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The Economics of a Lost Deal :

Kyoto - The Hague - Marrakesh

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Published in The Energy Journal*, volume 23, number 3, July 2002.*

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Abstract

This paper examines prospects for compromise between competing perspectives on four key climate change issues: costs, level of domestic action, environmental integrity, and developing world involvement. It focuses on the policy issues stemming from the uncertainty about abatement costs. Based on extensive simulations of a model integration tool, SAP12 (Stochastic Assessment of Climate Policies, 12 models), the analysis considers options for fine-tuning the Kyoto Protocol, such as concrete ceilings or levies on carbon imports; "environmental restoration payments" to be made on excess emissions; and credits for sequestration activities in Annex B countries. It demonstrates that the restoration payment (implemented through a safety valve) emerges as a superior means of addressing the cost uncertainty issue. The paper concludes that had this approach been taken at the COP6 climate negotiations, there would have been substantial room for compromise on payments of $35 to $100 per ton of carbon. Examining the Marrakech climate accord, it derives some lessons for attempts at completing Kyoto's unfinished business or at moving on to a new framework.

Key Words: climate negotiations, 2010 carbon markets, uncertainty about abatement costs

JEL Classification Numbers: Q25; D74; D78; D80

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* This work builds on a series of workshops organized by the *Centre International de Recherche sur l'Environnement et le Développement* (CIRED) and Resources for the Future to bridge the gap between U.S. and European Union views about the Kyoto Protocol. The modeling tool providing numerical assessment was developed by Frédéric Ghersi during a stay at RFF supported by the French *Agence de l'Environnement et de la Maîtrise de l'Énergie* (ADEME). The authors gratefully acknowledge helpful contributions by Henry Jacoby, Franck Lecocq, Richard Morgenstern, Michael Toman and three anonymous referees.

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Introduction

Many explanations can be given for the inconclusive outcome of the Sixth Conference of the Parties (COP6) to the United Nations Framework Convention on Climate Change (UNFCCC): diplomatic misconduct, cumbersome negotiation machinery, lack of political will,[1] or intrinsic defects of the Kyoto Protocol (Victor 2001). This paper builds on the intuition that, besides such factors, uncertainty about the costs of meeting the 2010 carbon emission targets already defined at the COP3 Kyoto negotiations fueled the main controversies that blocked the agreement. It demonstrates that, on pure economic considerations, a compromise might have been reached, and derives some lessons for attempts at completing "Kyoto's unfinished business" (Jacoby et al. 1998) after the Marrakech accord or at moving on to a new framework.

If we view the information from the Energy Journal Kyoto Special Issue (Weyant and Hill 1999) as representative of the expertise available in the year 2000, the marginal cost of meeting Kyoto targets ranges from \$21 to \$225 a ton[2] in case of Annex B trading.[3] In contrast, Annex B carbon abatement requirements show much less variation across the models.[4] This degree of cost uncertainty has fueled two opposite concerns. The European insistence that flexibility mechanisms be supplemental to domestic carbon abatement action, leading to the advocacy of a "supplementarity condition" under Article 17bis, stemmed from the fear that

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[1] For an overview of a European Union perspective, see Gupta and Grubb (2000) and Metz and Gupta (2001).

[2] Throughout this paper, marginal costs are \$1990 U.S. per metric ton of carbon in 2010.

[3] Throughout this paper Annex B and article numbers refer to Annex B and articles of the Kyoto Protocol (UNFCCC 1997).

[4] The five standard deviations across models of reductions required—"business as usual" 2010 emissions minus Kyoto targets—for five Annex B-covering zones (see below) range only from 3 to 13 % of their averages, while the slopes of linear approximations of the abatement cost curves show a standard deviation of 60 to 100%: the uncertainty on responses to a given price signal seems to significantly exceed the one about baseline emissions.

because of low abatement costs and the excess emissions quotas assigned to Russia and Ukraine, carbon prices with unlimited Annex B trading might not reflect the long-term value of a significant carbon constraint (Ha-Duong et al. 1999); in other words, carbon trading might become a way of escaping real efforts. The opposite concern was expressed by Japan, the United States, Canada, Australia, and New Zealand (JUSCANZ): that the costs of meeting the Kyoto commitments could be high enough to undermine the economic and political viability of the system. It lead the JUSCANZ group to question the Kyoto targets, at least implicitly, and to advocate options for hedging against the risks of excessive costs.

To analyze the effects of cost uncertainty on potential Kyoto outcomes, we developed SAP12 (Stochastic Assessment of Climate Policies), a model integration tool incorporating harmonized reduced forms of twelve global climate-economy models. The models encompass various degrees of optimism and pessimism about key factors underpinning negotiation stances. Policymakers have valid reasons for regarding the distribution of these models' results as representing the uncertainties found in the real world (rather than considering each of them as an independent best guess).[5]. This is why, despite some Delphi process in the runs used to produce our reduced forms, a probabilistic interpretation of SAP 12 results can be given in the form of “likelihood ranges” (see Box 1).

Using 1999 data, SAP 12 enabled us to analyze different packages of negotiation options under different values of such parameters as compliance payments, supplementarity constraints, "share of the proceeds" paid to developing countries, and carbon sequestration, with a view to delineating the range of possible compromise positions provided by the packages given competing views at COP6. Incorporating the latest information about emissions trajectories, SAP 12 also made it possible to analyze whether the subsequent Marrakech accord responds to the main concerns pervading the COP6 negotiations.

[5] Unless otherwise stated, the results reported below assume equiprobability between models.

We first clarify some conceptual ambiguities about compliance costs and explain why the supplementarity quarrel cannot be treated independently of the content of compliance systems. The second section, focusing on environmental performance and costs of different policy options, delineates the range for possible compromise among Annex B (developed) countries, excluding extended sequestration activities under Article 3.4. The third section compares such possible compromises with those including the expanded sequestration option, and the fourth section examines the potential financial flows to the developing world. A final section demonstrates that the Marrakech accord, the new benchmark of climate policy discussions, leaves unresolved the key structural questions of the climate policy regime.

1. Conceptual Ambiguities behind the Negotiations

The pre-COP6 process was shaped by divergences among Annex B countries on compliance costs and supplementarity, divergences that overshadowed more fundamental long-run contradictions between the Annex B and G77 groups. The failure to narrow these divergences was due, in part, to the very negotiation language—casual rhetorical compromises that blurred real economic issues. A detour through some conceptual clarification is thus necessary to minimize the risks of repeating such rhetorical deadlocks.

1.1. The Main Dividing Line: Compliance Costs and Supplementarity

The concern behind the supplementarity condition can be introduced by noting that six of the SAP12 models give a 2010 price lower than $30 per metric ton of carbon (/tC) for full Kyoto compliance if all Kyoto flexibility mechanisms are implemented: credit trading and project-based joint implementation (JI) among Annex B (developed) countries; and project-based Clean Development Mechanism (CDM) with non-Annex B (developing) countries. These results are all the more significant in that they do not incorporate the further price-deflating effect of carbon sinks. Arguably, such low carbon price levels may fail to create the appropriate incentives for longer-term infrastructure adaptation and research and development, and thus may make ambitious targets beyond the first commitment period much more costly (Lecocq et al. 1998). Similarly, percentages of domestic abatement on total abatement required for full compliance as low as 16–45% in the United States, 12–32% in the European Union, and 10–28% in Japan with full global trading might fail to trigger significant learning-by-doing in carbon abatement.

