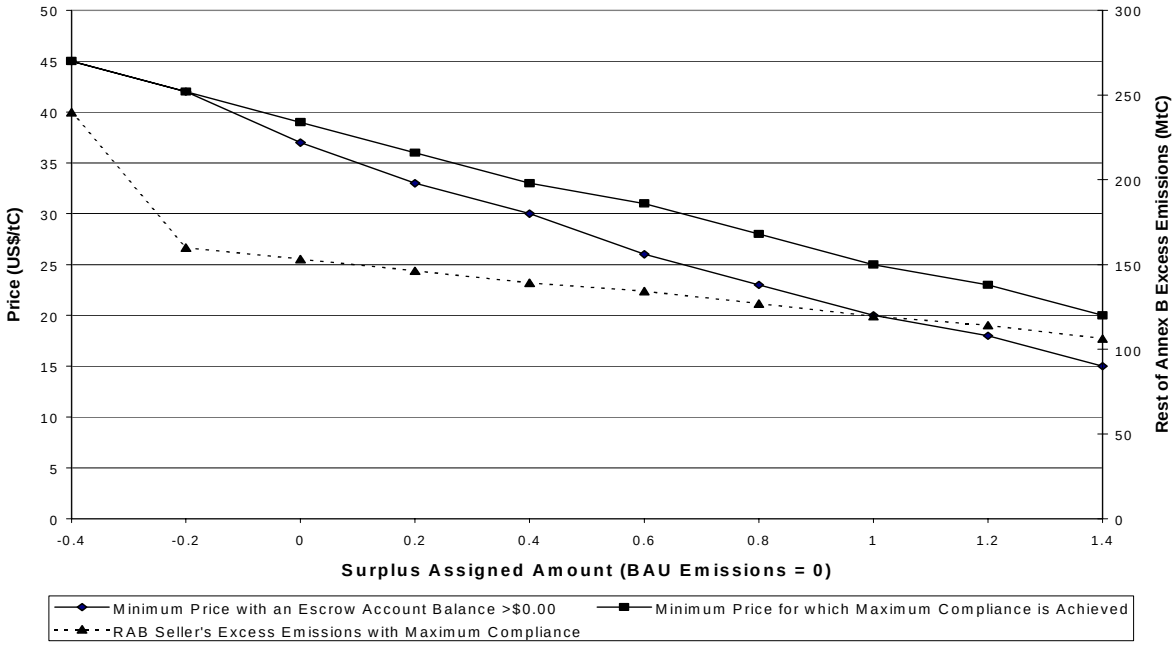


[52] See E. Haites, 1998, *op cit.*, for a discussion of this proposal.

The ability of the Annex B seller to set a minimum price obviously assumes that it is able to exercise market power. If the Annex B sellers are price takers, then they would adjust the quantity they sell at the market price. Revenue from AAU sales surplus to the seller's compliance needs will accrue to the seller. If the quantity sold includes some AAUs ultimately needed for compliance, the quota needed to achieve compliance will be purchased by the escrow account manager and only the balance of the funds will be paid to the seller. An escrow account clearly creates an incentive for each Annex B seller to sell only AAUs surplus to its compliance needs in this case. However, quantity adjustments by the Annex B seller are difficult in the model, so model results are not available for this case.

Figure 27 shows the price range over which the escrow account is effective depending upon the seller's national circumstances. The lower price leaves a positive balance in the escrow account. The higher price leads to maximum compliance and maximum revenue for the Annex B seller. Both prices rise for Annex B sellers with smaller surpluses available for sale. The excess emissions corresponding to the higher price are also shown. As modeled, the escrow account leads to a small amount of non-compliance (100 to 150 MtC) by all countries.

Figure 27
Minimum Price for Different Countries



The model is not well suited to an analysis of the performance of the escrow account proposal. The quantity adjusting behavior of the Annex B seller as a price taker can not be modeled. The seller's insistence on a minimum price when it is able to exercise market power is analyzed. The escrow account proposal can be effective in achieving compliance if the sellers are able to estimate the appropriate minimum price, but this price range is relatively

small. However, if the sellers have sufficient market power to affect the market price, it would be in their interest to demand a higher price for the AAUs.

The escrow account options used for the comparison with other liability proposals are minimum prices of $20 and $25/tC.

3.12 User Liability

User liability motivates the buyer to purchase only from sellers likely to achieve compliance. Under the user liability proposal, the buyer purchases AAUs for compliance use at its risk. If the Annex B seller does not achieve compliance, some, or all, of the AAUs purchased are returned to the issuer.[53] The issuer uses the returned AAUs to achieve compliance. The buyer may need to acquire other quota to achieve compliance. It is assumed that a grace period would be provided for this purpose.

The AAUs purchased can only be used after compliance by the Annex B seller is established.[54] In that respect, user liability is similar to proposals that limit transfers until compliance is established. However, by allowing sales on a user liability basis, prices for the buyers may be reduced and revenue can flow to the sellers earlier.

If the Annex B seller does not achieve compliance, some, or all, of the AAUs sold must be returned by the buyers. The transactions can be invalidated in one of two ways:

- Proportional invalidation. If sales of AAUs exceed the quantity surplus to the seller's compliance needs, all AAUs sold during the commitment period are reduced proportionally by the ratio: [assigned amount less actual emissions less ERUs sold]/[AAUs sold].[55]

- LIFO (last in, first out) invalidation. IET sales transactions are invalidated in reverse chronological order until the seller is brought into compliance.

[53] The sales agreement between the buyer and the seller would include provisions for reimbursement, and possibly penalties, in the event the transaction was invalidated. Those arrangements are not central to the liability proposal. It would be implemented by making all transfers subject to final approval by the secretariat once compliance had been established. However, if buyers insist on significant penalties in the event a transaction is invalidated, it could reduce the volume of IET quota sales significantly.

[54] It is possible that governments of Parties that are members of a "bubble" under Article 4 would allow the use of IET quota from other members of the same bubble before compliance by the seller is established because of the collective responsibility for compliance by the members of the bubble. Even in this situation, the individual Parties are responsible for meeting their own revised commitments in the event of non-compliance by the bubble members as a group.

[55] If the numerator is negative (actual emissions plus JI sales exceed the assigned amount), IET quota sales are reduced to zero and the seller is in non-compliance with its commitment.

User liability options are modeled by allowing the buyer to purchase AAUs up to its projected needs for 2012 during earlier years at a price discount that reflects the risk that the transaction will be invalidated. The risk that a purchase will be invalidated is estimated as follows:

- Proportional invalidation: 1 - [assigned amount (for the commitment period) less actual emissions (as this information becomes available) less ERUs sold]/[assigned amount (for the commitment period)]. Thus the risk of AAU sales being invalidated declines over time as better information on actual emissions becomes available. This will tend to delay AAU purchases until late in the commitment period.

- LIFO invalidation: the risk of a new AAU purchase being invalidated is equal to: [proposed AAU purchase]/[assigned amount (for the commitment period) less actual and projected emissions for the commitment period less actual and projected ERU sales for the entire period less cumulative AAU sales to-date]. Thus, the risk of a given quantity of AAUs being invalidated rises over time due to increases in cumulative AAU sales, which will tend to encourage early purchases of AAUs.

During the commitment period, the buyer does not know the seller's actual emissions for the entire period. To make a purchase decision, the buyer projects the seller's actual emissions on the basis of the available data (with a two-year lag) and ERU sales (with no lag). The price discount is applied to the market price during the year in which the purchase is being considered.

The buyer can be assumed to be risk neutral or risk averse, in which case, the price discount must be higher than the calculated risk. Different assumptions about the risk-taking behavior of the buyer have virtually no impact on the results. The reason is that risk aversion only affects the price paid for AAUs purchased for use in 2012 and this is a small part of the total compliance cost.

