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Trading rules for CO2 emission permits systems
A proposal for ceilings on quantities *and* prices

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1. Introduction

Tradable emission permit (TEP) systems for greenhouse gases (GHGs) as they could develop following the Kyoto Protocol – that is if they are limited to Annex B countries and are not bound by exchange regulations – do not appear to be greatly acceptable today, either to the United States or to the European Union.

The problem of the uncertainty related to the cost of reducing emissions is strongly highlighted in the United States : in fact, the approach adopted in the Kyoto Protocol, that of quantitative emissions targets, leaves the question of the reduction programme costs wide open. Next, the setting-up of a TEP system poses the problem of the "hot air" in countries in transition.It is known that a market limited to the Annex B countries could produce huge financial transfers, particularly to the former Soviet Union, through the purchase of permits consisting essentially of hot air. This is one strong reason for the American Senate opposing the ratification of the Protocol. Politically, the TEP system designed at Kyoto therefore has all the characteristics of a "shell game", a dialogue of the deafs, especially between the United States and Europe (Victor 1998). In order to alleviate these difficulties and make the Protocol more acceptable, several authors have suggested the setting of a price ceiling on permits (McKibbin & Wilcoxen 1997; Pizer 1998; Kopp et al. 1999a). This solution would have the effect of combining a permit system with a quasi-fiscal system. It would offer the opportunity to benefit from the flexibility inherent in the TEP system, whilst at the same time preventing the reduction programmes from becoming too costly.

For the European Union, the unregulated TEP system is hardly acceptable because it would not guarantee that the principle of "supplementarity" adopted in the Kyoto Protocol (Article 6.1(d)), that is, the fact that the purchase of permits should be in addition to action taken within each of the Annex B countries. With a non-regulated TEP system, industrialised nations would be able to comply without making sufficient efforts internally. Indeed, according to the analyses indicating that the socio-economic systems are characterised by severe inertia, it is important to avoid the "lock-in" in GHG intensive technological paths and to act early in order to develop new skills and technologies (Grubb et al. 1995; Hourcade & Robinson 1996; Ha-Duong et al. 1997). In order to take account of these elements, the European Council of Ministers, in May 1999, proposed the introduction of "concrete ceilings" for the exchanges of permits. This solution consists of regulating the permit market on a quantitative basis, by restricting imports or exports of TEPs in each country to a certain percentage of the overall reduction target.

Thus on both sides of the Atlantic, the TEP system is not yet politically acceptable and appears to involve some form of market regulation. However the regulation would be in terms of prices for some and in terms of quantity for others. The two approaches appear *a priori* to be irreconcilable, which calls into question the very possibility of implementing any form of TEP system. Section 2 of this paper is dedicated to an in-depth analysis of the European proposal relating to "concrete ceilings" for exchanges, following a summary of the structural data for a possible TEP "full-trade" market in 2010. The alternative proposals, formulated in the United States and relating more to permit price ceilings or "trigger prices", are examined in Section 3. After showing that each of the foregoing proposals could have consequences unacceptable to some or others of the parties to the Protocol, Section 4 offers the proposal of a hybrid formula for regulating the rights market. The analysis shows that, because of its properties this formula may provide a new basis for the continuation of the negotiation.

In fact, the main aim of this paper is to show that the implementation of a "hybrid solution", consisting of limiting the volume of exchanges while at the same time introducing a TEP price ceiling, could provide a market regulation framework effect allowing the benefits of most of the economic advantages to be enjoyed and also having characteristics acceptable to the various parties from an environmental as well as from an international fairness point of view.

As we will see, the combination of the two approaches will undoubtedly correspond to a " second-best policy ", but it will allow the total cost of implementing the aims of Kyoto to be reduced, the uncertainty relating to the cost of emissions to be lessened, and the principle of supplementarity to be respected. The other advantage of this solution would be an allocation of gains clearly more acceptable than that arrived at using either a fully competitive market or a "ceiling" system without any ceiling price. Besides, this hybrid solution would allow a better treatment of the problem of the "hot air" originating from countries in transition, at conditions acceptable to all parties. This is may be a very important feature at a time when this question is becoming more and more obviously the "Achilles heel" of the arrangement put in place at Kyoto.

2. The European proposal for "concrete ceilings": an economic analysis

In the summer of 1999, the Ministers of the Environment of the European Union, apparently more sensitive to the "vices" than to the "virtues" of the TEP systems, proposed the introduction of "concrete ceilings" into the permit trading system. This proposal echoes Article 6.1 (d) of the Protocol, which emphasises that "the acquisition of emission reduction units shall be supplemental to domestic action for the purpose of meeting commitments under Article 3.". In this way, a minimum percentage of reduction should be guaranteed within each Annex B country. After presenting the proposal in detail and analysing its economic implications through the use of stylised graphics, we will propose a qualitative evaluation of the various restrictive rules and their consequences, based on the POLES world energy model (Criqui et al. 1998).

2.1. The proposal by the Council of Ministers for the Environment

The proposal by the European Council for the Environment in May 1999 brought together a series of rules that took account of the "starting points" and the reduction-related aims of the Annex B parties (EU 1999); on the basis of the various rules mentioned, we have identified six hypotheses for "exchange restrictions".

According to the first rule (R1), the net purchases by an Annex B country for the three Kyoto mechanisms should not exceed 5% of the average between its 1990 emissions and the Kyoto objective. For the European Union, for example, imports of TEPs may not exceed 5% of the average of 1990 emissions and 92% of the 1990 emissions. Given that the 1990 emissions totalled 892 MtC[1], the maximum total of permits that the European Union could import would be 43 MtC. The advantage of this formula is that it is simple and can be calculated immediately: the number of tons that each country can import is obtained using calculations based on data already known.

[1] This estimation corresponds to the database and conventions used in the POLES model ; it may differ slightly from the official estimates supplied in the context of the UN - Framework Convention on Climate Change.

In the case of the second rule proposed (R2), the net purchases by an Annex B country for the three Kyoto mechanisms must not exceed 50% of the difference between the maximum emissions between 1994 and 2002 on one hand, and the Kyoto objective on the other hand. This formula allows the differing emission dynamics of the parties between the reference year and the year of implementation of the Kyoto mechanisms to be taken into account. The advantage of the formula is that it provides more flexibility than rule R1. On the other hand, it has the drawback of penalising those who made efforts to reduce emissions in the early years.

Rule R3 aims to introduce room for manoeuvre in relation to R1 and R2; the Council for the Environment proposes, in fact, that each permit importing Annex B country can choose from R1 or R2 the rule that it finds more advantageous.

Rule R4, which we call the "Council Rule" as it is the full proposition that was finally adopted, consists of imposing restrictions on both sellers and purchasers of emission credits; in actual fact, Rule R3 is applied to purchasers and Rule R1 to sellers. The countries of the former USSR included in Annex B, for example, cannot sell more than 5% of their 1990 emissions (because the region has undertaken to stabilise its emissions at the 1990 level in 2010). As the emissions for that region were about 800 MtC in 1990, the sale of emission credits in that area would therefore be limited to 40 MtC. This rule of exchange on restrictions will have the effect of limiting the amount of "hot air" introduced into the TEP system in the early stages; but it will not by itself resolve the whole problem of the "hot air" as we will see below.

Case R5 corresponds to a hypothesis put together only for purposes of analysis in this study and evidently not featured in the Council of Ministers' proposal. The aim is to test the hypothetical situation of a unilateral undertaking by the European Union to respect ceilings; it applies Rule R3 to the European Union only, without there being any restriction on other Annex B regions, whether they are in a situation to buy or sell emission credits.

Finally, mention must be made of the presence in the European proposal of an exception clause (sometimes called the "however clause"). This clause stipulates that the ceiling on purchases by an Annex B country can be extended during the budget period, provided that the country has been taking national action to reduce emissions and the action can be proved. This clause may apply both to potential purchasers of permits and to sellers. In an extreme situation, a country able to demonstrate that it has made an internal effort for reductions totalling 50% of its reduction target (that is, the difference between its reference forecast and its emission quota for 2010[2]) could buy or sell TEPs to the tune of the remaining 50%. This formula has the advantage of being less restrictive than R1 and R2, and therefore allows a significant increase in exchanges and in the associated economic gains. It does however have the major inconvenience of not relying on directly observable data, which is the problem with verifying national efforts at reduction (or in other words, defining the 2010 reference projection if there were no emissions reduction policy).