The model integration tool SAP12 (Stochastic Assessment of Policy, 12 models) incorporates reduced forms of the marginal abatement cost curves of 12 major climate-economy models. The curves are constructed by backward calibration from data published in *The Energy Journal* Kyoto Special Issue (Weyant and Hill 1999) for 10 of them and from the modelers themselves for POLES and WAGEM. Five of these models are American (MERGE 3.0, MIT-EPPA, MS-MRT, RICE and SGM), two Australian (ABARE-GTEM and G-Cubed), one Japanese (AIM) and four European (Oxford Model, POLES, WAGEM and Worldscan). All models were peer-reviewed either by members of the Stanford Energy Modeling Forum or by the International Panel on Climate Change for its *Third Assessment Report* (IPCC 2001).

Given the available data, calibration has been made in a consistent manner for four zones—the European Union, the United States, Japan, and the remaining non-Eastern European Annex B countries in the CANZ group. With simple assumptions, curves were then derived for the Economies in Transition (EIT) and the Clean Development Mechanism (CDM) potential from the Annex B- and Global trading equilibria. For a given model, the resulting set of six curves allows the computation of a market equilibrium under various assumptions regarding the implementation of the flexibility mechanisms.

Note that the resulting marginal costs correspond to levels of lump-sum recycled carbon taxes inducing a given abatement. Thus, they embody not only assumptions about technical costs but also the macroeconomic feedbacks as described in each model. Accordingly, “Total costs” are derived by integrating below the curves for domestic costs and adding the volume of imports priced at the international equilibrium price (all runs suppose an international market of emissions credits resulting from the three flexibility mechanisms).

The underlying methodology is grounded in the premise that policymakers can interpret the variance in results from the 12 models as revealing uncertainty in the real world regarding key parameters of cost assessment, such as technical change and behavioral reactions to policy signals. A conventional stochastic treatment is thus applied:

SAP12 runs each of the models separately and provides an expected value of basic economic and environmental indicators for the policy packages tested. Perhaps more importantly, we derive from its comprehensive results (a) the percentage of chance for each indicator to be above or below a certain value, given some subjective probability attached to the results of each model (in most of the runs we will assume equiprobability or an equal level of confidence); and (b) the likelihood ranges, used for most of the results reported, whose bounds are the average of the 12 results minus and plus the standard deviation observed: a 16–45% domestic action in a region under a given policy means a 30.5% average, with a 15.5% standard deviation.

A detailed technical description of SAP12, with full reference to the models listed, is available at http://www.centre-cired.fr/actualite/SAPdesc.pdf

Box 1. Model integration tool.

In May 1999, to address these concerns, the European Council of Environmental Ministers proposed concrete ceilings to limit carbon imports under Kyoto flexibility mechanisms according to two alternative formulas,[6] plus a “however” clause resulting *de facto* in a 50% ceiling. Pronk’s package[7] avoided such numerical precision, stating that parties “shall meet their emission commitments *primarily* through domestic action since 1990”, but it was interpreted by JUSCANZ delegations as an implicit 50% ceiling.

The results of the SAP 12 models also fuel concerns about excessive compliance costs. In a no-trade case, carbon prices higher than $250/tC are given by 33% of the models for the United States and the European Union, and 67% for Japan. Simulating a "full-trade" (all flexibility mechanisms implemented) scenario significantly lowers the cost range: only one model gives an international carbon price higher than $100/tC. However, as Weyant and Hill (1999) point out, carbon markets may not operate perfectly and gains from the three flexibility mechanisms can be reduced by administrative costs, costs of monitoring, or particularly of project selection and certification for JI and the CDM. Thus, a set of realistic (some will say optimistic) assumptions regarding transaction costs[8] results in a 50% chance (based on the SAP 12 results) that the international carbon price will exceed $100/tC.

To mitigate cost concerns, two alternative approaches have been advocated:

- A predetermined dollar-per-ton payment by which parties can cover their excess emissions and stay in compliance (Kopp et al. 1997). Such a provision creates a "safety valve" against excessive marginal costs while still allowing for the possibility that the Kyoto objectives be met cheaply, thus shifting from the strict quantity approach of

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[6] Net carbon importers must respect the least constraining of two ceilings: option A, 5% of the average between five times their base-year emissions and their assigned amount; and option B, 50% of the difference between five times their emissions in any given year between 1994 and 2002 and their assigned amount. But they can benefit from the “however” clause. Net exporters are subject to the 5% limit without alternative.

[7] We define “Pronk’s package” as the document distributed at the Hague by Jan Pronk, president of COP6, titled *Note by the President of COP6—23 November 2000* (UNFCCC 2000, p.4).

[8] All of the SAP12 results reported in this text use an identical quantity approach to those costs: export volumes were reduced to two-thirds of their unconstrained full-trade level for the Economies In Transition (EIT), and to one-fourth for the Rest of the World—a figure slightly higher than the 15% retained in Weyant and Hill (1999) for the share of the CDM potential likely to concretize. EIT and CDM cost curves were reassessed accordingly.

assigned targets to a hybrid quantity-price approach. The original proposal was refined into a "restoration payment", with the funds collected—either by a national authority, or by an international body, the choice resulting from a political bargain—recycled in further abatement during a “true-up” period through a reverse auction mechanism[9] (CIRED-RFF 2000).

- The extension of carbon sequestrating activities eligible under Article 3.4, which increases the availability of “cheap” tons in Annex B countries.

Typical of the difficulty in crossing the political dividing lines within Annex B, those options were perceived by the European Union as reducing domestic action in the energy sector and thus exacerbating the supplementarity concern. However, the second approach keeps within a strict quantity-based instrument pool and simply changes the accounting rules, while the first approach combines quantitative targets with a hedging mechanism.

1.2. Private and Social Costs: The Overlooked Distinction

Controversies about the level of compliance costs often ignore the distinction between net total social costs and carbon prices. High carbon prices may indeed prove politically problematic, increasing the prospect for compliance default if they exceed the willingness of energy consumers to pay for climate mitigation.[10] Extensive experience demonstrates that energy consumers are much more sensitive to the gross signal of energy prices than to the net impact including less tangible economy-wide compensating effects, such as the recycling of the proceeds of a carbon tax or auctioned tradable emissions permits. This is why motorists or

[9] In a reverse auction, each project is proposed at a given price per ton of carbon, but all the selected projects will receive the same price. The tonnage of selected projects valued at this price clears the collected funds; to be selected, a project must be priced lower than the clearing price.