Figure 28
Comparison of LIFO and Proportional Disallowance Approaches to Invalidation of Transactions

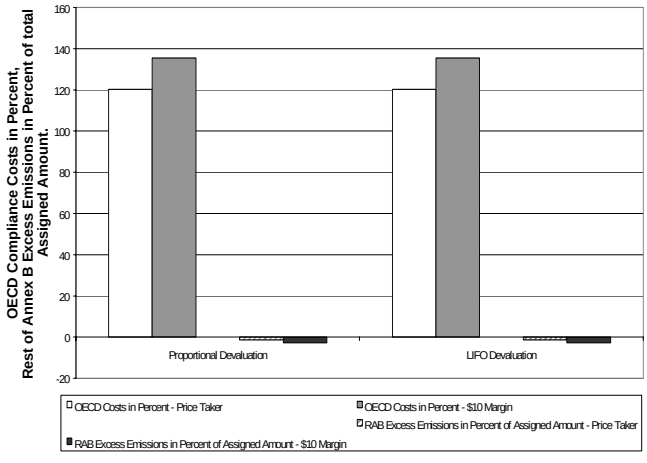


Figure 28 shows the OECD compliance costs and excess emissions of the Annex B seller for the two approaches to invalidating transactions. Both options lead to over-compliance because the buyer only purchases quotas up to its estimated demand for 2012. This is less than the seller's surplus quota, so the seller banks the remaining surplus quotas.

The proportional disallowance approach leads to lower prices being offered than the LIFO approach. But since the quantity purchased, the lesser of the buyer's projected demand for 2012 and the buyer's estimate of the seller's surplus,

is the same for both approaches, the quantity purchased is the same in both cases. The LIFO approach encourages earlier purchases than proportional disallowance. But with over-compliance by the reference case seller, the results for the two approaches are identical.

User liability is a special case of shared liability -- 100% user liability share. The other results for the user liability proposal are discussed with those for the shared liability proposal in the next section.

In summary, user liability leads to full compliance, but at a cost about 20% higher than for the full-compliance reference case. This is due to the assumption that AAUs purchased under the user liability provision can only be used in 2012 after compliance by the seller has been established. This means that the buyer must rely on domestic reductions and ERU and CER purchases for compliance in 2008 through 2011. This raises the compliance costs for those years.

3.13 Shared Liability

Under this option the risk of non-compliance by the issuer (seller) is shared between the buyer (user) and the issuer. If the Annex B issuer does not achieve compliance, some of the AAUs purchased are returned.[56] It is assumed that sufficient transactions are invalidated, if possible, to bring the issuer (seller) into compliance -- that the fraction of the AAUs returned from all of the sales invalidated is sufficient to bring the issuer into compliance. The buyer (user) keeps the balance of the AAUs purchased, but may need to acquire other quotas to achieve compliance. It is assumed that a grace period would be provided for this purpose.

To model this proposal the user liability share of AAUs purchased is returned to the Annex B seller if the issuer (seller) does not achieve compliance. The balance of the AAUs can be used by the buyer for compliance in 2012.[57] Four alternatives are tested:

4. LIFO invalidation with a user liability share ranging from 0 to 100%.

5. LIFO invalidation with a user liability share ranging from 0 to 100% and small penalty ($10/tC) for non-compliance by the issuer. The small penalty reflects the expected value of the sanctions imposed on the Annex B issuer due to non-compliance.

[56] The sales agreement between the buyer and the seller would include provisions for reimbursement, and possibly penalties, in the event the transaction was invalidated. Those arrangements are not central to the liability proposal, which would be implemented by making all transfers subject to final approval by the secretariat once compliance had been established. However, if buyers insist on significant penalties in the event a transaction is invalidated, it could reduce the volume of AAU sales significantly.

[57] Ideally, the buyer should be able to use the issuer liability share of the AAUs purchased for compliance during the year they are purchased rather than 2012. When the proposal was programmed in this way it led to a "loop" with the use of the AAUs affecting the level of no-compliance, which in turn affected the fraction of AAUs that could be used for compliance, which affected the level of non-compliance.

6. The seller transfers AAUs equal to the amount purchased plus the user liability share, i.e., the seller accepts the full risk since the penalties it faces for non-compliance are lower. LIFO invalidation with a user liability share ranging from 0 to 100%.

7. The seller transfers AAUs equal to the amount purchased plus the user liability share, with a user liability share ranging from 0 to 100% and small seller penalty ($10/tC) for non-compliance.

Figure 29 illustrates the performance of the first option for different countries. Since AAUs are only purchased for use in 2012, over-compliance is maintained for all sharing arrangements until the surplus is less than the buyer's demand for 2012. Thus the reference case seller (Surplus Assigned Amount of 1.0) remains in compliance for all sharing arrangements. For countries with a smaller surplus (Surplus Assigned Amount of 0 to 0.8) some sharing arrangements lead to excess emissions by the Annex B seller.

Figure 29
Annex B Seller's Excess Emissions as a Function of User Liability Share and National Circumstances

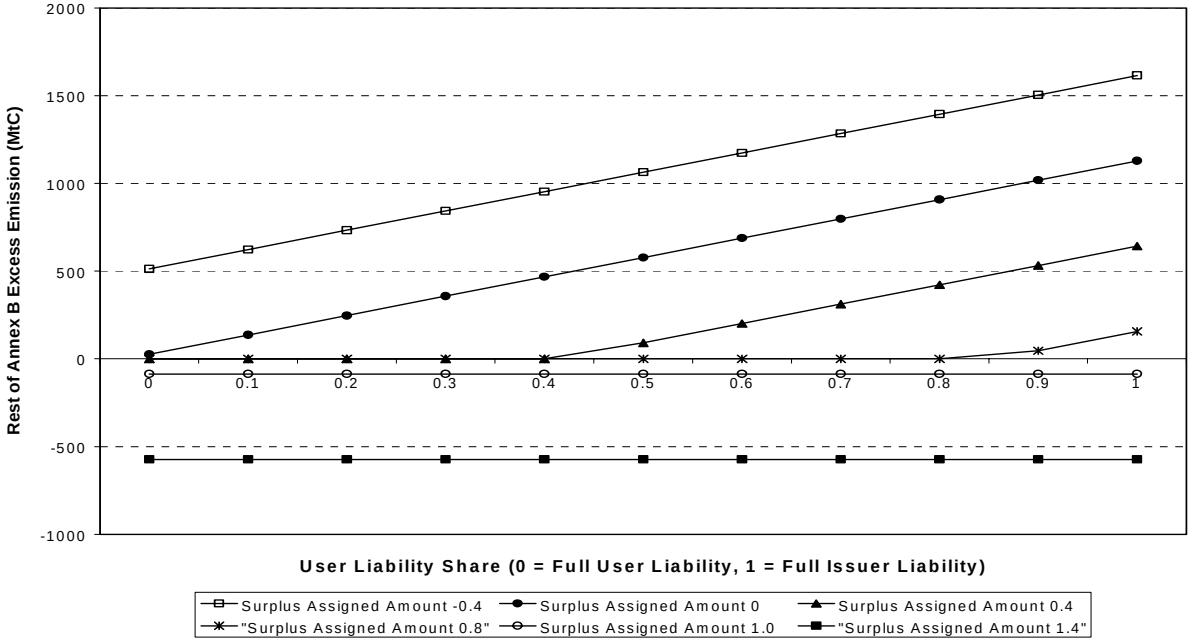
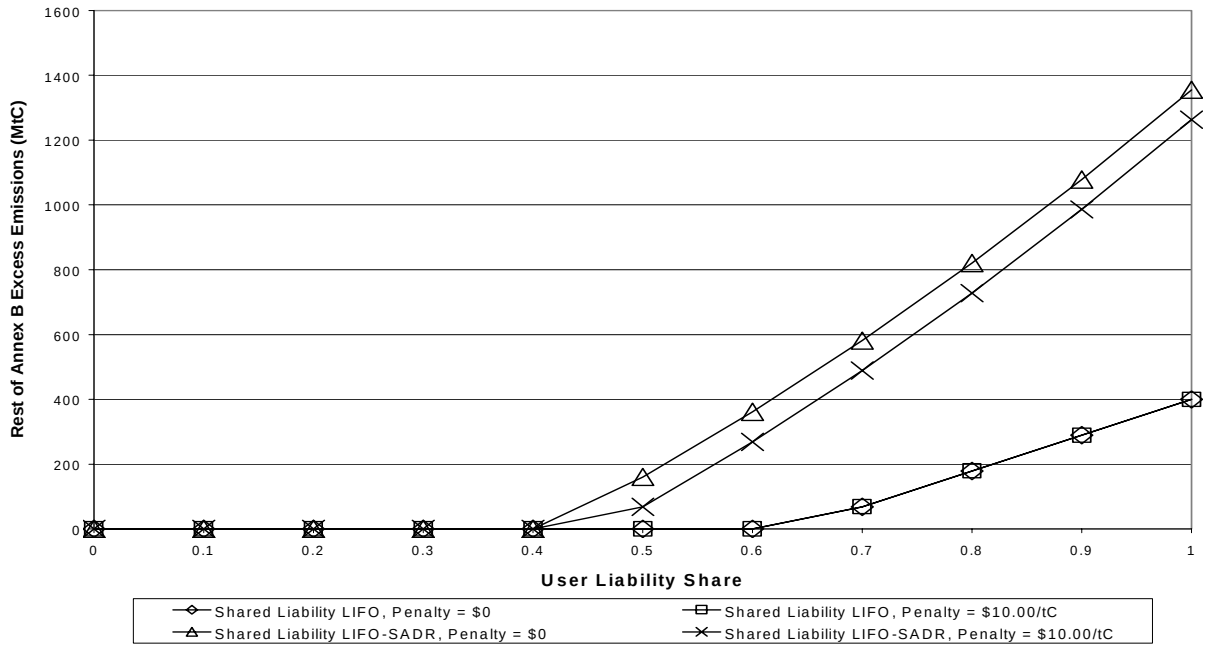


Figure 30 compares the performance of the four shared liability options for a country whose surplus assigned amount is 0.6. Option 1 results in the fewest excess emissions for a given sharing arrangement. Adding a small penalty for non-compliance, Option 2, does not change the results because the market price for the AAUs is always greater than the penalty.