2.2. The effects of ceilings on purchasers of permits: a few stylised facts

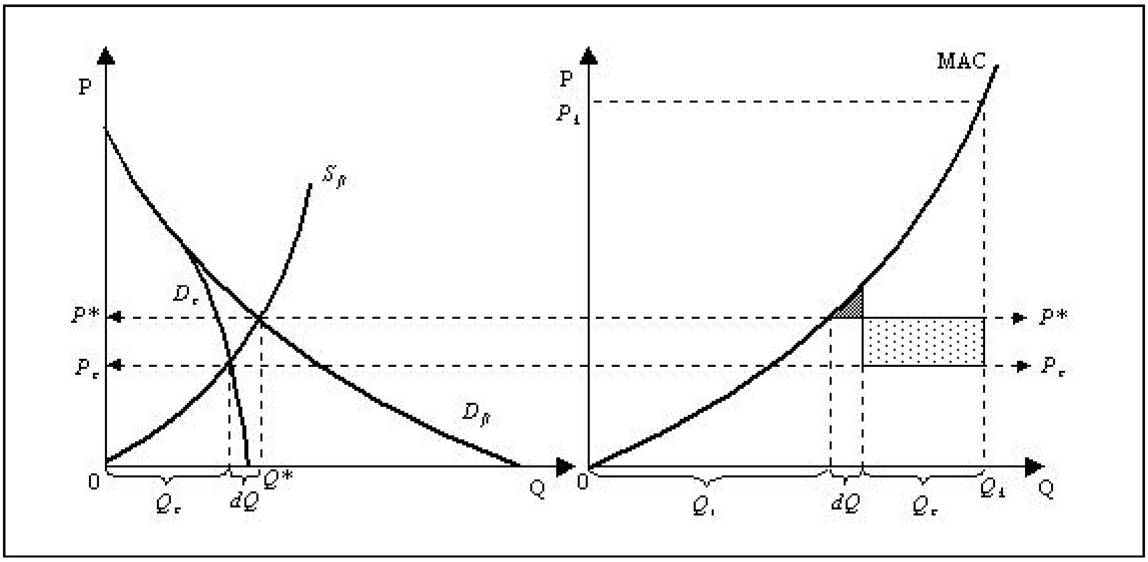
Let us suppose, initially, that a TEP system is set up within the Annex B countries. In graph 1, the X-axes represent the reduction values Q, while the Y-axes represent the value P of one ton

[2] For the sake of simplificity, although we are well aware that the aims and restrictions have been put together for the budgetary period 2008-2012, all our analyses and calculations have been made on the basis of the central year of that period, namely 2010.

of carbon. The left graph represents the TEP supply curve S_{ft} and the TEP demand curve D_{ft} in a competitive situation. In this case, market equilibrium will be established at Q^* for a permit price equivalent to P^*. The right graph represents the marginal abatement cost curve (MACC) for countries that have undertaken to reduce their GHG emissions.

In the absence of geographical flexibility, the marginal abatement cost that allows the Kyoto objective Q_k to be reached is equal to P_k. The total cost of this reduction is then equal to the area situated between the MACC up to the axis Q_k. If the Annex B countries have the opportunity to exchange TEPs, they will make a domestic reduction effort equal to the quantity Q_i and import a quantity of TEPs Q_k-Q_i.

Graph 1. Effects of slight restrictions on exchanges on the TEP market and emission abatement costs



Now let us accept that imports of permits are limited. The demand curve will now be D_c on graph 1. This restriction on demand will have the effect of limiting the volume of exchanges at level Q_c and will cause the price of the permit to change from P^* to P_c. Domestic reductions achieved by the restricted countries will then be increased by the quantity dQ, while the quantity of permits exchanged equals Q_c.

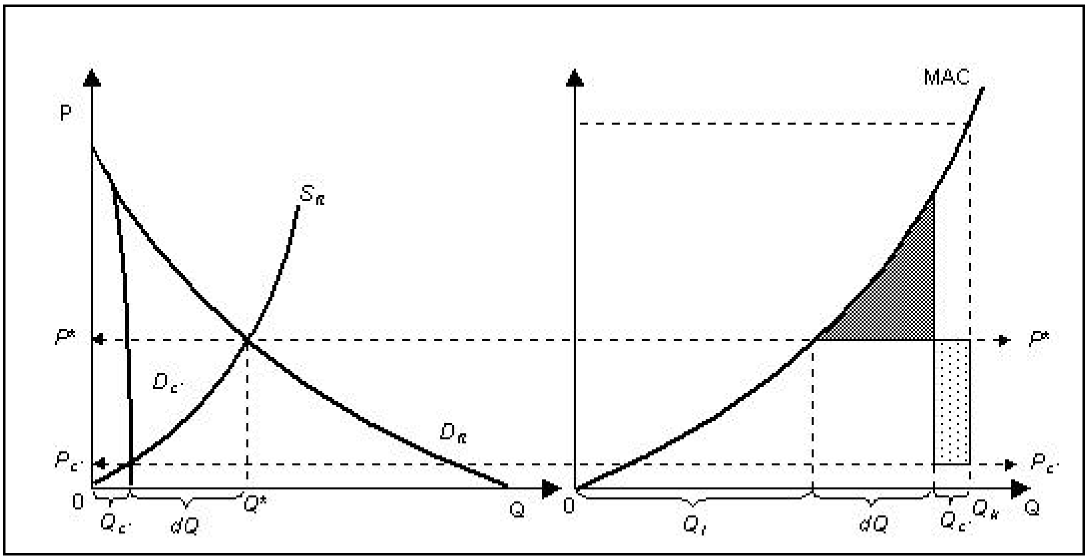
The restriction imposed on the demand for TEPs will have two effects on costs in countries importing permits, in comparison with a purely competitive case:

- on one hand, the increase in domestic reductions will show in an additional cost equal to the hatched triangle on the graph;
- on the other hand, the fall in permit prices linked to the reduction in total international demand for TEPs will allow the importing countries to enjoy a net gain on the market, equal to the hatched rectangle on the graph.

Up to a certain level of restriction, the measure of exchange limitations shows in a net reduction of the total cost of achieving the GHG emission reduction (in other words, the area of the triangle is lower than that of the rectangle). On the other hand, where there is severe restriction on TEP exchanges, the additional cost linked to the additional domestic reduction becomes greater than the gains derived from the drop in permit prices (cf. graph 2). The effect is doubly negative for exporting countries, as they export a lower quantity of TEPs than are sold in a competitive case, and moreover at a lower price.

This situation and the perhaps unexpected consequences of introducing restrictions on demand became evident during the first systematic research into restrictions on exchanges (Criqui et al. 1999); they were demonstrated and further explored by Ellerman et al. (1999) who even pointed out that the introduction of restrictions on exchanges could constitute "an invitation to monopsony". In order to carry out a full analysis of the effects of introducing restrictions, two different cases must therefore be distinguished: one of "slight restriction", which will bring about a drop in the total importer costs in relation to the competitive case, and one of "severe restriction", in which the total cost will increase again. In Ellerman's analysis there exists between these two situations the optimum situation of monopsony, or rather, in the case in point, an oligopsony of permit-purchasing countries.

Graph 2. Effects of severe restriction on exchanges on the TEP market and on emission abatement costs

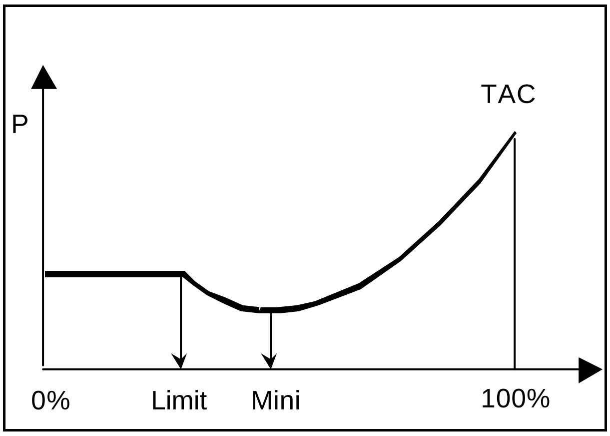


As we have already shown in an earlier article, the curve showing the total emission abatement costs (TAC) as a function of the constraint – expressed as a percentage of the total reduction from the reference – is U-shaped (Criqui et al. 1999). Ellerman et al. (1999) have demonstrated since then that this U-shape of the total cost curves is a general characteristic of the restrictions imposed on the demand for permits (cf. graph 3):

- up to a certain threshold, for example from 0% to 20% or 30%, the restriction has no effect on national or international carbon values, and therefore on total abatement costs; in fact, every country has the potential to reduce emissions and can make domestic reductions even if imports of permits are not restricted;
- beyond this threshold, the extent of the restriction on exchanges has an effect on the demand for permits; provided the restriction is not too severe, the additional cost linked to the increase in domestic reduction is less than the gains linked to the fall in permit prices, so that the total cost of the objective is lower than in a competitive case;
- when the restriction becomes too severe, the tendency moves in the opposite direction and the balance becomes negative. The fall in permit prices ceases to compensate for the increase in internal costs; the total cost reaches its maximum when flexibility is zero, in other words, when the Annex B countries are required to realise 100% of their domestic

reduction targets; for permit-exporting countries, the gains decrease on a continuous basis as the restrictions on demand increase.