[10] We do not strictly use the notion of “willingness to pay” in the classical sense of revealed preference for the benefits of long-term greenhouse gas abatement. Rather, we refer to a political limit on the willingness to bear a certain level of short-term cost for precaution. Note that the latter notion may well be less restrictive than the former, which available empirical studies set at a level much lower than those we consider in this text.

carbon-intensive industry can block measures like environmental fiscal reforms, even though these measures are supposedly Pareto-improving in specific circumstances.

As noted earlier, carbon prices may be high in certain circumstances, provided they equate the marginal cost of carbon control. However, Working Group III of the Intergovernmental Panel on Climate Change Third Assessment (IPCC 2001) indicates that the total social cost of carbon control may be more tolerable: gross domestic product losses for meeting Kyoto targets would range between 0.2% and 2% in a no-trade case and in the absence of carbon sequestration; they could be halved through the Kyoto flexibility mechanisms within Annex B, and could even be lower through use of the CDM or possibly turn into a gain, with a judicious use of revenue-raising instruments[11].

Governments seeking to stay in compliance even with high carbon prices could "socialize" compliance costs by funding carbon permit imports through public expenses, rather than letting energy prices bear the full brunt of the carbon constraint. However, annual carbon imports reaching billions of dollars[12] would affect trade balances,[13] and the concentration of these transfers to one or two main carbon permit exporters might entail unacceptable geopolitical risks. The only alternative is a subsidy to domestic abatement. Ultimately though, both options entail higher welfare costs than a purely price-triggered compliance.

1.3. Paradoxes Regarding Compliance Systems

At COP6, Pronk's package proposed that excess emissions in the first compliance period be subtracted from the second budget period quota negotiated in 2005, with a 1.5 penalty factor

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[11] The IPPC WG III report underscores some limitations in these findings, in particular the fact that simulations are made under the assumption that markets operate perfectly and that savings from carbon markets and from tax recycling are not systematically additive. What matters though is the fact that the aggregate macroeconomic costs can be viewed as moderate in policy debates, while the marginal costs reach more striking figures.

[12] 8–22, 4–26, and 2–11 billions of 1990 U.S. dollars annually for the European Union, the United States, and Japan, respectively, under a full-trade, full-compliance hypothesis, including transaction costs.

[13] Models representing trade and capital flows point out the impact of transfers on the exchange rates of currencies (McKibbin et al. 1998).

that should “be increased by 0.25 after the subsequent commitment period [if still needed].” In economic terms this constitutes a *borrowing facility* with the penalty as an interest rate. However, this form of compliance payment will not be effective in practice given the Kyoto system. Consider a country whose consumers show a political willingness to bear a $100/tC carbon price, while full compliance requires a $150/tC carbon price. Under the threat of (say) a $200/tC compliance penalty, a government acting in good faith will use public funds to support domestic action and pay for imports at $150/tC rather than risk the $200/tC penalty. Conversely, a bad-faith government—having taken the risk of deliberate noncompliance facing a $150/tC price rather than confront its taxpayers—will logically not change its position for a $200/tC payment.

In fact, any economically credible compliance system would require a threat beyond the internal rules of UNFCCC. An obvious solution would be the World Trade Organization (WTO) legitimating trade barriers against countries not in compliance with global environmental treaties. But because a linkage between UNFCCC and WTO has not been considered so far, an option of Pronk’s sort appears the only possible compliance provision.

This has a critical implication for the benchmark with which negotiation packages should be compared. A scenario in which governments socialize the costs of meeting the targets regardless of their extent assumes a form of “Candide” conduct.[14] A more realistic assumption is that even good-faith governments will take full advantage of the flexibility in legal provisions.

1.4. The Real Terms of the Supplementarity Problem

The preceding sections force reconsideration of the terms of the supplementarity quarrel.

[14] Candide is a character from Voltaire, a naïve young man who, though a repeated victim of the common flaws of human nature, sticks to the very end to his overly optimistic mentor’s teaching that “everything is the best in the best of the world”—that is, everybody’s conduct is good-faith conduct.

First, the transaction costs associated with CDM credits raise the international carbon price and thus considerably reduce the prospect that a 50% limit on carbon imports would be breached. SAP 12 model results shown in Table 1 (columns 1 and 2) indicate this prospect disappears altogether for the United States, seems low for the European Union, and is significant only for Japan—an unsurprising result, since all models reveal a steeper marginal cost curve in Japan than in the other zones. Second, governments may consider the hidden cost of foreign carbon payments, including terms of trade concerns and geopolitical concerns about large transfers concentrated on one or two exporters. Column 3 in Table 1 provides results assuming a 30 percent hidden cost multiplier,[15] in which case domestic action very likely will exceed the symbolic 50%. A closer scrutiny of detailed results gives a 100%, 92%, and 42% probability for such an outcome for the United States, Europe, and Japan, respectively. Third, these odds are even higher if one accounts for the possibility of substantial exercise of market power by an EIT coalition (column 4),[16] although their market power is limited by the competing supply from CDM projects.

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[15] This value, commonly found in macroeconomic literature (CGP 1984), is purely indicative. It should be differentiated according to importing zones and their geopolitical concerns. Note that the existence of the hot air moderates the impact of the shadow price of imports : consider one importer with target T and abatement cost $p=aA$, and an exporter with abatement cost $p=b(I-H)$, where H is hot air. Compliance yields $\frac{\partial A/T}{\partial b} = \frac{T-H}{T}\frac{a}{(a+b)^2}$ and a variation in b (e.g., including the shadow cost of imports) has little impact on domestic abatement.

[16] The impacts of EIT forming a coalition were modeled assuming EIT acted as a Stackelberg leader in the emission credit market, setting their profit-maximizing sale volume with perfect knowledge of abating potentials in other zones. The profit maximization is static, disregarding speculations about future carbon prices and the resulting potential banking of EIT credits.

	"Full Trade" w/o transaction costs	"Full Trade" with transaction costs,...	...a 1.3 shadow price of the currency,...	...and the EIT Stackelberg leader
European Union	12–32%	43–65%	45–68%	47–71%
United States	16–45%	58–85%	61–89%	64–91%
Japan	10–28%	33–55%	35–58%	36–59%
Market price	$6–74	$39–204	$32–169	$34–176

Table 1. Share of required abatement operated domestically (domestic abatement) under full compliance.

It thus appears that the supplementarity issue vanishes as more realistic assumptions are made regarding market conditions, provided the CDM does not encompass a large amount of sequestration. However, the issue resurfaces through a different channel: Table 2 displays how domestic action drops if one makes the realistic assumption that governments take advantage of the possibility of postponing abatements in the face of politically uncomfortable carbon prices. Three levels of Annex B-wide political threshold prices are considered here, $50/tC, $75/tC, and $100/tC. The contraction of domestic abatement is striking: if the EIT do not form a coalition the expected value of domestic action falls below 50% for the European Union under a threshold price as high as $100/tC. At $50/tC WP, the expected value falls below 50% for the United States too, as does the entire likelihood interval for the European Union and Japan. The ability to postpone abatement is thus confirmed as a major threat to significant domestic effort. The assumption of EIT market power does not significantly change this result.[17]

[17] In Table 2 as in others below, the O (oligopoly) row in italic and light script assumes the EIT exert their market power (cf. footnote 16), as opposed to the C (competition) row.