Option 3, not surprisingly, leads to much higher excess emissions by the seller. Under this option the seller transfers AAUs equal to the amount purchased plus the user liability share to

the buyer. This means the seller bears the full risk. But since the seller incurs no penalty for non-compliance, the result is simply more non-compliance. Adding a penalty for non-compliance by the seller reduces the extent of the non-compliance as shown by Option4.

Figure 30
Comparison of Shared Liability Options



While some sanctions for non-compliance are likely, it is not clear whether a shared liability rule could force buyers and sellers to behave in accordance with Option 2 rather than Option 4. The seller could simply agree to transfer more AAUs to the buyer for a nominal price to offset the risk to the buyer. In other words, any shared liability rule is likely to yield results similar to Option 3 or 4, depending upon the penalty for non-compliance.

In summary, analysis of the shared liability proposal indicates that full user liability always performs at least as well as any shared arrangement. In general, the larger the issuer share of the liability, the greater the extent of the non-compliance.

To compare shared liability with other liability proposals, Options 2, 3 and 4 are used with issuer and user shares of 50%. The choice of the issuer/user share does not affect the results for the reference case seller, as can be seen in Figure 29, for Assigned Amount Surplus = 1.

3.14 Double Liability

If the Annex B issuer (seller) does not achieve compliance, AAU sales are invalidated as necessary to bring the issuer into compliance in the same manner as under user liability. In addition, the seller is subject to penalties for non-compliance.

It is not clear whether the issuer is subject to sanctions based on the extent of the non-compliance *before* the transactions are invalidated or the extent of the non-compliance *after* the transactions have been invalidated. We interpret double liability to mean that the issuer will be subject to sanctions for the extent of the non-compliance *before* the transactions are invalidated. The reason is that Annex B Parties will be subject to sanctions for non-compliance under Article 18 regardless of whether they participate in emissions trading. Those sanctions will apply to excess emissions *after* transactions have been invalidated, which means that double liability is identical to user liability under this assumption.

The performance of the double liability proposal can be assessed from the results reported for shared liability. Figure 30 indicates that a penalty for non-compliance by the issuer can, but need not, reduce excess emissions. However, this is true only if the liability is shared. With full user liability, 0 on the horizontal axis in Figure 30, the penalty on the seller yields no additional benefit.

It can be argued that this result reflects the model assumptions. The buyer is assumed to be risk averse due the high domestic penalties it faces. In addition, the government is assumed to accept AAUs only if there is no risk of the transaction being invalidated. Thus, in the model, transactions are virtually never invalidated under user liability proposals. This means that the penalty faced by the issuer does not affct the results.

In summary, the model results for double liability are identical to those for full user liability. As a result, double liability is not included in the comparison with other liability proposals.

3.15 Traffic Light

The traffic light proposal allows sales to be made on an issuer liability basis until a defined condition, indicating a risk of non-compliance, is reached. Thereafter, further sales are made on a user liability basis. If a condition that suggests a high risk of non-compliance is reached, further sales are prohibited.

To model this proposal we test the following conditions to trigger a switch from issuer to user liability:

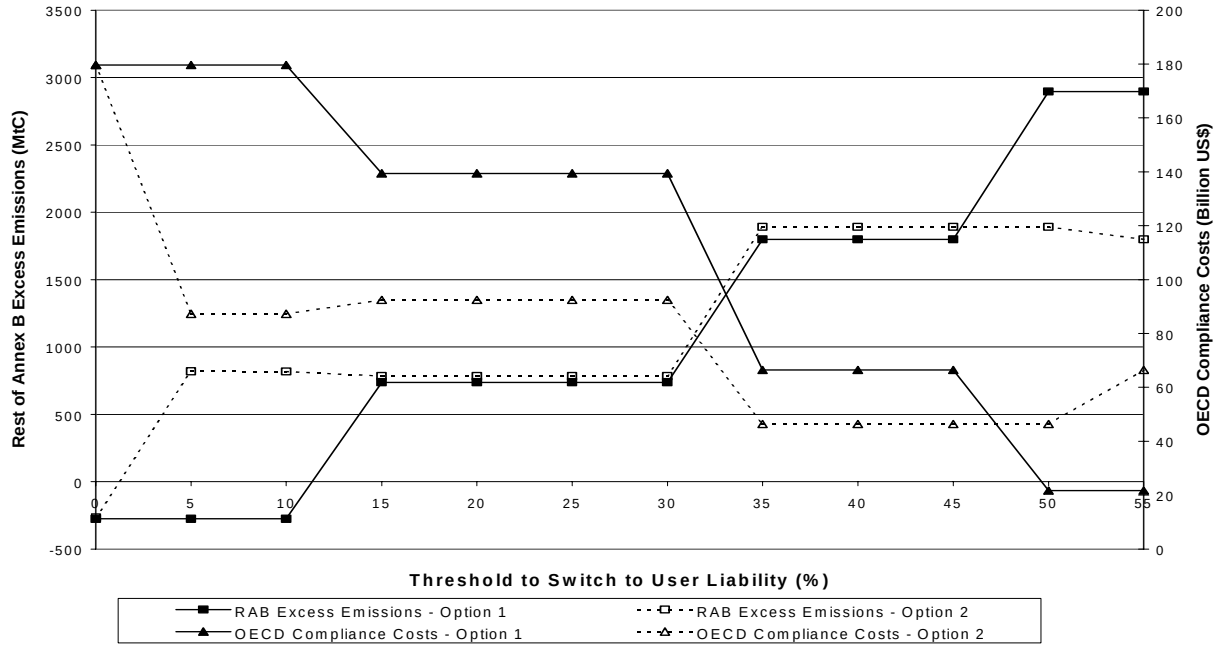
- AAU sales limited to V% of assigned amount. Values of V ranging from 0 to 50% are tested.

- Cumulative actual emissions plus AAU sales ▶ [(assigned amount/5) * years of data available + V% of assigned amount/years of data available]. Values of V ranging from 0 to 50% are tested.

Until the applicable limit is reached, sales proceed without restriction on an issuer liability basis. Beyond the applicable limit AAU sales are subject to user liability with LIFO invalidation. All AAUs sold on an issuer liability basis can be used by the buyer during the year they are purchased. AAUs purchased under user liability can only be used in 2012 if the seller achieves compliance.

Figure 31 shows the effectiveness of different limits under the two options assuming that the Annex B seller is a price taker. Under Option 1 values of V up to 14% lead to over-compliance because sales under the issuer liability provision are less than the seller's surplus. Any higher value of V leads to substantial non-compliance (about 750 MtC) by the Annex B seller. Under Option 2 values of V up to 2% lead to over-compliance and any higher value leads to substantial non-compliance.

Figure 31
OECD Compliance Cost and Excess Emissions of the Annex B Seller for Different Traffic Light Formulae



The model structure causes the results to exhibit the sharp discontinuities shown in Figure 31. There is only one Annex B seller, so a change in its status has a big impact on the results. Similarly, the seller's status can only change from one calendar year to the next, leading to discontinuities in prices such as those reported for the eligibility proposal. In practice, the changes probably would be smaller and more continuous; some countries would switch to

user liability while others would continue to operate under issuer liability and changes of status would occur at different times.