Graph 3. Relation between restrictions on imports and total cost of reduction target



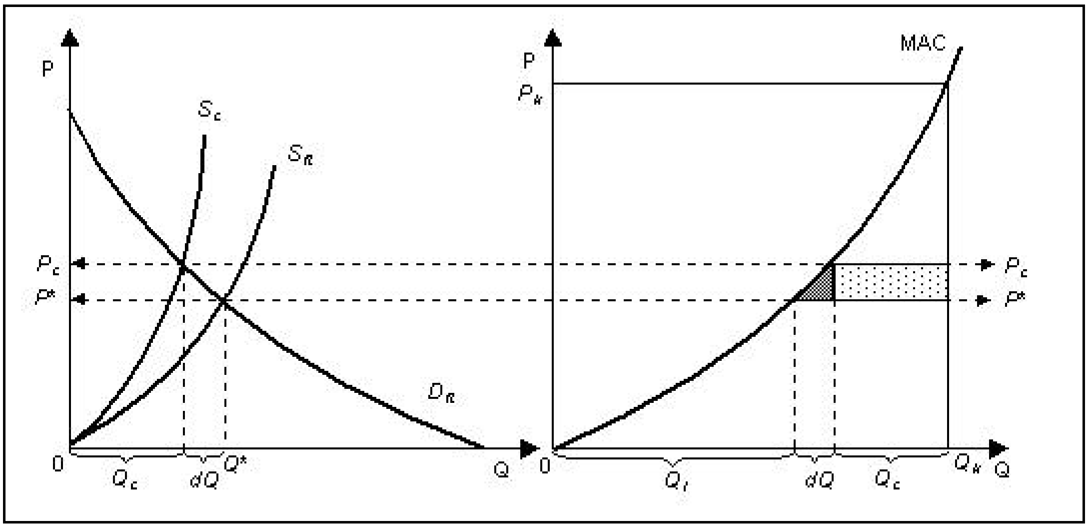
2.3. The introduction of ceilings on sellers of permits

Let us now assume that measures are brought in with the aim of limiting also the supply of permits (example of Rule R4). The supply curve is no longer the one used in a competitive case (S_{ft}) but instead is known as S_c (cf. graph 4). With this restrictive measure in force, exports of permits and exchanges are limited to the level Q_c and are made at a price P_c that is higher than P^*.

For countries required to make an effort to reduce emissions, this means an additional cost linked to the increase in domestic reductions, equal to dQ (hatched triangle) and an additional cost linked to the increase in the price of imported permits (hatched rectangle).

This restriction on supply favours exporting countries, as it allows them to sell little but at a high price, and therefore increase their gains in comparison to a competition-based situation. Suffice it to say that the introduction of restrictive measures on supply allows the artificial creation, through the purchasers' initiative alone, of conditions similar to a monopoly or oligopoly market.

Graph 4. Effects of restrictions of supply on the TEP market and on the cost of reducing emissions



Rule R4 or the "Council Rule" actually includes restrictions on both purchasers and sellers. We will examine the economic consequences and stakes of this double restriction in the following sub-section, which shows the application of the various plans of rules in the specific case of the Kyoto Protocol.

2.4. An evaluation of concrete ceilings using the POLES model

In this section, we will assess the economic impact of the introduction of restrictions on exchanges on the TEP market using the POLES model and the ASPEN software[3]. On the basis of the results obtained in a fully competitive case, we will then be able to assess the influence of the various restriction rules on the cost of the objective defined in Kyoto and to analyse their redistributive effects.

The Annex B permits market in a fully competitive case

In accordance with the Kyoto Protocol, it is likely that a TEP market will be set up in Annex B countries. In the first instance, their markets are supposed to be fully competitive; the potential participants are not limited by restrictions on exchanges; participation in exchanges is on economic grounds only; the market operates without any transaction cost; there is no monopolistic behaviour. Because of this hypothesis of the perfect market, the value of the permit should be interpreted as a minimum value, and the exchange level as a maximum value. The results therefore remain largely theoretical, but they allow reasonable orders of magnitude to be identified and a number of analytical conclusions to be drawn. The works shown in an earlier article (Criqui et al. 1999) may be summarised as follows[4]:

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[3] POLES is an energy system model, for the world in 30 regions and the 2030 horizon; it combines some features of the "top-down" models in that prices play a key role in the adjustment of most variables in the model, while it also resembles the "bottom-up" models because of the degree of detail shown in the treatment of technologies. The dynamics of the model is given by a recursive simulation process that simulates energy demand, supply and prices adjustments (Criqui et al. 1996). The ASPEN software has been developed in order to simulate, from the POLES' Marginal Abatement Cost curves, the economic consequences of flexibility systems.

[4] The quantitative results are slightly different because of the revisions made to the POLES mo del in the interim, but the analytical information is identical.

- if an emission permit market is established between all the countries that have subscribed to quantitative objectives in Kyoto, the permit price is 64 $90/tC (cf. table 1).
- at this market price, the volume of exchanges is 410 MtC. The permits are purchased by OECD countries from Eastern European Annex B countries and the former USSR; the former USSR represents 92% of supply; 73% of permits originate from "hot air".
- the introduction of a TEP market within Annex B will have the effect of reducing the cost of compliance to the Kyoto targets for the OECD countries (19 G$90) and of producing profits for Eastern Europe (1 G$90), and especially for the former USSR (21.5 G$90).

Table 1: Effect on abatement costs of full flexibility within Annex B

2010 Kyoto	Emissions (MtC)				Trade : Permit price 64,1 $/tC					No trade			
Full flexibility	2010 Ref (Mt)	2010 Kyoto (Mt)	2010 Scen-ario (Mt)	% of within reduc.	Trade (Mt)	Trade value (M$)	Cost within (M$)	Total cost (M$)	% of GDP	Marg. cost ($/tC)	Total cost (M$)	% of GDP	Gains (M$)
USA	1 743	1 240	1 484	51,5	-243,8	15 621	7 812	23 433	0,27	*159,2*	*34 030*	*0,39*	*10 597*
Canada	142	109	126	47,1	-17,6	1 126	443	1 569	0,19	*207,3*	*2 727*	*0,34*	*1 158*
European Union	995	821	914	46,8	-92,7	5 940	2 476	8 417	0,10	*168,9*	*12 980*	*0,15*	*4 563*
4 PECO Annex B	199	197	172		25,2	-1 614	821	-793	-0,13	*3,8*	*4*	*0,00*	*796*
Other PECO Annex B	74	72	66		5,8	-374	232	-142	-0,07	*13,3*	*12*	*0,01*	*154*
Ex-USSR Annex B	515	800	422		378,8	-24 270	2 768	-21 502	-1,53	*0,0*	*0*	*0,00*	*21 502*
Japan	350	279	320	41,6	-41,6	2 664	889	3 553	0,11	*213,1*	*6 324*	*0,20*	*2 771*
Australia + NZ	126	89	103	61,8	-14,1	906	679	1 585	0,25	*125,1*	*1 981*	*0,31*	*396*
Total Bubble	4 143	3 607	3 607	49,9	(410)	(26257)	16 121	16 120	0,07	-	*58 057*	*0,24*	*41 937*
Rest of World	4 205	4 205	4 205	-	-	-	-	-	-	-	-	-	-
World	8 348	7 812	7 812	-	(410)	(26257)	16 121	16 120	0,03		*58 057*	*0,12*	*41 937*

The case of restrictions expressed as a percentage of total reduction

In this sub-section we analyse, using the POLES model as a basis, the economic consequences of introducing a restriction on demands for TEP in an Annex B market. We consider, at this stage, the ceilings for all the Annex B countries expressed as an increasing rate of domestic reduction representing between 0% and 100% of total reduction (relatively to the reference).,.

As we noted above, the restrictions require the importing countries to make more substantial domestic reductions, and lead to an increase in domestic reduction costs and therefore in the national price of carbon, but conversely to a drop in demand and in the international price of the permits. International and national carbon values, which are identical in a competitive market, differ when the market is restricted; the overall effect of a restriction on imports on purchasers may thus be positive or negative. This depends on the marginal abatement costs in the importing country and on the level of restriction imposed on imports. For exporters, on the other hand, the combined reduction of the quantities exchanged and the price of permits will always lead to a reduction of gains. Suffice it to say that the limitation of exchanges is a measure that is likely to have significant redistributive effects.