		Candide (No postponement)	With postponement... ...beyond $50	...beyond $75	...beyond $100
European Union	C	43–65%	22–43%	30–53%	34–59%
	O	*44–68%*	*22–43%*	*30–53%*	*35–61%*
United States	C	58–85%	27–65%	39–74%	47–78%
	O	*61–87%*	*27–66%*	*39–75%*	*48–80%*
Japan	C	33–55%	15–41%	21–48%	26–51%
	O	*34–57%*	*15–41%*	*21–49%*	*26–52%*
Market price	C	$39–204	$47–52	$59–80	$64–105
	O	*$41–215*	*$47–52*	*$60–80*	*$66–106*

Table 2. Domestic abatement under limited willingness to pay (WP) (without shadow cost of imports).[18]

2. Annex B Compromise Space *without* Extended Activities under Article 3.4

Let us now turn to the analysis of various compromise packages. Among these packages, we consider two options addressing the criticism that a concrete ceiling exacerbates risks of excessively high compliance costs: as an amendment, a waiver that operates when domestic costs exceed a given level; and as a substitute, a per-ton import charge levied by parties on their acquired emissions credits. For the sake of clarity, we report results under Candide conduct (complete compliance, no postponement) before those with more realistic behavioral assumptions.

2.1. Supplementarity and Compliance Costs under Candide Conduct

We first analyze the consequences for supplementarity of a 50% concrete ceiling on buyers.[19] Regardless of a possible EIT coalition, such a condition has a significant impact only on Japan, restraining its imports for seven of the SAP12 models. Table 3 displays a lower-bound increase of 12 percentage points for Japanese domestic action. The increase is only 4% for

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[18] The shadow costs of imports are drastically lower than in the Candide case because beyond a certain price per ton, postponements have been substituted for imports.

[19] The proposition of a concrete ceiling on sellers was soon dropped because it gives market power to carbon exporters, with results (not reported here) similar to those assuming the EIT exert their market power. The 50% ceiling or "however clause" is, however, a more lax constraint than option A (see footnote 6) in all cases, and more lax than option B in 46 of 48 cases, the only exceptions being the United States and CANZ group in one scenario. Estimates for option B are derived from Baron et al. (1999).

Europe, but the United States shows a decrease: reduced Japanese demand results in a slight decrease in international carbon prices, causing those countries or zones with marginal costs not constrained by the ceiling to increase their imports. All in all, with a competitive market, a 50% condition increases Annex B abatement by an average of only 3.7 MtC. If the EIT form a coalition, Annex B abatement is even more stable, showing a 2.0 MtC increase.

		Unrestricted compliance	50% concrete ceiling	50% ceiling + waiver $75	50% ceiling + waiver $100
European Union	C	45–68%	49–66%	47–68%	49–67%
	O	*47–71%*	*50–69%*	*47–70%*	*50–70%*
United States	C	61–89%	60–88%	61–89%	61–88%
	O	*64–91%*	*63–89%*	*64–90%*	*63–90%*
Japan	C	35–58%	47–57%	37–58%	39–58%
	O	*36–59%*	*48–58%*	*39–59%*	*40–59%*
Market price	C	$32–169	$30–168	$32–169	$31–168
	O	*$34–176*	*$32–175*	*$33–176*	*$33–176*

Table 3. Percentage of domestic abatement with European ceilings on buyers.

The deflating effect on carbon prices explains why the likelihood range of total compliance costs (domestic abatement expenditures plus carbon imports) does not change for the European Union, increases only by 3.8–3.1% in Japan, but decreases by 4.2–0.4% for the United States.[20]

These findings suggest that the dispute about a concrete ceiling is mostly rhetoric under a Candide-conduct assumption: the option dramatically increases neither domestic action, as hoped by its proponents, nor the total burden, as feared by its detractors. Rather, it has the paradoxical but explicable outcome of placing more burden on Japan and making the United States better off.

The span of the discrepancy between the constrained and unconstrained scenarios explains why adding a waiver to the concrete ceiling has little numerical impact: it decreases

[20] For detailed results on costs see Table 3b under http://www.centre-cired.fr/actualite/site_cired.htm. An EIT coalition has a strong impact on them: imposing a ceiling on imports forces a form of collusive action that benefits the importers (Ellermann and Wing 1999). Lower bounds for total costs decrease by as much as 15.9% (for the United States), higher bounds by 11.2% (for the European Union), falling back to levels very close to those assuming perfect competition in carbon markets.

both the extra burden for Japan and the United States gain. However, the total of domestic abatement in the importing parties increases only by an average 0.4% for a $100/tC waiver.

The economic logic of an import charge is different, since it necessarily increases domestic effort in all countries for all scenarios—the paradox that occurred with ceilings regarding the United States disappears. However, its effect vis-à-vis supplementarity is significant only with high charges: the overall improvement is a 0.8–1.1% shift with a $5/tC charge, and 2.0–2.3% and 3.4–3.4% shifts for $10/tC and $15/tC, respectively. Still, this is superior to the 0.2–0.4% obtained under a concrete ceiling plus a $100/tC waiver.[21]

2.2. Supplementarity and Compliance Costs under Realistic Behavior

Let us now turn to the assumption that even good-faith parties, facing a limit on their consumers' willingness to pay, will take advantage of the compliance provision of Pronk's package by postponing abatements that would imply too high domestic energy prices.

2.2.1. Ineffective Supplementarity Tools

Under this assumption, neither a 50% concrete ceiling nor an import charge significantly increase domestic abatement, regardless of whether the EIT form a coalition or not:

- A 50% concrete ceiling operates only in zones or countries that simultaneously have a domestic effort below this level *and* face a compliance carbon price lower than the consumers' willingness to pay. With a $100/tC WP, these conditions occur in 9 cases of 48, and under a $50/tC WP, in 2 cases. The largest upward shift of the likelihood interval for the Japanese domestic effort occurs at $100/tC WP, but it is offset by the opposite impact on the United States, because of the price deflation in the international carbon market explained above. On average, the total tonnage of domestic abatement in the

[21] This modest result is due to transaction costs impairing the flexibility mechanisms. The impact would be more substantial with high amounts of cheap sequestration in the CDM. For detailed results see Table 3c. under http://www.centre-cired.fr/actualite/site_cired.htm.

importing zones shifts only by 0.2%, 0.5%, and 0.8% for WP of $50/tC, $75/tC, and $100/tC, respectively.

- An import charge increases domestic abatement only when the carbon price is lower than the WP: a $10 charge over a $100/tC WP causes a 3 percentage point shift in the likelihood range for domestic abatement for all zones. However, when the WP is binding, imports cease at a marginal price equal to the WP minus the import charge. Thus total abatement decreases, since domestic abatement is unchanged.