User liability transactions are rare in the model. Since the Annex B seller operates on an issuer liability basis for 2008 or until the limit triggering a change in status has been reached. Sales of AAUs during this period represent most of, often more than, the seller's surplus assigned amount. This affects the buyer's assessment of the probability of compliance by the seller with the result that very few user liability transactions are consummated.

As might be expected, the threshold values needed to keep the seller in compliance differ by country. This is shown in Figure 32, which shows the maximum value of V under each option sufficient to keep the Annex B seller in compliance. The model only finds values for countries with relatively large surplus assigned amount, 0.8 or higher. The reason is that the switch from issuer to user liability must be made at the end of a calendar year in the model. The buyer always buys AAUs in 2008. But its purchases in 2008 exceed the surplus assigned amount of countries with a smaller surplus assigned amount. Hence there is no limit that will keep the seller in compliance after the sales in 2008 have been made.

Figure 32
Maximum Limit that Achieves Compliance and Associated Excess Emissions Assuming the Annex B Seller Exercises Market Power for Different National Circumstances

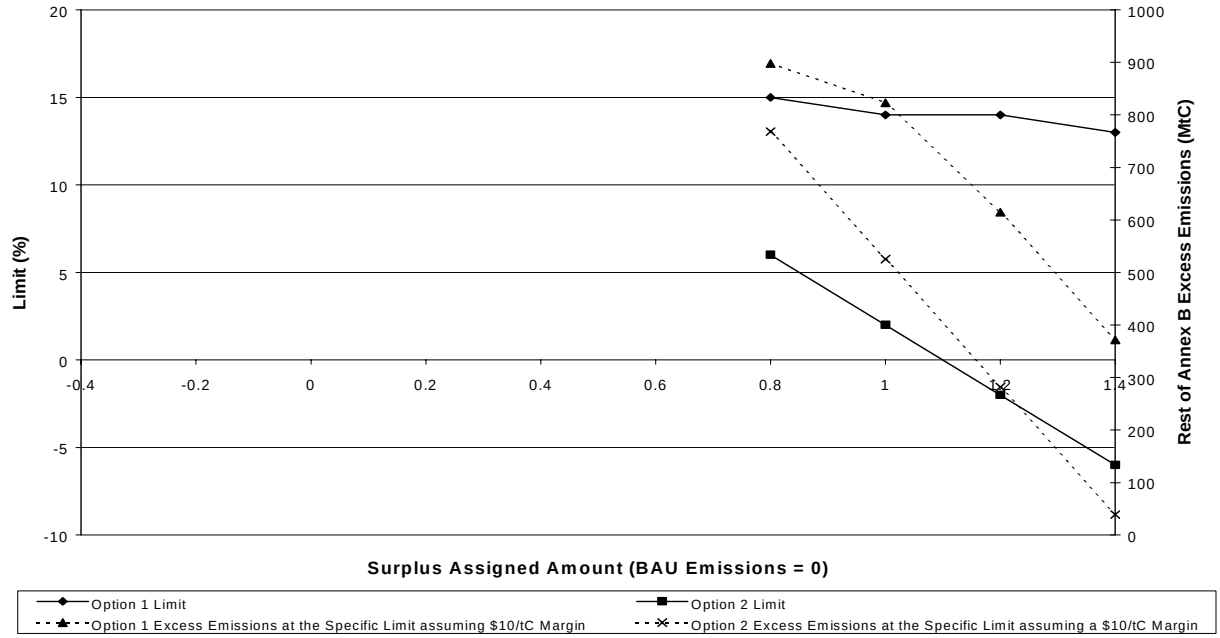


Figure 32 also indicates how sensitive the traffic light proposal is to market power by the Annex B seller. It shows the amount of over-compliance associated with the competitive their market limit that keeps each country in compliance. The over-compliance ranges from 350 to 900 MtC in the case of Option 1 and from 40 to 800 MtC in the case of Option 2.

In summary, the traffic light proposal can achieve compliance. Compliance means significant over-compliance (about 250 MtC), which increases OECD compliance costs by over 25% from the full-compliance reference case. The limit that triggers a change in status varies with each country's national circumstances. It would be difficult to find the most appropriate limit for each country in advance. The results are also sensitive to the ability of the Annex B seller to exercise market power.

The comparison with other liability proposals is based on Option 1 with a limit of 14% and Option with a limit of 2%.

4. Comparison of Liability Proposals and Conclusions

4.1 Cautionary Note

Liability proposals are intended to prevent an Annex B seller from benefiting financially through emissions trading and deliberate non-compliance given weak or poorly enforced penalties. The liability proposals have been analyzed using a model and assumptions designed to generate the worst outcomes.

It is appropriate to focus on the worst outcomes -- the maximum non-compliance and increase in compliance costs if trade is excessively restricted -- because they best reveal the performance of each liability proposal. Comparison of the performance under these circumstances may identify some proposals that are superior to others.

Using a model means that the results are sensitive to the structure and assumptions of that model. By comparing the liability proposals with the least-cost, full-compliance equilibrium, we focus on *relative*, rather than *absolute*, emissions and compliance costs. This focuses on the relative performance of the proposals, rather than specific estimates of compliance costs and excess emissions, which are more sensitive to the model structure and assumptions.

The analysis is intended to provide insights such as, whether any liability proposal can work effectively, which proposals dominate others, appropriate operational specifications for proposals, and the sensitivity of the results to specific assumptions. While some proposals are difficult to incorporate into the model, the analysis nevertheless provides insights into the operation of each proposal.

The model results should be interpreted with care and be used as only one of the inputs to the evaluation of the liability proposals.

4.2 Comparison of Liability Proposals

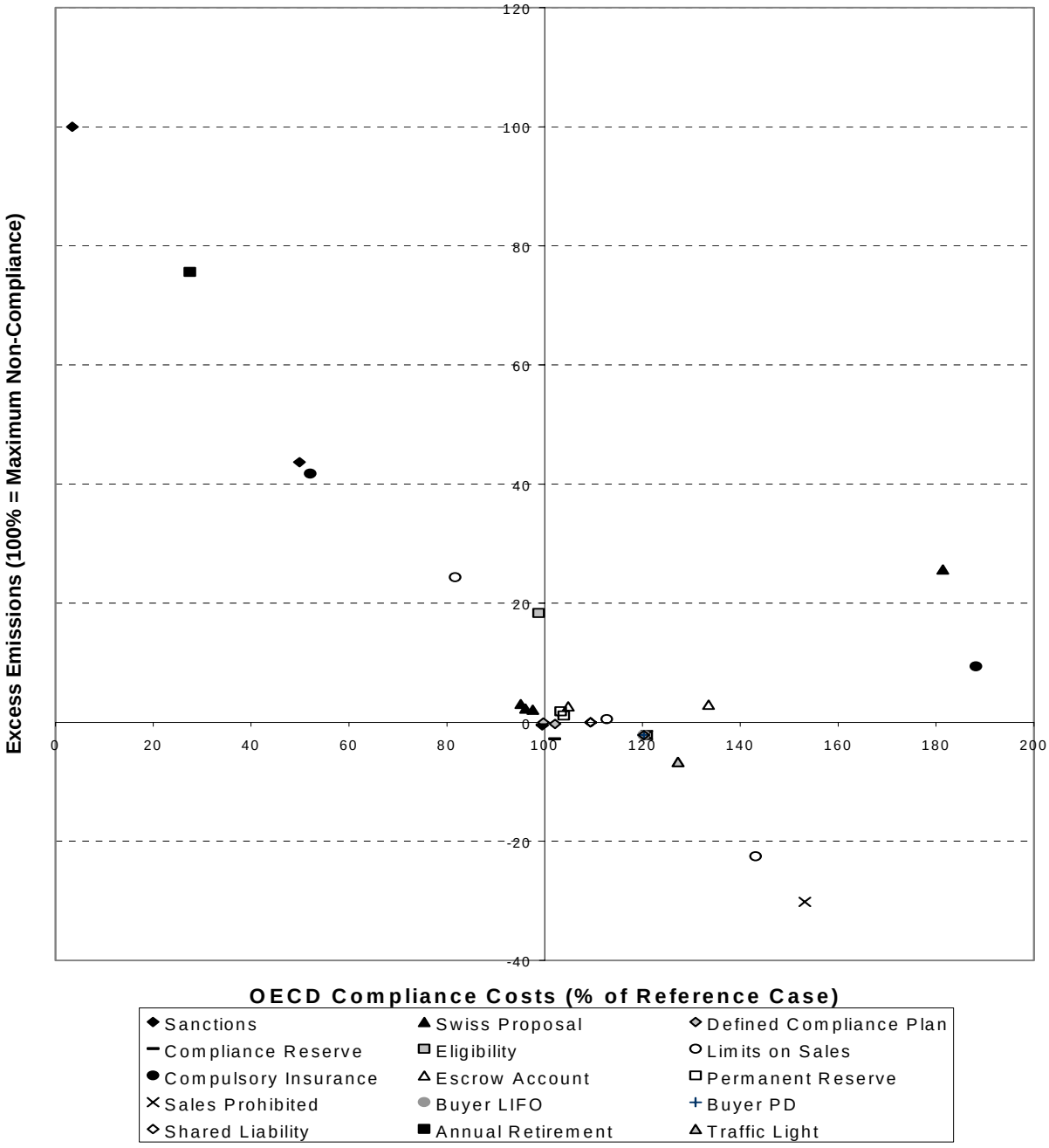
The liability proposals analyzed are intended to limit non-compliance due to AAU trading. The analysis finds that they differ in terms of their effectiveness in limiting excess emissions by the Annex B seller and their impact on OECD compliance costs. The proposals also affect the mix of actions used by the OECD buyer to achieve compliance and the distribution of costs among different regions. These issues are addressed in turn.