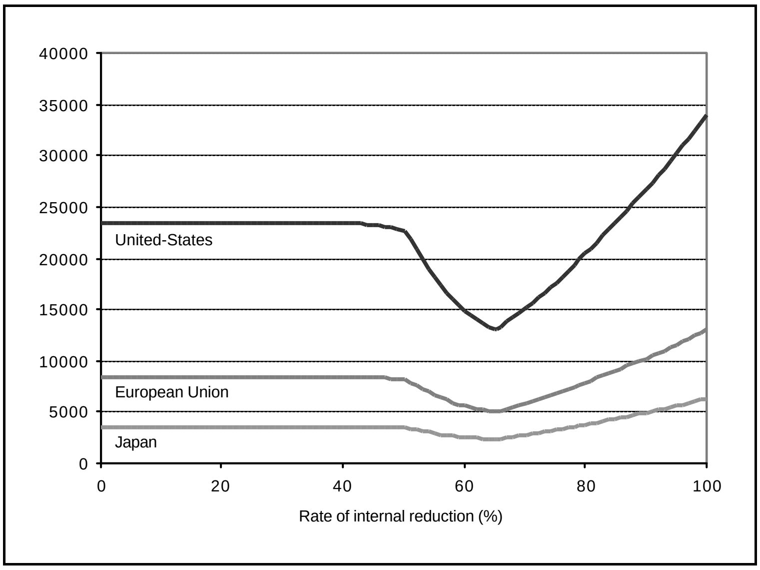
Graph 5 illustrates the total cost U-curves mentioned above, for the United States, Europe and Japan in the case of Kyoto:

- as long as the restriction remains below 40% of imports, the conditions on the TEP market do not change; the price of the permit and the quantity exchanged remain identical, as all

- the importing countries realise a reduction of at least 40% of their objective with or without limitation;
- the total abatement cost tends to decrease up to an domestic abatement level of 65%, after which it then increases again;
- after that, a restriction of 80-85% must be reached before the total abatement cost once again reaches the cost estimated in the absence of any restriction.

For the exporting countries, that is primarily the former Soviet Union, a restriction on exchanges means a reduction in gains on the TEP market; the heavier the restriction, the less the gain realised by permit sellers. For a restriction of below 40%, the price of the permit and the volume of exchanges remain unchanged; the gains realised by the exporting countries do not change (22.5 G$90). Beyond 40%, the gains decrease as the price of the permit and the volume of exchanges decrease progressively. They will be nil for any restriction of over 65%, as not all the "hot air" will be able to flow through.

Graph 5: Effects on the total abatement costs of the introduction of restrictions on exchanges (in M$)



The case of the European "concrete ceilings"

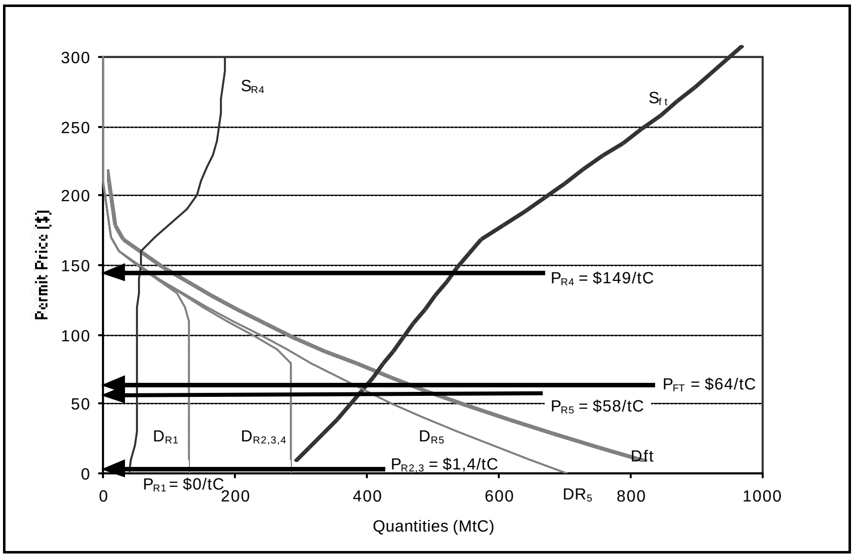
Graph 6 provides a comprehensive description of how the "concrete ceilings" rules are likely to alter the supply and demand curves on the emissions permit market and therefore to analyse their consequence in terms of permit prices. In a fully competitive case, the demand for emission permits corresponds to the curve D_{ft} and the supply of permits to the curve S_{ft} (cf. graph 6). As we have shown, the international value of carbon is now 64 $90/tC. The introduction of Rule R1 causes a shift in the permit demands curve (D_{R1}). According to POLES results, the price of a permit is then nil, as the maximum volume of demand (130 MtC) is less than the volume of hot air (286 MtC). In fact no real exchange of permits takes place in this case.

The adoption of Rule R2 is less restrictive for importers than R1; its effect is to limit the demand for permits to 300 MtC (curve D_{R2}). Under these conditions the price of the permit would be very low (1.4 $90/tC), as the maximum demand volume is only slightly above the volume of hot air.

The introduction of a restriction also on supply (R4) alters the equilibrium of the market radically. With R4, the maximum supply of permits is limited to 185 MtC (supply curve S_{R4}), while demand is shown in curve D_{R2}. At this level, the restriction on demand does not enter into play but the one on supply does, so that the price of permits increases sharply (149 $90/tC) and exchanges are limited to about 55 MtC. In this situation of a market restricted by supply and while Ellerman & Wing (1999) emphasise the fact that restrictions on demand can lead to monopsony, what is in fact obtained, in the "Council Rule", is a monopoly situation, but one that the buyers impose upon themselves...

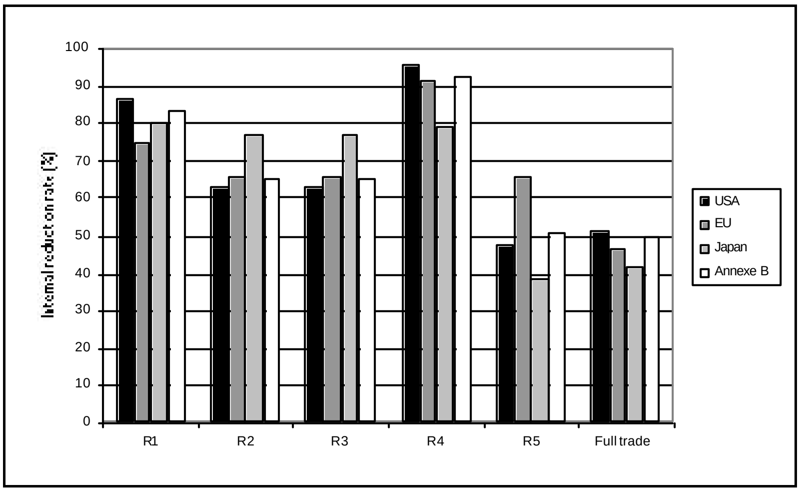
A unilateral undertaking by the European Union to respect R3 has a limited effect on the operation of the TEP market within Annex B. The price of a permit falls from 64 $90/tC to 58 $90/tC under the influence of a small reduction in overall demand for permits (curve D_{R5}). Evidently the other purchasers would benefit from a fall in prices brought about by self-restriction in Europe.

Graph 6: Effects of the European "ceilings" on the Annex B TEP market



Given that the ultimate aim of the rules proposed by the European Union is to establish conditions of "supplementarity", it is important to assess their impact on the Annex B countries' reduction efforts. It is interesting to stress, first of all, that the internal reduction rates are already significant in a purely competitive case; in the absence of any rules of restriction, the United States and Europe realise about 50% of the reduction targets internally, compared with 42% for Japan (cf. graph 7). This is explained by the fact that all the Annex B countries offer significant potential for reduction in emissions, at a cost below 64 $90/tC.

Graph 7: Internal reduction rates for various restriction rules



The adoption of Rule R1 leads the Annex B countries to realise internally an average of 85% of their reductions: the United States would achieve 87% of their reduction effort at a national level, compared with 80% for Japan and 75% for the EU. These differences can be explained both by the increases of emissions in the reference scenarios (+31% for the USA, +18% for Japan and +12% for the EU), and by the differences in marginal abatement costs between these regions (cf. Criqui et al. 1999).

As indicated previously, Rule R2 offers a greater degree of flexibility than Rule R1. The internal reduction rate only averages 65% for all the Annex B countries. This formula tends to penalise the areas that have had a limited increase in emissions early in the period – the European Union (66% domestic reduction rate) and above all Japan (77%) – in comparison with the USA (63%). In each case examined in this Kyoto framework, Rule R2 is more favourable than R1 for all the Annex B parties to the Protocol, which indicates that R3 is equivalent to R2.

Finally, Rule R4, the one proposed by the European Union, is also the most restrictive, on average, the Annex B countries achieve 93% of their emission reductions internally. The restriction is however less severe for Japan than for the United States: having the highest marginal abatement costs, Japan can only achieve 80% of its reductions at below 149 $90/tC.