2.2.2. The Supplementarity Effect of Restoration Payments

A restoration payment (RP) set at the same level as the WP of private agents dramatically increases the risk of excessive foreign transfers for importing countries: even if the funds are collected nationally, the cheaper projects selected through a reverse auction (see footnote 9) will likely be in developing countries, Russia, and Ukraine. As stated earlier, it is impossible to predict how the shadow price of carbon imports considered in public policies might evolve. We can say that the multiplier associated with the cost of carbon permit imports that equates the total foreign transfers under an RP regime to those obtained without such payments and a zero shadow cost of carbon imports is 2.4 to 3.7 for a $50/tC RP and still 1.4 to 1.7 for a $100/tC RP.

Table 4 indicates the order of magnitude of how a 1.3 multiplier[22] applied by all Annex B zones affects domestic action. Compared with Table 2, likelihood intervals for domestic abatement shift upward by 3% to 10%. The same supplementarity effect appears in the tonnages of domestic abatement by importing zones, with 24–16%, 19–11%, and 11–7% increases for $50/tC, $75/tC, and $100/tC WP, respectively.

[22] Contrary to the Candide case, under a restoration payment a shadow price will necessarily induce increased public spending—subsidies to carbon-efficient technologies, investment in infrastructures—since any diminution of the imports through a tax would be exactly compensated for by increased restoration payments.

		RP $50	RP $75	RP $100
European Union	C	28–50%	35–61%	38–65%
	O	*27–51%*	*35–62%*	*39–67%*
United States	C	34–75%	47–81%	53–82%
	O	*34–75%*	*47–83%*	*54–84%*
Japan	C	18–47%	26–52%	29–54%
	O	*18–48%*	*26–53%*	*30–55%*
Market price	C	$44–53	$52–80	$53–98
	O	*$44–53*	*$53–81*	*$55–100*

Table 4. Domestic effort under restoration payments with 1.3 shadow cost of imports.[23]

Of course, this higher domestic abatement, while maintaining the level of marginal effort, comes at some expense in terms of total costs—all the more so when the WP is low, since it implies a greater number of tons to be covered by the RP. On average, total costs of importing zones increase by 70%, 36%, and 17% for a $50/tC, $75/tC, and $100/tC RP, respectively. This is significant compared with a scenario with no compliance payment. However, it does not contradict the purpose of the restoration payment, since it lowers costs by 44%, 28%, and 19% compared with a Candide full-compliance scenario.

A restoration payment thus significantly makes up for the absence of compliance payments or of border taxes on non-complying countries: good-faith governments can guarantee consumers a maximum energy price increase and have a rational incentive to adopt public policies to attenuate both geopolitical risks and the pressure on their current account, without incurring a dramatic additional macroeconomic burden. Devised to address the concerns of the pessimists on costs, this tool is demonstrated also to be useful in promoting domestic action.

Perhaps more importantly, the distinction between a good-faith and a bad-faith government will immediately be apparent, since the latter will not make the restoration payment. In its absence, on the other hand, both types are indistinguishable at the start (both use the

[23] Again, the EIT's behavior does not impact on results in a significant way. This is true of most of the market configurations in which CDM projects restrict the scope for oligopolistic behavior. From this point onward, for the sake of clarity and space, we will stop reporting and commenting on the coalition case, turning back to them only when we assess the Marrakech accord.

postponement capability). In the long run a bad-faith government will act only if the political cost of its cumulative environmental debt becomes significant, though as the total postponed tonnage reaches excessively high levels, the debt will be downgraded and the corresponding abatement definitively abandoned. This outcome is observed repeatedly in the case of conventional economic debt, so there is no reason why it should not occur in the case of an environmental debt.

2.3. Environmental Assessment of Compromise Packages

Despite the significant supplementarity effect of a restoration payment, it is still uncertain whether any particular price cap would be acceptable to those who seek environmental integrity as well as to those who emphasize cost control.

Judgment on environmental integrity under a non-Candide scenario depends on the level of confidence attached to the making up of postponed abatement. One easy indicator of the risk of ultimate default is the total tonnage postponed: 291 MtC under a $50/tC WP, and still 104 MtC for a $100/tC WP (with upper bounds of 741 and 572 MtC, respectively), when the likelihood range of the overall abatement required to meet the Kyoto targets is 810–1,077 MtC.[24]

As noted earlier, none of the supplementarity tools envisaged improve significantly upon this result, whereas a restoration payment lowers the risks of endlessly postponed abatement by prepaying part of the restoration. However, placing an upper bound on carbon prices comes at the expense of a gap between targeted and real environmental performance. A measure of this gap is shown in Figure 1, which displays the likelihood interval (shaded boxes), extreme bounds (dashes) and median values (crosses) of emissions for various levels of willingness to pay with and without the RP.

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[24] Those figures stand regardless of the EIT's market power: either the WP is binding in the competitive equilibrium and it is too in the oligopolistic case; or it is not, and remains so in the oligopolistic case because of the CDM competition. In the latter case, abatement in the importing zones is simply substituted to abatement by the EIT.

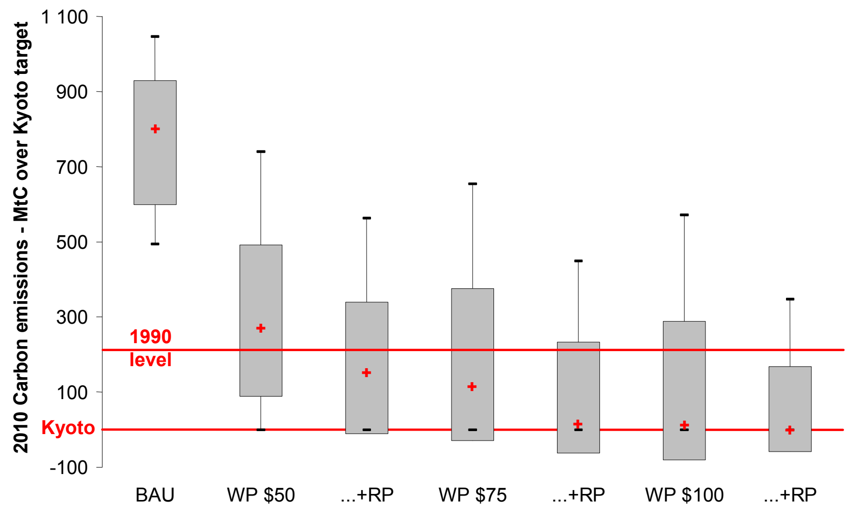

Figure 1. Effect of restoration payments on environmental integrity.[25]

The gain from an RP provision can be seen from the downward shift of the likelihood intervals of environmental performance for various levels of willingness to pay. A $100/tC RP secures a high probability of meeting the Kyoto targets, and the chance is still 50% with a $75/tC RP (the median is close to the Kyoto level).[26] With a $50/tC RP there is still a good chance of abating to 1990 levels, but meeting the targets is much more uncertain (25%). It follows that a negotiable range of RP levels could be between $75 and $100 per ton. Although this is not a very wide range, it can be enlarged from two perspectives.

First, to facilitate full ratification, abatement objectives more lax than the Kyoto targets might be accepted. For example, Dominique Voynet, France's environment minister, declared: "...what really matters: to begin reducing emissions.... starting from there, the reduction level, be it 1% or 5%, is not essential" (*Le Monde* 21 April 2001). The 1% reduction could correspond to a stabilization of emissions from the energy sectors at 1990 levels plus a 1% sequestration by

[25] Again, the results presented do not depend on whether the EIT exert their market power or not (see footnote 23).