4.2.1 Impact on Compliance Cost and Excess Emissions

The liability proposals analyzed are compared in Figure 33. The reference scenario -- full compliance -- is defined as the origin. The lower left quadrant is preferred since this means both lower compliance costs and lower total emissions. Although it is not clear here, it will be seen in Figure 34 that two of the proposals fall into this quadrant very close to the origin.

This is surprising since it means that a liability proposal, which may restrict sales, achieves compliance at a lower cost than in the reference case, where there are no restrictions on trade. Closer examination reveals that these results are due to smaller rounding errors than the 38 MtC for the reference case.

Figure 33
Comparison of Liability Proposals



Proposals in the upper right quadrant are undesirable because they involve both higher emissions and compliance costs. Variants of the escrow account, compulsory insurance and seller specified compliance plan (Swiss proposal) fall into this quadrant.

Proposals in the upper-left and lower-right quadrants involve a trade-off between compliance costs and excess emissions. At the far left hand side of the chart are proposals that reflect no compliance effort. They have the maximum excess emissions (4,029.28 MtC = 100%) and reduce the OECD compliance costs to about 3% of the reference case. These proposals include issuer liability with a penalty of zero and a non-binding limit on sales.

At the lower right of the chart are proposals that restrict AAU sales to levels below the amount surplus to the seller's compliance needs. These proposals force the Annex B seller to bank part or all of its surplus assigned amount, reducing total emissions substantially below those of the reference case and increasing OECD compliance costs significantly. A prohibition on sales until after compliance is established in 2014 leads to banking of about 30% and increases OECD compliance costs by over 50%. The European Union proposal to limit sales leads to banking of over 20% and increases OECD compliance costs by over 40%.

The important result from Figure 33 is that several of the liability proposals lie very close to the origin, meaning they lead to outcomes very close to the least-cost, full-compliance reference case. In other words, under the worst case assumptions several of the liability proposals lead to results very close to the reference case. This means that they protect against deliberate abuse of emissions trading for a small "premium" which can take the form of increased compliance costs or a risk of non-compliance or both.

The liability proposals close to the origin are preferred to the others. These proposals are shown in Figure 34, which is a close-up of the area around the origin of Figure 33.

Eleven liability proposals are shown in Figure 34:

- Issuer liability with sanctions of at least $40/tC for non-compliance
- Permanent reserve, with the size of the reserve defined by option 1
- Permanent reserve, with the size of the reserve defined by option 3
- Sales surplus to the seller's compliance plan (Swiss proposal) with a regular start and annual emissions up to 33% above the average assigned amount
- Sales surplus to the seller's compliance plan (Swiss proposal) with a prompt start and annual emissions equal to the average assigned amount
- Sales surplus to defined compliance plan with a regular start and annual emissions defined by option 1 with Z = -14%
- Sales surplus to defined compliance plan with a prompt start and annual emissions defined by option 3 with Z = -7%
- Compliance reserve defined by option 1 with a limit of 300%
- Compliance reserve defined by option 2 with a limit of 1600%
- Escrow account with a minimum price of $20/tC

While all of these proposals ***can*** achieve results close to the reference case, not all of them ***ensure*** this result for different sellers as will be discussed below.

Figure 34
Comparison of Liability Proposals

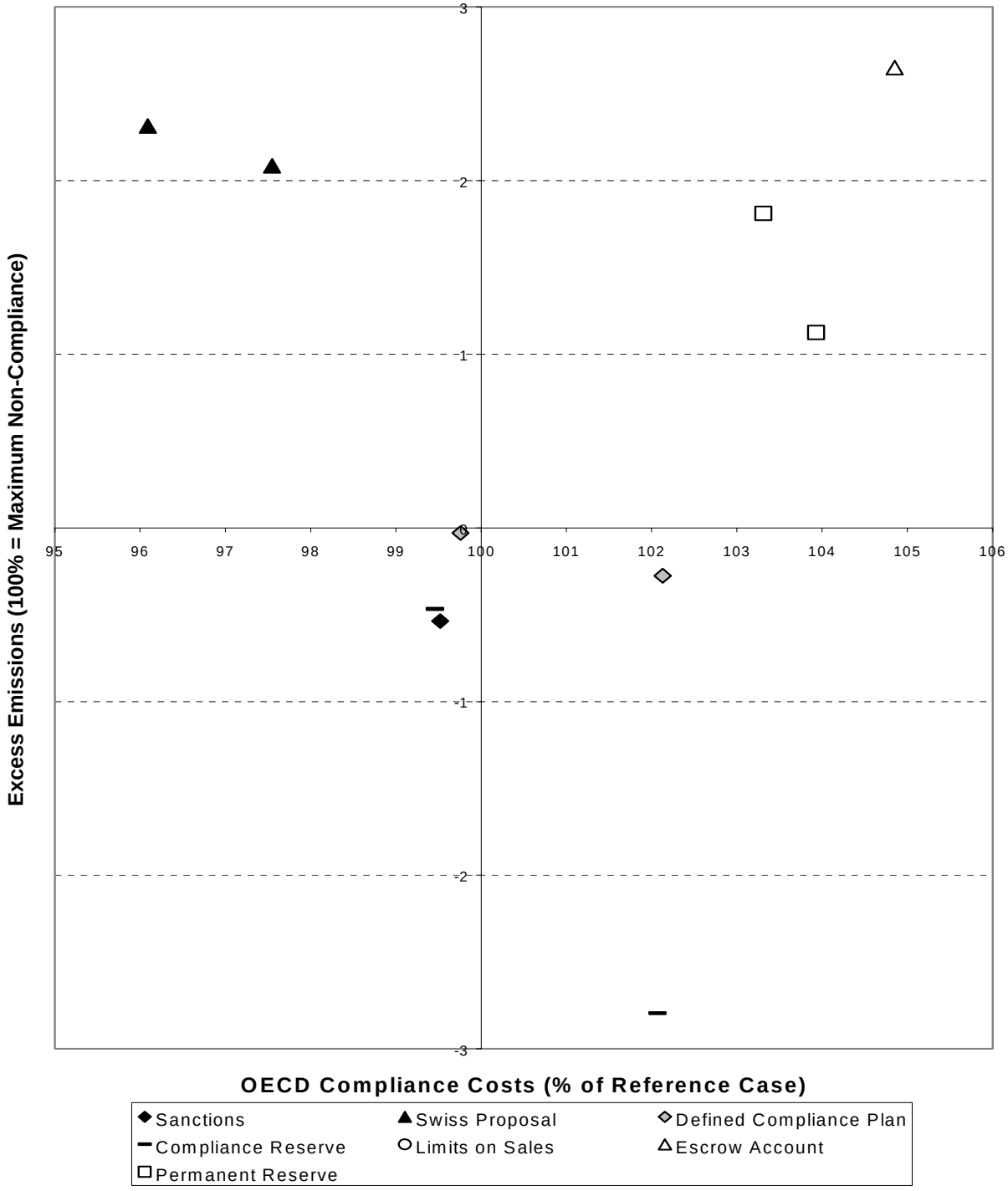


Figure 34 shows only the proposals whose excess emissions are within 2% (80.6 MtC) **and** within 5% of the OECD compliance cost for the reference case. Other proposals, such as user

liability and shared liability, limit excess emissions to this range, but at higher cost. And the eligibility proposal can limit the cost to this range, but with larger excess emissions.