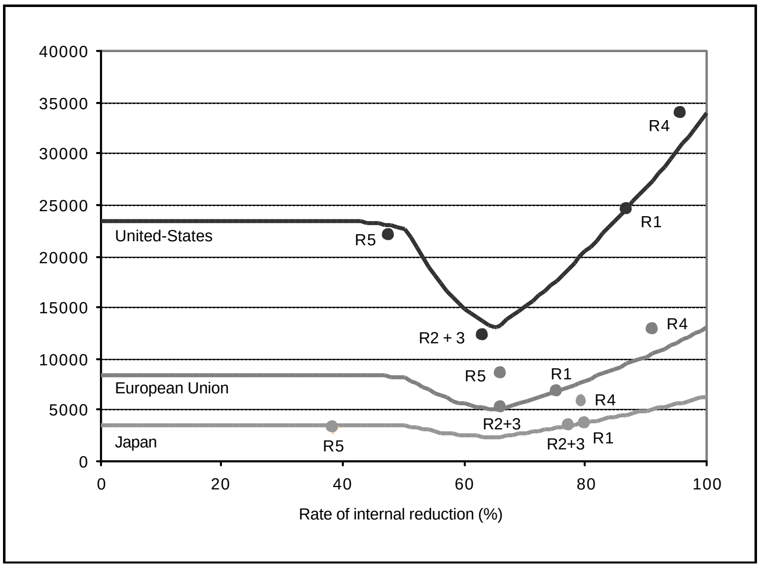
The total cost of reductions in emissions for the various regions covered by Annex B may therefore vary sharply, depending on the exchange restriction rule laid down. Rule R1 produces results very close to the full competitive case for the USA and Japan; the total cost of Kyoto rises from 23.4 G$90 to 24.7 G$90 for the USA and from 3.6 à 3.8 G$90 for Japan (cf. graph 8). The European Union, on the other hand, will be favoured if R1 is adopted, because the total cost of observing it is 20% lower than in a competition situation (from 8.4 G$90 to 6.8 G$90).

Rule R2 allows the USA and the EU to minimise the cost of compliance. This “concrete ceilings” formula is particularly advantageous for the USA: the total cost of achieving the planned reduction in GHGs falls to 12.3 G$90, that is, about one half of the cost in a full competitive case and one third of the no-flexibility cost. However, the European Union would also enjoy a significant gain, as the total cost of Kyoto falls by 38% compared with the full flexibility situation. Japan would lose out in this arrangement, as its total cost increases by 0,2 G$90 if Rule R2 is introduced. It should be noticed however that R2 is more favourable than R1 for Annex B as a whole.

Graph 8 shows that if Rule R4 is adopted, the cost of reductions for the Annex B countries will be very similar to the cost borne if there is no flexibility at all. Only Japan will be able to benefit to a limited extent from the reduced flexibility granted (-0,4 G$90).

Our analysis also stresses some effects of a unilateral undertaking by the European Union to respect Rule R3. By adopting this strategy, the European Union would move from an internal reduction rate of 47% to one of 66% for a relatively small additional charge (0,2 G$90). However, the effect of this option will be to reduce the cost of Kyoto to 1.4 G$90 for the USA.

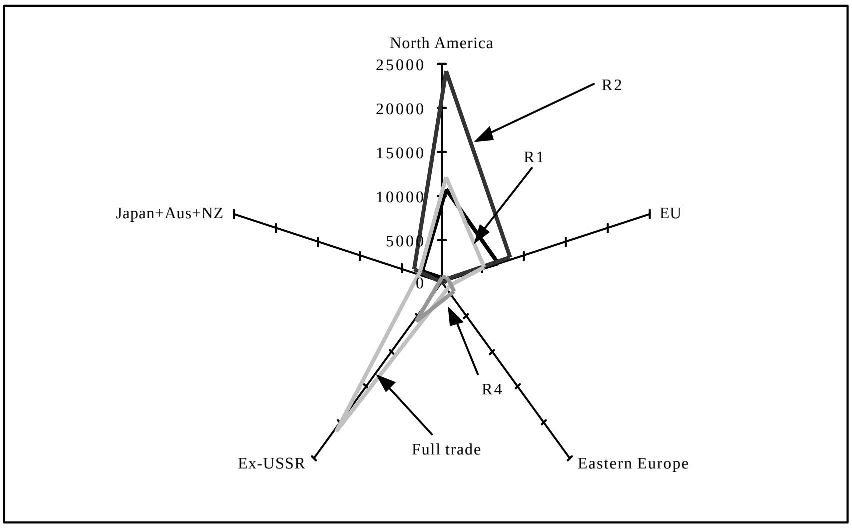
Graph 8: Effects of the introduction of the European rules on overall abatement costs (in M$)



As Bernstein et al. (1999) and Ellerman et al. (1999) have already stressed, the European "concrete ceilings" proposal could in some cases be more favourable for the USA, even though they are opposed to these steps, than for the European Union. As graph 9 shows, adopting Rule R1 will allow the EU to increase its gains by 1.6 G$90 in comparison to the competitive case, while the USA would lose about 1 G$90. On the other hand, the USA would gain in most respects if the 50% rule (R2) was adopted.

For the exporters, exchange gains are sharply reduced in comparison with their present levels if exchanges are not restricted. The gains enjoyed by the former Soviet Union would drop from 21.5 G$90 in a fully competitive case to 6 G$90 in the R4 situation and less than 400 M$90 in the R2 situation. Rule R4 could nevertheless be very favourable for Russia if that country could set up a banking system for the unsold rights (this hypothesis is indeed provided for in the Protocol). The restrictions laid down on supply allow the country to sell only very small amounts of hot air (40 MtC out of a total of 285 MtC) but at a very high price (149 $90/tC). It can therefore "bank" 245 MtC, which it would be able to use at a future date.

Graph 9: Effect of the European ceilings on exchange gains (in M$)



3. The American proposals for limiting costs by a "trigger price" for permits

In the previous section we analysed the economic effects of the European proposal for a regulation of the TEP systems in terms of quantities. In this section we will attempt to explore a second hypothesis, which is more favourable to the United States – that of regulation in terms of prices.

3.1. The proposal for regulation by prices and "hybrid systems"

Weitzman's pioneering article (1974) on the regulation of pollution through prices or quantities explored the importance of uncertainty in the choice of environmental policy instruments: when information on costs and on the benefits of environmental action is perfect, then the same result can be obtained from a regulation in terms of quantities as from a regulation in terms of prices. Weitzman, however, shows that in an uncertainty context, the choice of instrument depends on the relative slopes of the marginal damages/benefits curve and of the marginal abatement costs curve: generally, it is preferable to opt for a regulation in terms of quantities when the slope of the damage curve is higher than that of the abatement cost curve.

Following the initial results of Weitzman's work, some authors proposed hybrid solutions that consisted of combining permits and taxes (Roberts & Spence 1976; Weitzman 1978)[5]. A tradable permit market is set up, but a price ceiling is imposed: as long as the market price remains below the price ceiling, producers go to the market but when the price ceiling is reached, producers buy additional permits from the government at the fixed price or "trigger" price. This solution allows the uncertainty surrounding the cost of the programme to be reduced; in fact the maximum cost of the programme, the purchase of all the permits at the ceiling price, is known *ex ante*. On the other hand the level arising from emissions is, as in the case of a tax, unknown.McKibbin & Wilcoxen (1997) proposed this solution in the case of climate change. They suggested that each government may set up a national permits market and propose the sale of additional permits to businesses at a given price, for example 10

[5] It should be emphasised that the real pioneers of the "hybrid instruments" were W. J. Baumol and W. E. Oates, who as long ago as 1971 proposed the combined use of environmental standards and prices (taxes) for controlling the environment (Baumol & Oates 1971).

$90/tC: this would in effect result in the creation of a “second window” through which permits would be available at a fixed price. What these authors proposed was not reckoned to apply on an international level (no international exchanges are supposed), but it was designed as something that allowed national policies to be co-ordinated. According to McKibbin and Wilcoxen, this hybrid approach would allow the cost of programmes and of “monitoring and enforcement” to be reduced, and the appearance of imbalances in international business to be avoided.
Following McKibbin and Wilcoxen, Pizer (1998) tested the idea of a negotiable permit market combined with a ceiling price, initially below 25 $/tC. His works showed that in an situation of uncertainty, the hybrid policy is more effective economically than either pure system (tax or permit). In addition, the combination of instruments allows one of the most interesting aspects of the permit systems to be preserved – the possibility of controlling the income distribution arising from emissions rights.

In order for the USA to become involved as quickly as possible in GHG reduction policies, even on a modest level, researchers working for Resources For the Future (Kopp et al. 1999a) have recently suggested the setting up of a national tradable emissions permit system in the context of a policy of “early action”. According to them, such a system should be administered from above (the “upstream approach”), in order to cover all sources of emissions. For the programme to be fair, the permits should be sold at auctions to energy producers and importers, and the income derived would be spent on domestic consumers as a matter of priority. Given that there is a high level of uncertainty with regard to the effects of climate change, the cost of reducing emissions and the actions to be taken by other countries, the programme should in their view remain modest in size and advance gradually. For this purpose, Kopp et al. propose the laying down of a “trigger price” to prevent the programme from becoming too costly. This price would be 25 $/tC in 2002 and increase by 7% per year above the rate of inflation until 2007; by that date, that is, before the beginning of the first budgetary period of the Kyoto Protocol, it would have reached 35 $/tC.

This permit price ceiling clearly functions as a “safety valve”: when the market price is lower than the ceiling price, businesses can exchange permits in order to reach their objective, and when the price of permits exceeds this price, the government opens the “second window” and offers additional permits to businesses at the ceiling price. As a consequence emissions exceed the target, which is the main disadvantage of this situation in which, on the other hand, the maximum compliance cost to be borne has not been exceeded.