[26] The extension of some likelihood intervals beyond the Kyoto targets is a pure artefact. Models do not consider any sort of overshooting, and the fact that the standard deviation around the expected value reaches below Kyoto simply indicates that the underlying probability distribution is biased in that direction.

carbon sinks.[27] Following Figure 1 it would be consistent with a \$50/tC RP, and indeed even with a \$35 level—the lower limit for a 50% chance of reaching the redefined target.

A second perspective assumes that the European Union is consistent with its concerns about low prices and gives more credibility to optimistic models. Table 5 displays how probabilities of reaching both Kyoto and 1990 levels evolve from a neutral stance to an optimistic stance, obtained by weighting model results before averaging them, with the following multipliers: 1 for the four most pessimistic model results, 2 for the four medium, and 3 for the remaining four.

	Neutral stance		Optimistic stance	
	Models reaching Kyoto commitments	Models keeping emissions below 1990 levels	Models reaching Kyoto commitments	Models keeping emissions below 1990 levels
RP \$35	8%	50%	13%	67%
RP \$50	25%	75%	50%	83%
RP \$75	50%	83%	67%	92%
RP \$100	75%	83%	83%	92%

Table 5. Distribution of modeling results on environmental integrity under a restoration payment.

Chances of meeting the Kyoto targets with a \$50/tC RP switch from 25% to 50%, with the more lax target quite guaranteed (83% chance). Besides, the \$35/tC level yields a 67% chance of meeting the relaxed target, and the odds of meeting the Kyoto targets improve slightly, from 8% to 17%.

3. Annex B Compromise Space with Sequestration under Article 3.4

Let us now turn to the option of increasing carbon sequestration in Annex B under Article 3.4. as a way to control compliance costs, alleviate the burden on the energy system and reduce the international transfers required for compliance.

[27] A 1% reduction below 1990 levels is still compatible with keeping greenhouse gas concentrations under a 450 ppm level (Ha-Duong et al. 1997, 1999).

To discuss this option as opposed to a restoration payment, we compared levels of both options leading to the same expected value of compliance costs. The cost of carbon sequestration is generally expected to be far lower than that of carbon abatement in the energy sector. However, there is a significant difference between engineering methods of cost-assessment lying behind available cost curves for sequestration potential under Article 3.3 (IPCC 2001), and approaches considering economic feedbacks, especially considering the actual behavior of landowners (Stavins 1999). Moreover, there are no data on sinks under Article 3.4. To avoid arbitrary assumptions that would blur the core of the argument, the estimated tonnages for different proposals were simply subtracted from the Kyoto targets to obtain the new level of abatement to be achieved in the energy sector. For the sake of simplicity we report only on the Umbrella proposal circulated during COP6, with the following tonnages estimated by French forestry experts: 13 MtC for the European Union, 115 for the United States, 4 for Japan, 21 for the EIT.

Under these assumptions, overall costs for the importing zones countries drop to $37.7 billion on average, a 40% decrease from their $67.7 billion full-compliance level. To achieve an equivalent (expected value) cost reduction, a restoration payment should be set at $54/tC.

3.1. Effect on Environmental Integrity and Supplementarity

Comparing the sequestration and RP options depends on three key policy judgments.[28] The first regards the integrity of postponed tons, which entirely depends on the credibility of their recovery during further commitment periods. The second regards sequestered tons: critics argue that they correspond to reductions that would have occurred anyway and/or that the

[28] The minimization of international transfers, correlated to the supplementarity condition, is not retained as a key to the comparison, being found of lesser significance: an overall $7.7–31.4B likelihood range for the Umbrella option is close enough to the $9.6–40.8B for the RP to justify an undifferentiated value for the shadow cost of imports.

underlying activities were not taken into account at Kyoto,[29] and that carbon sinks should not be given the same environmental value than non-emitted tons because of the uncertainty about the duration of the sequestration. Others oppose this critique and support the view that the IPCC Land Use, Land Use Change and Forestry special report gives far greater credence to the legitimacy of activities beyond those recognized in Article 3.3 if properly monitored and registered. The third policy judgment flows directly from the argument in favor of the supplementarity condition; it considers action in the energy sector indispensable to the long-term objective of climate control and minimizes sequestration, even if it takes place domestically.

We will not venture to settle these controversies but rather report on basic outcomes, leaving it to the readers to form their own judgments. This is why Figure 2 distinguishes among (a) domestic (energy sector) abatement, (b) genuine tons imported, (c) hot air tons imported, (d) tons abated during a true-up period through the restoration payments, (e) tons sequestered, and (f) tons postponed to a subsequent compliance period.

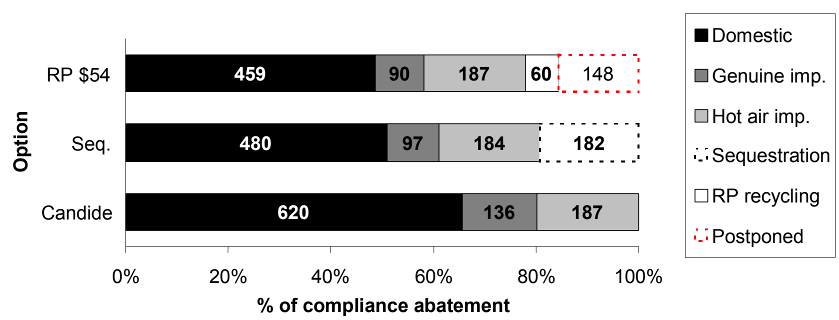

Figure 2. Split of annual abatement for the importing zones, Candide perspective.

Under Candide conduct, those who prioritize action on the energy sector (categories a, b, and d) give a slight advantage to the restoration payment, which guarantees 64.6% of the target, compared with 61.2% for the sequestration option. However, an equal expected value of expenses in both options masks the fact that under the sequestration option carbon prices can go

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[29] Note that the "hot air" does not induce the same problem: the larger its amount, the higher the emissions from importing countries, but without any effect on total Annex B emissions.

far beyond the \$54/tC limit set by the RP. This takes us back to the comparison between Candide and non-Candide conduct: under a \$75/tC limit on the WP the Umbrella proposal decreases the domestic and genuine imported tons, inducing 74 MtC of postponed abatement because the sequestration remains at the same level as without WP. Going down to a \$54/tC limit causes a postponement of 123 MtC, and action in energy sectors consecutively drops to 48.1% of Kyoto targets (Figure 3).