To put the cost range into perspective we compare it to the sensitivity tests for transactions costs and the supply of CDM quota available from prior to 2008. If the transactions costs for JI and the CDM are both 10%, rather than 15% and 25% respectively, the OECD compliance cost for the reference case is reduced by 5.4%. And if the transactions costs for JI and the CDM are 35% and 50% respectively, the OECD compliance cost for the reference case is increased by 8.3%. If the CDM supply from prior to 2008 is set at its maximum value of 1.4, the OECD compliance cost for the reference case is reduced by 18.9%, while if the CDM supply from prior to 2008 is reduced to 0.5 (from 0.8) the OECD compliance cost for the reference case is increased by 11.7%. Thus the cost of the liability proposals shown in Figure 34 lies within the range of uncertainty for JI and CDM transactions costs and is much smaller than the uncertainty due to the supply of CDM quota available from prior to 2008.

The liability proposals shown in Figure 34 are compared in Table 7. All of the proposals are able to approximate the competitive market result -- the full-compliance reference case -- cost-effectively. Specifically they can keep excess emissions to within $\overline{2}$% while keeping the OECD compliance cost to within $\overline{5}$% of the reference case. All but two of the proposals allow trading to begin in 2008. Although a market for CDM quota, and possibly JI quota, will exist before 2008, prompt establishment of the market for AAUs may be important to facilitate establishment of the market. A "spot" market usually needs to be established before derivatives such as forward contracts and options can be developed.

Most of the proposals listed in Table 7 have two drawbacks:

- The operational specification that leads to full compliance by the seller varies with national circumstances. The size of the compliance reserve needed for full compliance, for example, is different for each Annex B seller. Furthermore, the appropriate specification for each country can not be determined accurately in advance. And the seller has an incentive to argue for a different limit to increase its net income. Deviations from the specification that achieves full compliance for each country lead to excess emissions or higher compliance costs.

- The results achieved are sensitive to the ability of the Annex B seller(s) to exercise market power. If one or more of the Annex B sellers is able to exercise market power, it banks some of its AAUs to drive up the price and increase its net income. This raises the compliance cost for the OECD. The quantity banked can be large, typically 200 to 1,000 MtC.

The permanent reserve proposal is the only one that does not suffer from those drawbacks.

Table 7
Comparison of Selected Liability Proposals

Proposal		**Able to Approximate Competitive Market Result Cost-effectively[a]**	**Supply of AAUs Available for Trade beginning in 2008**	**Operational Specification of the Liability Proposal NOT Sensitive to National Circumstances[b]**	**Performance NOT Sensitive to Annex B Seller Market Power[c]**
Sanctions >$40/tC		✔	✔		
Permanent Reserve	Option 1	✔	✔	✔	✔
	Option 3	✔	✔	✔	✔
Swiss Proposal	Regular Start, 33%	✔			
	Prompt Start, 0%	✔	✔		
Defined Compliance Plan	Regular Start, Option 1, -14%	✔			
	Prompt Start, Option 3, -7%	✔	✔	✔	
Compliance Reserve	Option 1, 300%	✔	✔		
	Option 2, 1600%	✔	✔		
Escrow Account	$20 Minimum Price	✔	✔		

Notes: a Results within ±2% of emissions and ±5% of OECD compliance cost for full-compliance reference case
b Specification leads to excess emissions within ±2% of full compliance for all countries.
c Results when Annex B seller is able to exercise market power are within ±2% of those for a competitive market.

4.2.2 Mix of Compliance Actions and Distribution of Costs

Liability proposals change the mix of actions used by the OECD buyer to achieve compliance. Figure 35 shows the mix of compliance actions used by the OECD buyer for selected liability proposals. The mix of compliance actions used varies significantly with the OECD compliance cost. Differences among proposals with similar costs are relatively small. Thus, the proposals shown in Figure 35 have been selected to represent the spectrum of compliance costs.

The left-hand bar in Figure 35 corresponds to the right-hand side of Figure 33, issuer liability with no sanctions. Assuming that the Annex B seller is a price taker, the buyer achieves compliance primarily through buying AAUs. As indicated in Figure 33, this leads to substantial non-compliance by the Annex B seller.

The second bar from the left in Figure 35, issuer liability with a penalty of $15/tC, corresponds to a compliance cost of about 50% of the reference case, which still involves non-compliance of over 40% by the Annex B seller. Reliance on purchased AAUs is significantly lower, while domestic reductions and purchases of CDM and JI quotas rise relative to the previous bar.

The third bar from the left in Figure 35, issuer liability with a penalty of $40/tC, involves a compliance cost of about 99.5% of the reference case. The liability proposals close to the origin in Figure 34 involve a mix of compliance actions similar to this case. The mix of compliance actions is very similar to that of the reference case as presented in Table 4.

The right-hand bar in Figure 35, sales prohibited until 2014, entails compliance costs 53% higher than the reference case. Emissions trading is not allowed during the first commitment period under this proposal, so compliance is achieved through domestic reductions, and purchases of CDM and JI quota.

Figure 36 shows the distribution of compliance costs for the liability proposals portrayed in Figure 35. The compliance cost for the OECD buyer and the net income for the Rest of Annex B and the Non-Annex B sellers rise moving from left to right. The net income is roughly $50 billion for both the Rest of Annex B seller and the Non-Annex B seller for the issuer liability case with a penalty of $40/tC as in the reference case (see Table 3).

The liability proposals shown in Figure 34 and listed in Table 7 produce results close to those of the reference case and issuer liability with a penalty of $40/tC in Figures 35 and 36. The mix of compliance actions implemented and the distribution of costs are not very sensitive to the different liability proposals that lie close to the reference case. Thus, the liability proposals can be compared on the basis of their impact on OECD compliance costs and RAB excess emissions because the distribution of costs will be similar for all of those proposals.