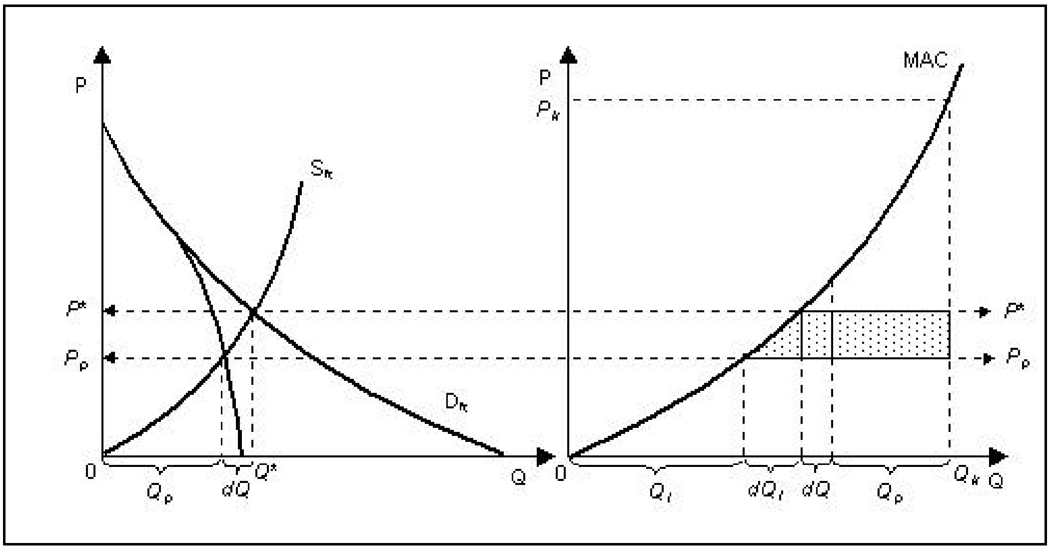
The proposals of McKibbin & Wilcoxen and the RFF researchers were initially designed to be applied at the national US level, but it can be envisaged, following Kopp et al., that a second window and therefore a ceiling price could also be opened on an international level (Kopp et al., 1999b). It should also be noted that the analysis of this solution also provides an appreciation of the effects of a system of penalties that would be imposed on countries that fail to comply to their Kyoto targets. In fact, if such a penalty was imposed, it would be logical to expect, from a strictly economic point of view, that the various parties would make any possible reductions at a cost lower than the total of the penalty and agree to pay the penalty for any discrepancy between the emissions and the target. From this point of view, the second window system with price ceiling and the penalty system are strictly speaking equivalent, even though (only in the exposition) the former appears to provide a more favourable solution for purchasers.Graph 10 shows the effects of adopting such a price ceiling on the permit market with restrictions, on the total costs of reduction, and on GHG emissions. As in the preceding graphs, the left graph represents the TEP supply curve S_{ft} and the TEP demand curve D_{ft} in a fully competitive case, while the right graph represents the marginal emission abatement costs for countries required to make an effort to reduce their emissions.

Suppose that a price ceiling P_p is imposed, to prevent the reduction programme from becoming too costly. As long as the market price P^* remains below P_p,, the price regulation laid down does not enter into play, and the Annex B countries will be able to fulfil their undertakings while minimising the cost of reduction through the exchange of permits.

On the other hand, when the price ceiling is exceeded ($P_p < P^*$), the quantity of permits exchanged is limited to Q_p (on the left graph) while the internal reduction effort does not exceed Q_i (right graph). In these conditions, the total cost for the countries required to reduce their emissions consists of three parts (left graph): the cost of internal reduction effort Q_i; the cost of purchasing a quantity of permits Q_p for a total cost equal to Q_p*P_p; the purchase of additional permits ("second window") linked to a shortfall in domestic reductions achieved (dQ_i) and to the shortfall in the supply of permits at the ceiling price (dQ) for a total cost equal to $(dQ_i+dQ)*P_p$.

In this sample situation, the emissions do not correspond to the quantities of permits initially distributed; the reduction target is exceeded by a quantity dQ_i+dQ. In comparison with a fully competitive case, the countries purchasing the permits realise a net gain equivalent to the hatched area on the left graph.

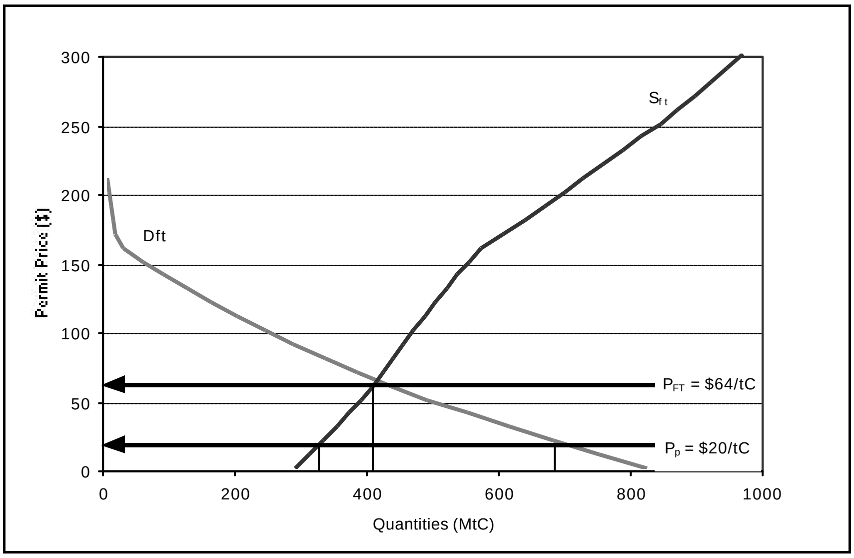
Graph 10: The effects of an international price ceiling on the permits market and on the total emission abatement costs



3.2. An evaluation of the price-ceiling system using the POLES model

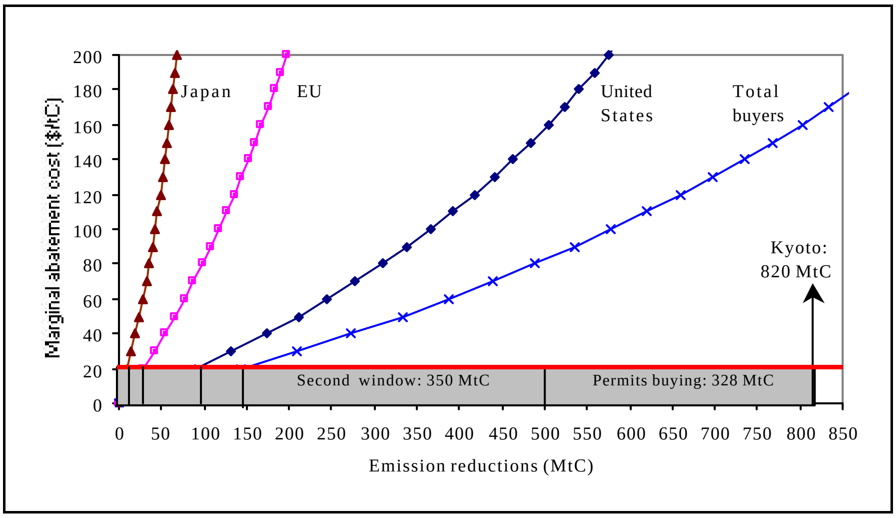
A permit price ceiling of 25 \$/tC would correspond to a value of 20 \$/tC at 1990 prices. At 20 \$90/tC, the supply of permits is limited to 328 MtC, while the demand for permits is equal to 675 MtC (cf. graph 11).

Graph 11: The effects of a price ceiling on the Annex B TEP market



At 20 $90/tC, the domestic reductions made by the Annex B countries are limited to 143 MtC (cf. graph 12), that is, 90 MtC for the USA, 28 MtC for the European Union, and 10 MtC for Japan. Given that the supply of permits does not exceed 328 MtC, for a permit price of 20 $90/tC, the Annex B countries are therefore required to make use of additional permits (the second window) for a total equal to 350 MtC. The environmental target is far of being reached in this case, as effective reductions total only 470 MtC with the "hot air", that is, only 57% of the Kyoto objective.

Graph 12: Total cost of the programme with permit price ceiling at 20 $90/tC



The imposition of a price ceiling at 20 $90/tC will first and foremost have the effect of diminishing the reduction rates. While the reduction rates averaged 50% for the USA, the EU and Japan in the competitive case, the internal reduction rates are currently between 16% and 18% for these regions (cf. table 2). The proposal for a price ceiling on exchanges would therefore clearly pose the problem of respect for the principle of "supplementarity" adopted in the Kyoto protocol.

If this step were however taken, the total cost of the programme would only be 8.5 G$90 for the whole of the Annex B section, that is, a cost lower of 49.6 G$90 relatively to the no-flexibility case and of 7.6 G$90 relatively to the fully competitive market.