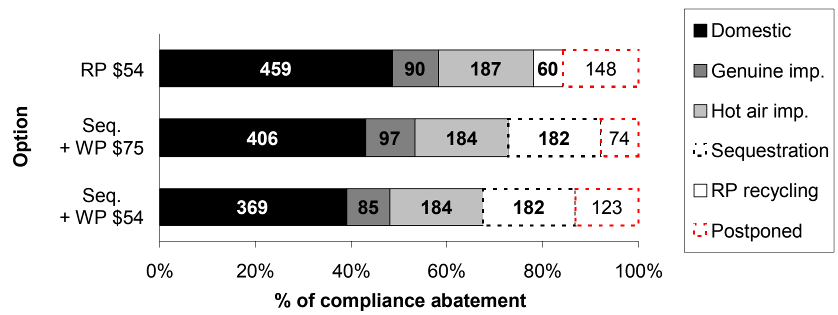

Figure 3. Split of annual abatement for the importing zones, realistic perspective.

3.2. Effects on Costs Uncertainty

The very principle of a restoration payment is to set an upper bound to the marginal cost to energy consumers. It is a different economic rationale than that of extended sequestration, which *de facto* amounts to a downward shift of all cost curves. For this reason the insights derived from Figure 4 are not surprising. But the order of magnitude of the difference between the two options in the likelihood interval of carbon prices is more striking. Figure 4 presents the modeling results in a format equivalent to the one used in Figure 1, for both the competitive (shaded box) and oligopolistic (non-shaded box) markets. In both cases the reduction in uncertainty is dramatically higher with an RP than with the sequestration proposal: the likelihood interval's width in the Candide scenario is reduced by 90% under the RP, compared with only 16% in the sequestration option.

We do not plot here the results in terms of total compliance costs, although the differences are of the same order of magnitude: sequestration produces a $13 billion to $63 billion likelihood interval, compared with $31 billion to $44 billion for the restoration payment.

Note that the lowest bound of carbon prices (and compliance costs) is higher with an RP than with an extended sequestration. This is because the $54/tC price cap is never reached in the very optimistic models and thus does not affect the results, whereas tons from sequestration shift the cost curves of every model in the same downward way, whatever their optimism on costs.

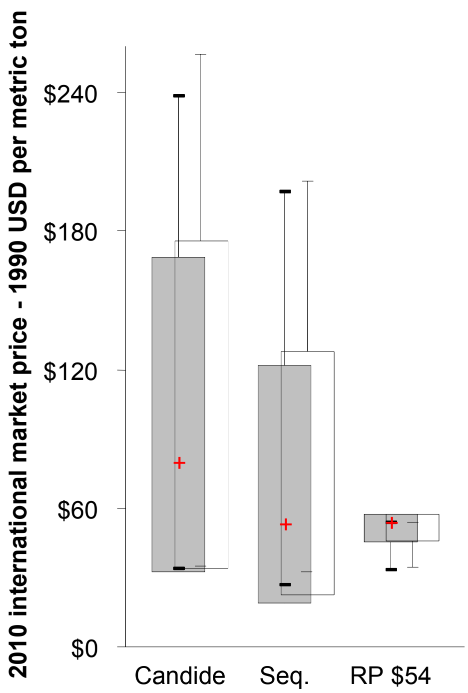

Figure 4. Sequestration vs. RP Effect on marginal prices

The policy implications from these results can be derived in two ways corresponding to the symmetrical and contradictory concerns about compliance costs:

- For a reduction of the expected value of compliance costs identical to the one obtained with a $54/tC restoration payment, extended sequestration is less efficient in allaying the concerns of pessimists about abatement costs. A closer scrutiny of modeling results reveals that the risks that carbon prices may exceed $120/tC and $90/tC are still 17% and 25%, regardless of a possible EIT coalition, while the RP guarantees a $54/tC level by definition.
- The difference in the lower bound of the likelihood intervals has a very important implication for minimizing risks of too-low price signals over the first budget period, which is the basic rationale behind the supplementarity condition. A $19/tC lower bound for carbon price under sequestration aggravates the deficit in supplementarity, compared with a $45/tC lower bound with a $54/tC price cap.

4. Effects on Developing Countries

COP-6 negotiations had to reconcile two contradictory views: the G77 demanded that developed countries demonstrate their willingness to combat climate change while the United States Senate (Byrd-Hagel resolution, June 12, 1997) demanded that developing countries face "new specific scheduled commitments to limit or reduce greenhouse gas emissions." The Clean Development Mechanism (CDM) was meant to reconcile these views through abatement projects apt "to assist non-Annex I countries in achieving sustainable development" and "to help Annex I countries in achieving compliance with their commitments".

Even though the argument prevails in many quarters of the G77 that technological and financial transfers through this mechanism may not provide development benefits (Estrada 1998)[30] it is widely held that the CDM will be the main Kyoto instrument of interest for non Annex B countries.[31]

The total amount of net transfers accruing to such countries will depend on the magnitude of the surplus generated by projects and on the capacity of the host country to conserve part of it. In the sequestration option, this surplus is $0.9–2.8B for a $50 WP and $1.6–4.4B for a $100 WP. Under the RP option, the upper bounds for this surplus are increased by factors of approximately 3.5 and 2.8.[32] Admittedly, a restoration payment restricts the primary market for CDM projects because of a higher level of domestic action in Annex B, but the reverse auction guarantees that rents accrue to the host country, thereby more than compensating for this contraction.

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[30] Under certain circumstances, CDM projects can have a leverage effect on development (Mathy et al. 2001). The corresponding field of research is marred by the continuing confusion between the CDM and joint implementation.

[31] One additional proposal in Pronk's text was the extension to all flexibility mechanisms of the Article 12.8 "share of the proceeds" of CDM transactions if Annex B countries did not provide a $1 billion assistance (reaching this value would require a $4/tC levy on all mechanisms under a Candide scenario).

[32] For the sake of simplicity, the simulated auction is directed to the developing world only. It thus provides an upper estimate of the capacity of the system to attract developing countries. This assumption does not affect in any way the RP results previously reported.

5. From a Lost Deal to an Incomplete Deal

COP6's failure and the US withdrawal at Bonn in July 2001 were partly overcome at COP7 in Marrakech, in November 2001. An accord amongst all UNFCCC parties but the United States was reached thanks to two concessions made by the European Union: the absence of supplementarity condition and higher amounts of sequestration in exchange of a more precise accounting.

It is tempting to assess the environmental cost of The Hague's Lost Deal by comparison with the Marrakech accord. But this would involve hazardous political judgments about whether the United States would have endorsed either the sequestration or the RP deal analyzed in this paper, whether this would have made the rejection of the Protocol more difficult for the new administration, and what the United States abatement outside Kyoto's framework will be. SAP12 simply indicates that its abatement in the energy sector would have been 172–377 MtC under an RP option at $54/tC and 206–366 MtC under the sequestration option. More informative for the future is to analyze how Marrakech resolves the cost-uncertainty issue.

To do so, we updated key SAP12 data. The previous sections consider the results in Weyant and Hill (1999) as representative of the information available between COP5 and COP6 about compliance costs; but as time passes new information became available, in particular about 2000 emissions and the likely amount of hot air. To remain consistent with the methodology of this paper, which concentrates on possible compromises between opposite views, we thus used the latest information available to decision-makers (UNFCCC website and UNFCCC 2001).