Figure 35
Mix of Compliance Actions

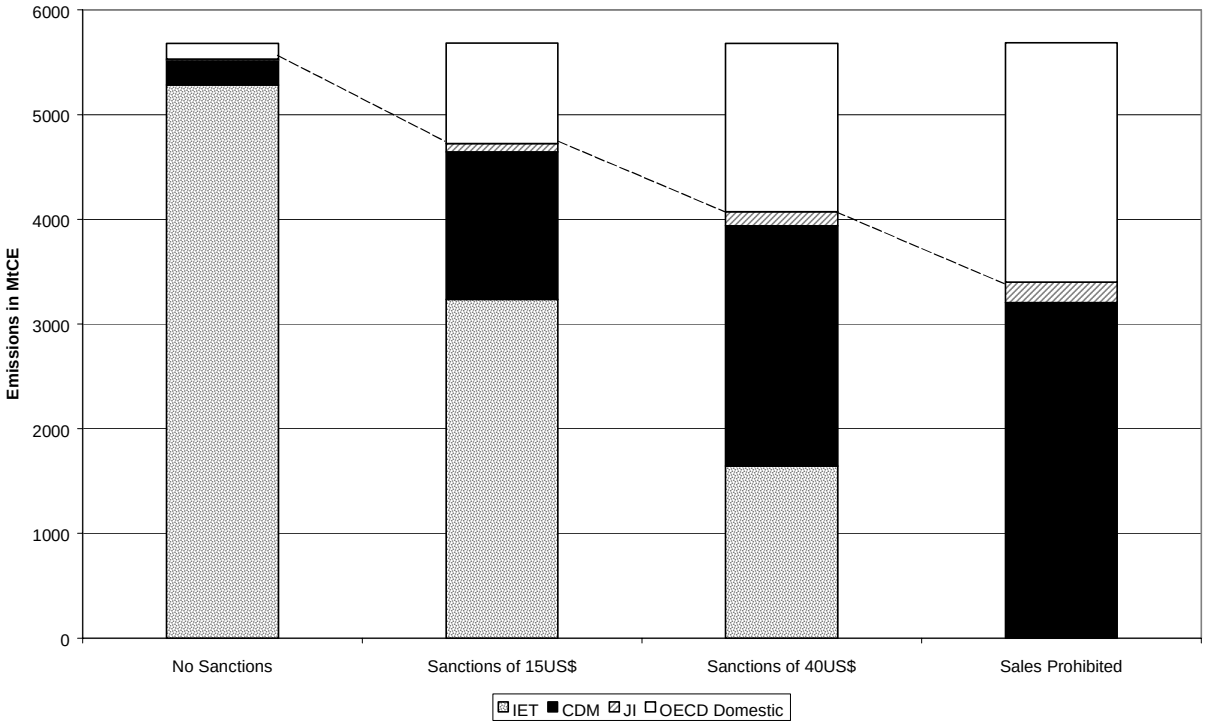
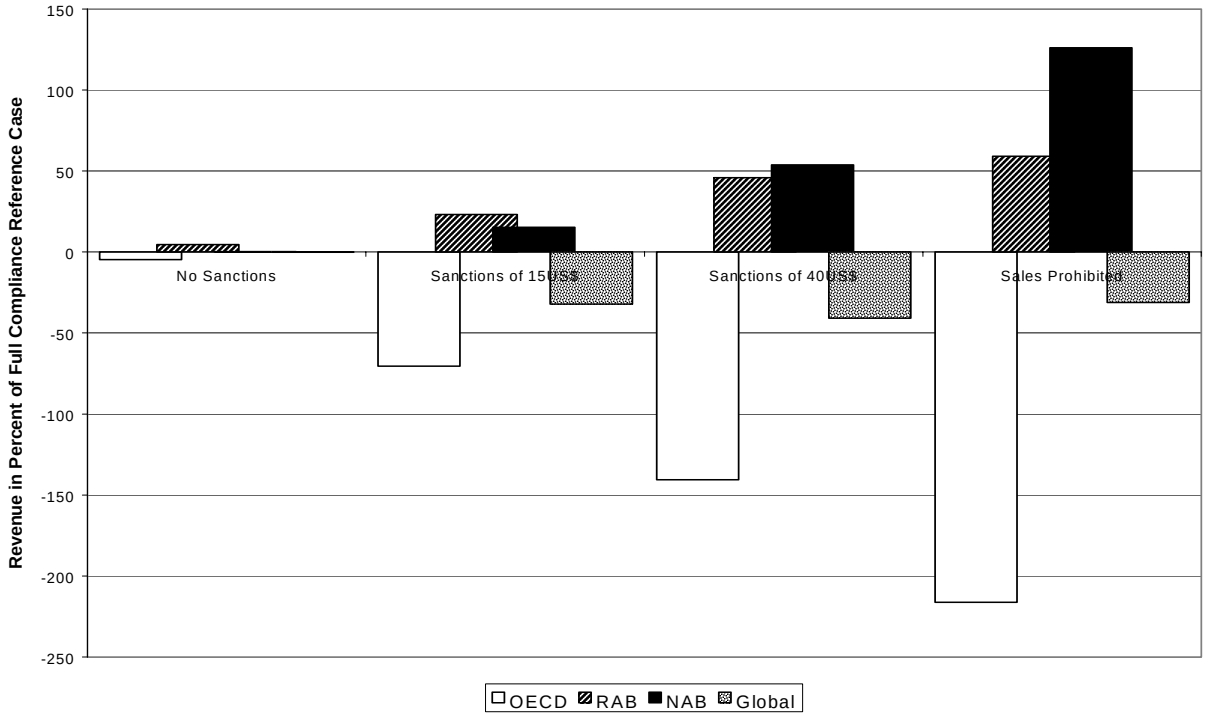


Figure 36
Distribution of Compliance Costs



4.3 Sensitivity Tests

A number of sensitivity tests were identified in section 2.11. Several of them have already been discussed, but they are summarized again here.

Transactions costs. If the transactions costs for JI and the CDM are both 10%, rather than 15% and 25% respectively, the OECD compliance cost for the reference case is reduced by 5.4%. And if the transactions costs for JI and the CDM are 35% and 50% respectively, the OECD compliance cost for the reference case is increased by 8.3%. The results will be similar for all of the proposals listed in Table 7 since they all entail approximately the same mix of compliance actions.

CDM quotas from prior to 2008. If the CDM supply from prior to 2008 is set at its maximum value of 1.4 (rather than 0.8), the OECD compliance cost for the reference case is reduced by 18.9%. If the CDM supply from prior to 2008 is reduced to 0.5, the OECD compliance cost for the reference case is increased by 11.7%. And if there is no CDM quota from prior to 2008, the OECD compliance cost for the reference case is increased by 38.2%. The results will be similar for all of the proposals listed in Table 7 since they all entail approximately the same mix of compliance actions.

JI assumptions. The sensitivity of the results to JI quotas as a share of the emissions reductions available in the Annex B seller countries and the fraction of JI quota that corresponds to "real" emission reductions is discussed in the next section on the application of the liability proposals to JI quotas.

Risk aversion by the buyer. Risk aversion by the buyer applies only to proposals with an element of user liability. The results for those proposals -- user, shared and double liability and the traffic light -- are not sensitive to risk aversion by the buyer, at least to the manner in which this was modeled. The reason is that risk aversion only affects the price paid for AAUs purchased for use in 2012 and this is a small part of the total compliance cost.

Sensitivity to national circumstances. The sensitivity of the application to different Annex B countries is discussed explicitly for each proposal where this might be an issue. Countries are characterized in terms of their ratio of assigned amount to their projected "business-as-usual" emissions. A country with no surplus assigned amount is designated 0 and a country with assigned amount equal to that of the Annex B seller in the model is designated 1. For most liability proposals, the operational specification that keeps the Annex B seller in compliance varies with the country's national circumstances.

Sensitivity to the behavior of the Annex B seller. The impact of the seller's behavior on the results is discussed explicitly for each proposal where this could affect the performance. The buyer may be able to affect the results in two ways. The buyer may choose, or argue for, a specification that increases its revenue relative to the specification that just keeps it in compliance. Second, the buyer may be able to exercise market power. Where a buyer is able to exercise market power, the effect is to increase compliance, often by a substantial margin, and to increase compliance costs for the buyer.

Discount rate. Compliance costs are calculated as the present value in 2008 of the compliance costs incurred during the period 2008 through 2012. An inflation-adjusted discount rate of 5% is used. Figure 36 presents the OECD compliance costs and Rest of Annex B compliance costs for selected liability proposals using inflation-adjusted discount rates of 2%, 5% and 10%. The main concern is whether the discount rate changes the relative performance of the proposals. It is clear from the figure that the discount rate does not have a significant impact on the relative performance of the different proposals.

4.4 Treatment of ERUs Under the Liability Proposals

The sale of JI quotas (ERUs) by Annex B countries can contribute to non-compliance just as the sale of AAUs can. The sale of AAUs reduces the seller's remaining assigned amount. If the remaining assigned amount is insufficient to cover the country's actual emissions, the sale can be argued to have led to non-compliance. Under Article 3.11 of the Protocol, any ERUs transferred reduce the seller's assigned amount. Thus a sale of ERUs can also lead to non-compliance if the seller no longer has enough assigned amount available to cover its actual emissions. This line of reasoning suggests that ERUs should be subject to the same liability provisions as AAUs.

A JI project should reduce emissions or enhance sequestration from what would otherwise have occurred. If that is the case it can be argued that the ERUs reflect a corresponding reduction in emissions, or enhancement of sinks, so that their sale has no impact on the country's compliance. This line of reasoning suggests that ERUs should be considered valid once issued and not be subject to the liability proposal.