The solution of a permit market with a ceiling price of 20 $90/tC has the added advantage of bringing about an allocation of gains that is apparently more acceptable by the different parties than a fully competitive case or a market regulated by European Rule R2. In a fully competitive market, in fact, there would be a problem of very substantial transfers to the countries in transition, which would receive 51% of the total gains from flexibility, as opposed to only 28% for the USA and 11% for the EU. Conversely, in the case of R2, it would be the USA that enjoys the greatest advantage: 67% of the total gains may be realised by the USA, as opposed to 22% for the EU and only 1% for the countries in transition, which would in addition have to sell all their hot air. With a price ceiling of 20 $90/tC, the USA would account for 54% of the gains, as opposed to 20% for the EU and 13% for the former USSR.

Table 2: The effects of a price ceiling on abatement costs

	Internal reduction rate (%)	Internal reduction (MtC)	Cost within (M$)	Trade (MtC)	Trade value (M$)	Total cost (M$)	Gains / no trade (M$)	Gains / FT (M$)
USA	17,9	90	887	413	8260	9147	24882	14286
Canada	17,3	6	58	27	540	598	2129	972
European Union	16,3	28	281	146	2920	3201	9779	5215
4 PECO	508,7	8	93	-8	-160	-67	71	-725
Other PECO	147,9	1	26	-1	-20	6	6	-148
Ex-USSR Annex B		319		-319	-6380	-6380	6380	-15122
Japan	14,7	10	103	61	1220	1323	5001	2230
Australia + NZ	22,2	8	82	29	580	662	1319	923
Total Annex B	53,5	470	1 530	348	6960	8490	49567	7630

4. A hybrid system with "concrete ceilings" and "trigger price": combining the advantages of the two instruments?

Each market regulation system proposed – concrete ceilings on one hand, trigger price on the other hand – therefore has advantages but also major drawbacks:

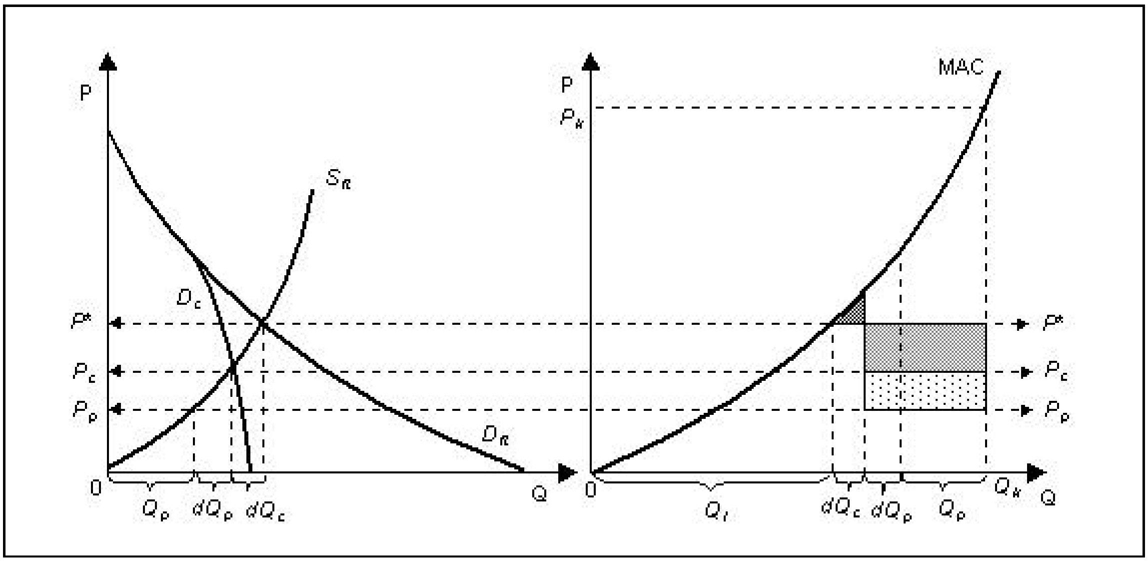
- the regulation of a permits system by prices – a price ceiling of 20 $90/tC – ensures that costs will not be too high and also that the allocation of gains will be relatively fair; on the other hand, it poses the double problem of non-respect for the principle of supplementarity and failure to respect the overall undertakings by Annex B countries to reduce their emissions.
- restriction on exchanges by regulating quantities guarantees that the environmental objective will be achieved and the principle of supplementarity respected; however, this solution also poses a double problem, that of total cost and or fairness in allocation of exchange gains.

The question is therefore one of knowing whether the combination of these two types of regulation is likely to lead to a better result from the environmental and economic points of view, and also in terms of international fairness. In the following paragraphs we will show that the combination of a system of concrete ceilings on imports (allowing a minimum level of supplementarity to be guaranteed) and of a permits price ceiling (allowing the costs of monitoring to be limited) may be acceptable for all the parties to Annex B and as such could constitute the basis for an agreement on the regulation of emissions rights markets up until the 2010 horizon.

4.1. Concrete ceilings + trigger price: maximum quantity at maximum price (MQ-MP)

Using the graphs shown in the previous sections (cf. graph 13), it is possible to represent market equilibrium and analyse the various components of the total emissions abatement cost. Let us suppose that a restriction is imposed on exchanges so that the demand curve alters from D_{ft} to D_c. We have explained that in this case, the quantity of permits exchanged is reduced by dQ_c and that the equilibrium price is no longer P^*, but P_c. The internal reduction effort is then increased by the quantity dQ_c on the right graph, which leads to an increase in the total abatement cost equal to the hatched triangle. The reduction in permit prices following the fall in demand will allow a gain on the market corresponding to the dark rectangle.

Graph 13: Effects of Rule R2 combined with an international price ceiling on the permits market and on total emission abatement costs



Let us suppose now that the price of permits is capped at P_p so that $P_p < P_c$. At this price P_p, the supply of permits no longer equals the demand for permits. The quantity of permits exchanged will be reduced by dQ_p in comparison with the previous situation (R2). The Annex B countries will then be obliged to reduce their national emissions by a quantity Q_i+Q_c, to import permits in a quantity Q_p at the ceiling price P_p, and to resort to the "second window" for a quantity dQ_p. In comparison to the competitive case, the Annex B countries will bear an additional internal cost equivalent to the hatched triangular area, but will benefit from a net gain linked to the restriction imposed on prices, equal to the hatched rectangular area.

As can be seen, this solution allows the principle of supplementarity to be respected while the uncertainty relating to total abatement costs is reduced, although not fully eliminated. It also allows the aim of mastering costs to be taken into account without moving too far away from the environmental objective – the quantities bought through the "second window" are better monitored than in a market controlled through prices only.

4.2. Maximum Quantities at a Maximum Price (MQ-MP): the results of the POLES model

The application of Rule R2, that is, the "Council Rule" without constraint on the sellers, would lead the Annex B countries to reduce their domestic emissions by 533 MtC, that is, an average effort of 65% of the objective as opposed to only 50% in the competitive case (cf. graph 14 and table 3). The total cost of these domestic reductions is estimated at 22.3 G$90 and the price of permits would fall, as we showed earlier, to 1.4 $90/tC (see above, Graph. 6).

If a price ceiling of 20 $90/tC is added, the supply of permits will exceed the demand for permits on the market: the sellers will be in a position to put 328 MtC on the market at less than 20 $90/tC, while demand will be restricted to 289 MtC through Rule R2.

The price ceiling therefore has a chance of becoming the market price or at least a reference price or "benchmark" on the market. In fact, given that Russia is almost in a monopoly situation on the permits market, it would have, on a non-regulated market, the opportunity of adopting strategic behaviour patterns: in particular it could choose to put only a portion of its hot air on the market, so that the price of equilibrium is increased. The introduction of a price ceiling of 20 $90/tC onto the market would then allow the opportunities for strategic behaviour by the offerers to be significantly limited. In particular, this step would have the effect of preventing the formation of a supply cartel and the creation of a situation similar to that brought about in the case of Rule 4, with a restriction on supply "self-imposed" by the purchasers.

In our case, and given the results produced by the POLES model, there would be no need to resort to the "second window". The environmental objective can be fulfilled without the governments being obliged to sell additional permits to the purchasers. The total cost of imported permits, at 20 $90/tC, would then be 5.8 G$90.