Reassessed hot air levels reach a range of 237–516 MtC across various projections, with an average of 376 MtC, more than twice as high as the former 179 MtC average. Reassessed European emissions are 915 MtC,[33] lower than the 1,024–1,170 MtC forecast embodied in the

[33] This figure was obtained by linearly prolonging the observable trends. It is very much compatible with the 340 Mt CO_2-equivalent effort estimated by the European Commission in its latest report on the matter (CEC 2001).

Energy Journal figures. To avoid underestimating compliance costs we chose to consider that the 109–255 MtC reductions between the two baselines "eroded" the low-cost abatement potential appearing on the Energy Journal curves; we thus truncated these curves so that the resulting costs curves show a much steeper slope.

The main result shown in Figure 5 is that the Marrakech accord exacerbates concerns regarding supplementarity without fully countering the hard core of the pessimists on the risks of excessive costs. The key uncertainty parameter is political in nature, *i.e.* the oligopolistic capacity of the EIT.

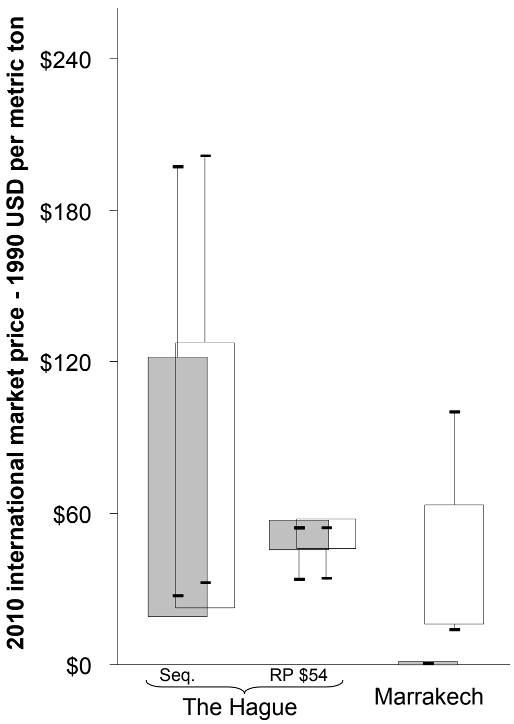

Figure 5. Effect of Marrakech on marginal prices

On the one hand, indeed, the conjunction of a lower baseline for the European Union, sequestration allowances totalizing 159 MtC (Locatelli and Loisel 2002) and the absence of U.S. commitments (430–546 MtC) leads to total required reductions substantially lower than the revised hot air estimates: even the 237 MtC hot air lower bound exceeds demand for all twelve models, by 15–58%, when sequestration is taken into account.[34] Thus, in a competitive framework the resulting market price would be $0/tC, resulting in the absence of any domestic action in the importing zones and of any market for CDM projects. A fair comparison with other results requires us to keep in mind that the 109–255 MtC difference between former European baselines and the reassessed ones embodies some extent of domestic action—together with a growth component:

[34] The role of sequestration is not negligible: the full range of total abatement requirements (from 225 to 327 MtC) is below the sum of hot air and sequestration (396–675 MtC); it is not below the hot air only (237–516 MtC).

altogether the reduction from former baseline amounts to 58–76 % of the former European-required reductions.

On the other hand, the EIT can limit the amount of credits they put on the market so as to maximize their aggregate rent. Contrary to the results in the COP6 context, EIT market power makes quite a significant difference compared with the competitive equilibrium, the absence of a flatter abatement cost curve in the United States lowering the price-elasticity of demand. It turns out that the EIT set their exports at 84–127 MtC, *i.e.* at around half the 174–238 MtC exports on a competitive market, causing prices to rise up to $15–63/tC. Note that, again, the results are quite insensitive to the assumption about hot air: even the lower bound of hot air suffices to cover all required reductions, and the quantity beyond the total abatement requirements does not matter. Still, it is evident from Figure 5 that the likelihood interval of marginal costs remains lower than the intervals found in the COP6 context. In terms of total costs, a country such as Japan cuts its expected burden by a factor of 3 compared with the oligopoly case under COP6 conditions ($1.0–4.7B compared with $3.0–15.1B).

However, it is remarkable that this cost control is made at the expense of a far higher risk of low prices and low levels of domestic action by comparison with results obtained in the COP6 context: 100% of null prices in a competitive market, and a 50% chance of a price lower than $35/tC under an oligopolistic market. It also entails far lower net transfers to the developing countries, ranging from a highly probable $0.0 to $0.7 billion. Moreover, and perhaps more surprisingly, it still provides a weaker response to the hard core of the pessimists about marginal costs than the $54/tC RP option in the COP6 conditions: 17% of the estimated carbon prices are above its $54/tC limit, one model giving $100/tC.

Conclusion: The Narrow Pathway to a Recovered Deal?

The central issue of the post-Kyoto process was that hedging against uncertainty on compliance costs, either in the form of a price cap or through the extension of sequestration activities, risked creating a loophole in the Kyoto cap-and-trade system. The analysis presented here suggests that the two hedging tools are very different in nature, and that a restoration payment provides a negotiation space large enough to accommodate all the prevailing world views:

- As regards environmental integrity, the restoration payment compensates for the absence of financial penalties or formal linkage to the WTO in the compliance system, since good-faith conduct is immediately distinguishable by a government's contribution to the restoration fund. It is, moreover, an efficient supplementarity tool because of the risks of extraterritorial payments. And finally, it limits the risks of endlessly postponed abatements in case energy consumers have a limited willingness to pay.
- As regards costs control, the restoration payment provides a more efficient hedge against the risks of too-high carbon prices than an equivalent amount of tons under Article 3.4, which symmetrically exacerbates the risk of too-low prices.
- A restoration payment provides a significant source of transfers to the developing countries in the spirit of the Brazilian 1997 proposal, whereas extending sequestration activities under Article 3.4 undermines the prospects for significant CDM and share-of-the-proceeds revenues.

Ultimately, the restoration payment option, instead of *ex ante* revising Kyoto targets, would have given Kyoto targets a chance until an *ex post* assessment in 2012: it more than triples its 8% probability under a $50 willingness to pay, and can even raise it to 50% if one gives greater credence to the more optimistic models. In contrast, the Marrakech accord provides less efficient cost-control while increasing the chance of excessively low carbon prices and the corresponding risk of not triggering any domestic action in the participating countries.

The hope of economic analysis is to inject some objectivity into policy discussions. To pursue this aim in climate change affairs is a daunting task because parties with opposing expectations and visions of fairness are likely to view all models as controversial. The lesson from our exercise is that it is essential to incorporate uncertainty into the framework of international coordination, rather than engage in infinite controversies that delay action and could make ambitious targets unreachable.

Beyond the Kyoto targets and timetables, it appears that a hybrid quantity-price instrument is a robust approach to cope with uncertainties, hence facilitating the negotiation of further budget periods and the appeal of active climate policies to developing countries. The usefulness of such an economic message depends on two conditions: first, that every party acts in a manner consistent with its stated world view and is not motivated by a hidden agenda; and second, that diplomats, policymakers, and environmentalists remember an old Roman saying, *Audi alteram partem:* Listen to the other side.

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