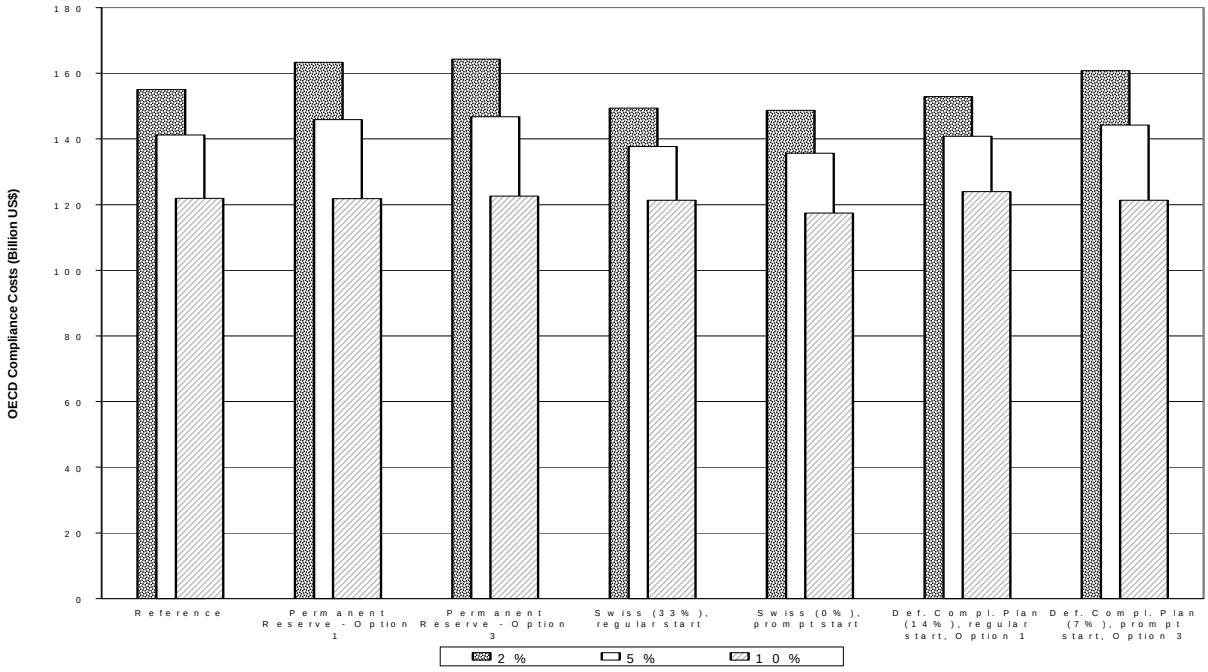
The process for determining the quantity of ERUs awarded for a JI project, then, is a key factor in resolving their treatment under the liability proposal. If the quantity of ERUs awarded is decided through an independent international process, it can be argued that they should be valid once issued in the same way as CERs. On the other hand, if the decision on the quantity of ERUs awarded is left entirely to the host government, it can be argued that ERUs and AAUs are equivalent and that ERUs should be subject to the same liability provisions as AAUs.

It could also be argued that JI is a small component of the mix of compliance actions, so the validity of the ERUs has little impact on the extent of non-compliance. The model can be used to assess this argument. The model includes a parameter for the fraction of ERUs that correspond to "real" emission reductions. For the analyses that include JI it has a value of 1.0, reflecting the assumption that the ERUs represent reductions in the emissions of the host country.

To test the assumption that the validity of ERUs has little impact on the extent of non-compliance values from 1.0 to 0.05 are tested. A value of 0.05 means that only 5% of the ERUs issued represent real emission reductions. The results for various liability proposlas are shown in Figure 37.

Figure 36

Sensitivity to the Discount Rate - OECD Compliance Cost



Sensitivity to Discount Rate - Rest of Annex B Revenue

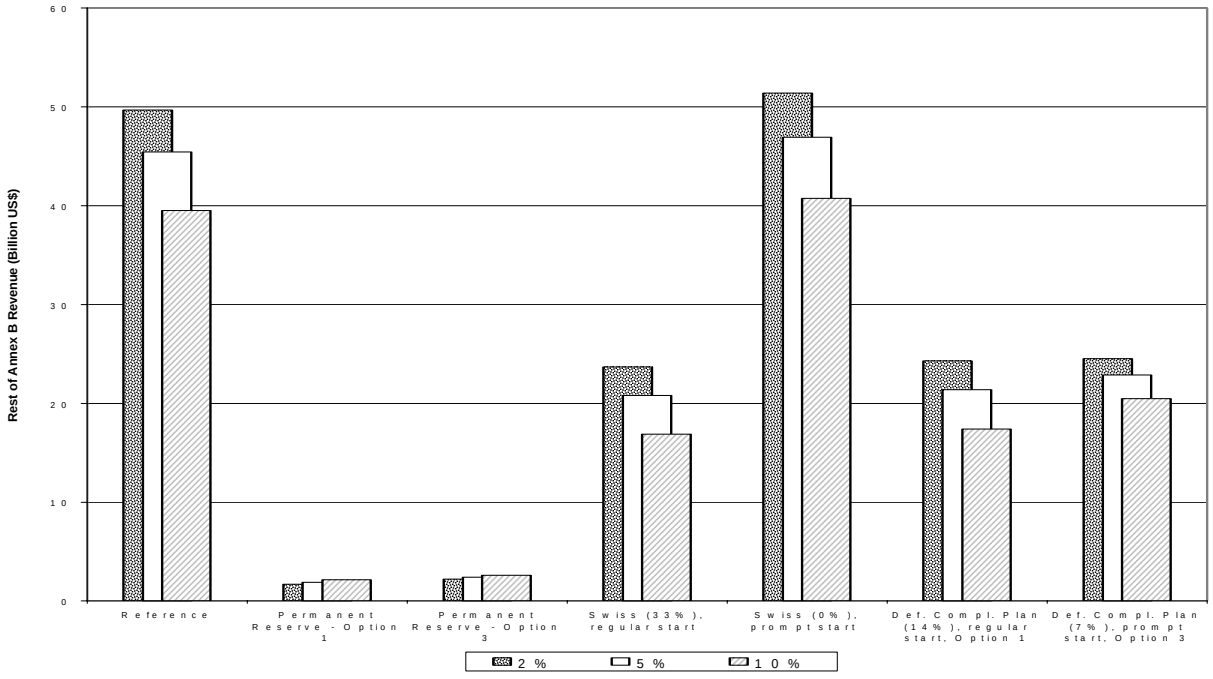
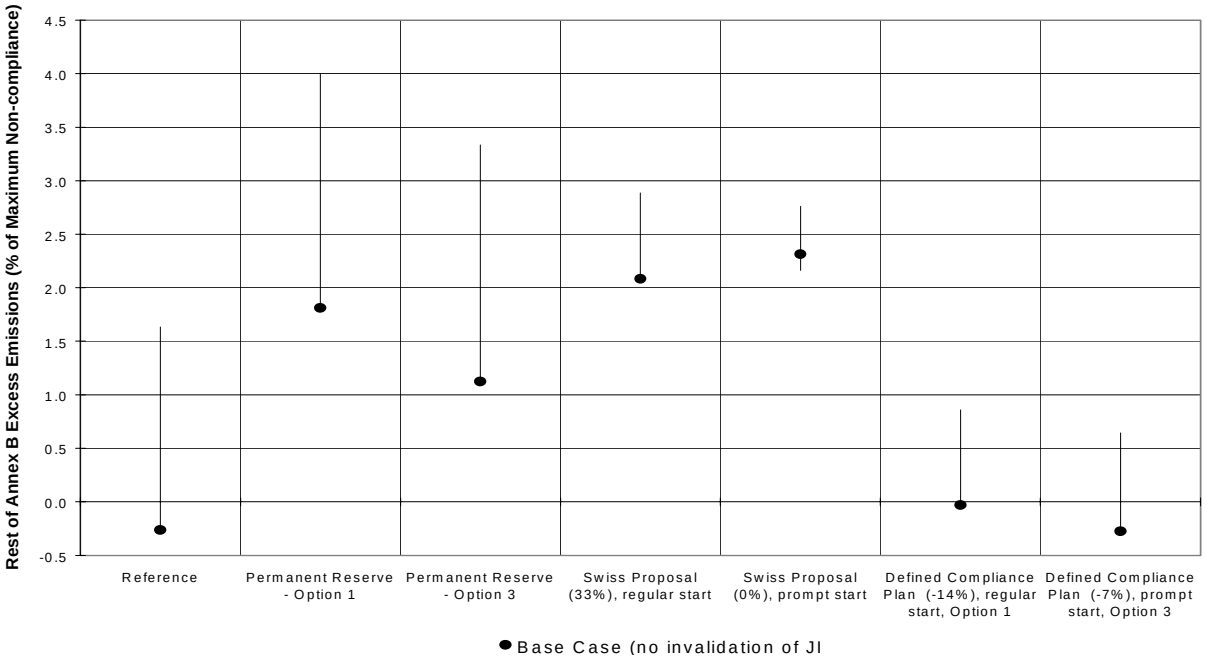


Figure 37
Impact of Making JI Quotas Subject to the Liability Proposal



The figure indicates that excluding ERUs from the liability provisions could increase non-compliance by the Annex B seller by 1% to 2%. This result assumes that JI projects represent 25% of the potential emission reductions in Annex B countries. If a higher share of the potential reductions is implemented as JI projects, the possible scale of non-compliance would increase accordingly. Thus, if JI projects accounted for 75% of the potential emission reductions, the possible scale of non-compliance would increase to 3% to 6%.

The possibility of non-compliance in the range of 1% to 6% suggests that ERUs should be made subject to the same liability provisions as AAUs if the decision on the quantity of ERUs awarded is left entirely to the host government.

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