Graph 14: Total cost of the programme with a market regulated by R2 and a price ceiling of 20 $90/tC

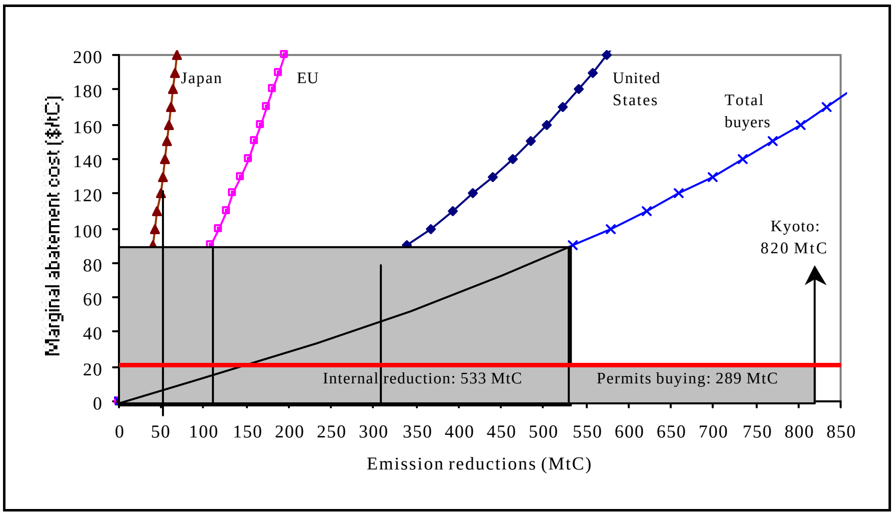


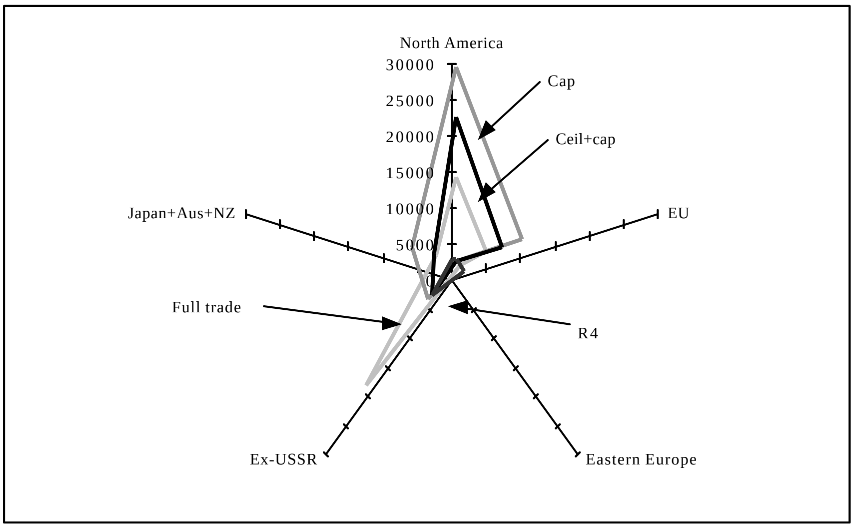
Table 3: The effects of a price ceiling combined with concrete ceilings on abatement costs

	Internal reduction rate (%)	Internal reduction (MtC)	Cost within (M$)	Trade (MtC)	Trade value (M$)	Total cost (M$)	Gains / no trade (M$)	Gains / FT (M$)
USA	63,0	317,0	12 042	-185	3700	15742	18287	7690
Canada	57,0	18,8	689	-14	280	969	1758	600
European Union	66,0	114,8	5 164	-60	1200	6364	6616	2052
4 PECO	41,4	0,8	1	-1	22	22	-19	-815
Other PECO	12,1	0,2	0	-2	32	32	-20	-174
Ex-USSR Annex B			2	289	-5773	-5772	5772	-15730
Japan	77,0	54,7	3 438	-17	340	3778	2547	-225
Australia + NZ	74,0	27,4	1 007	-10	200	1207	774	378
Total Annex B	65,1	533,7	22 343	(289)	(5773)	22343	35714	-6223

The combination of a ceiling on purchasers alone, of the R2 type, with a price ceiling of 20 $90/tC, would ensure an allocation of gains similar to that obtained with a price ceiling of 20 $90/tC without restrictions on quantity (cf. graph 15). This solution would allow the principle of supplementarity to be respected while limiting the total cost of achieving the objectives of Kyoto. Finally it would create, with the price ceiling in the second window (which, let us remember, is also equivalent to a penalty), a reference price level on the permits market that would undoubtedly allow the risks of strategic behaviour on the part of both sellers and purchasers to be reduced.

The other advantage of this type of policy instrument is its environmental effectiveness. The restriction in R2 increases the chances of the supply of permits exceeding the demand at the ceiling price. In the specific case studied, and using the POLES results as a basis, the environmental effectiveness will be complete, as compared to the full-trade solution: the supply of permits is enough to satisfy demand without the need to introduce additional permits. For there to be a requirement to resort to the second window, there would need to be a very limited restriction on demand and/or a much lower supply than in the POLES model (for example, if the volume of hot air was in fact only 100 MtC instead of 300 MtC in POLES).

Graph 15: Allocation of exchange gains for the various market regulations (in M$)



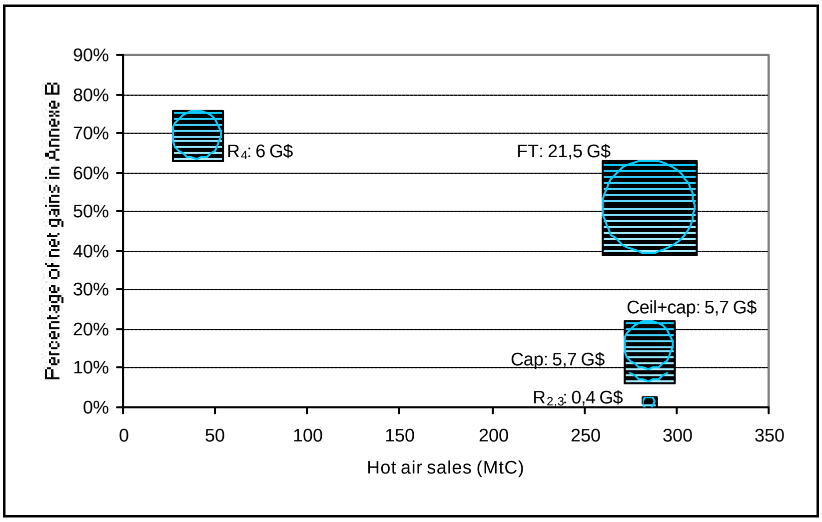
As we indicated in the introduction, a non-regulated system of permits limited to the Annex B countries could be judged to be unacceptable by both the United States and the European Union. It would indeed lead to a massive transfer of resources to the countries in transition and to Russia, originating in the sale of "hot air": 21.5 G$90 representing about 50% of gains by all the Annex B countries (cf. graph 16).

The European proposals would not allow this question to be dealt in an acceptable way. In the case of Rule R2, the countries in transition would be required to sell all their hot air at 1.4 $90/tC. It is difficult to imagine that they would then agree to sell their hot air "cut-price" and realise a gain of only 0.4 G$90. In the case of the full "Council Rule" R4, the situation is the opposite: these countries would sell very few permits at a very high price. Their gains would then total 6 G$90, representing almost 70% of the Annex B gains.

The Resources For the Future proposal to regulate the market through prices (Pizer 1998; Kopp et al. 1999a) would lead the countries in transition and Russia to sell all their hot air at 20 $90/tC. This solution would allow the problem of hot air to be overcome in the early stages for a total of 5.7 G$90 (that is, 13% of Annex B's gains). On the other hand, this total is more reasonable than the 21.5 G$90 obtained in the competitive case or, conversely the 0.4 G$90 obtained with the European Rule R4.

From the point of view of hot air sales and financial flows to countries in transition, the hybrid solution here proposed would allow a result very close to that obtained with the pure price ceiling system.

Graph 16: Gains by Russia linked to hot air sales, according to ceilings



5. Conclusion

Several different approaches to the regulation of the future international tradable emissions permit system can therefore be considered. The European Union has proposed a regulation scheme through quantities, which would allow the principle of "supplementarity" to be respected. This approach has its drawbacks. In particular it would have unfortunate redistributive effects and would lead to large uncertainties on the cost of achieving the emission reduction objectives, as well as potentially serious instability in the price of permits.

Some American experts, taking account of the political and economic restrictions on the ratification of the Protocol, have opted for proposing a regulation through prices, that is, the introduction of a price ceiling allowing the maximum cost of reduction programmes to be determined "ex ante" against a background of serious uncertainty in relation to costs. Our analysis has shown that this approach would have the advantage of bringing about a more satisfactory allocation of exchange gains and allowing the problem of the "hot air" in countries in transition to be dealt with more efficiently. However, it would lead the Annex B countries to reduce their emissions by very much less than targetted in the Kyoto Protocol, and would therefore considerably reduce its environmental efficiency.

The "maximum quantity at a maximum price" hybrid approach (MQ-MP), which we propose in this paper, combines a regulation through quantities and a regulation through prices. It brings onto an international level some of the proposals drawn up by American economists for domestic "early action", while at the same time preserving the concern over environmental effectiveness. According to our initial quantifications with the POLES/ASPEN models, this "second best" solution would in fact allow the countries to benefit considerably from the main advantages and from regulation through prices and from regulation through quantities. In particular, it would allow the objectives of economic and environmental efficiency and international fairness that each of the previous solutions offers to be better reconciled. Consequently, it could constitute a more acceptable basis for the continuation of negotiations on the question of emissions rights markets for the 2008-2012 horizon, the horizon for the first budgetary period envisaged in the Kyoto Protocol.

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