Should Developing Countries Join a Global Market of Emission Permits?

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Abstract

We use a simple approach base on the marginal abatement curve in order to evaluate the role of developing countries in global warming issues. It appears reasonable to convince developing countries to join the Kyoto Protocol or any other agreement and to get them to commit to reduce their emissions, due to the fact their forecasted emissions will sharply increase in the near future. It would be necessary to propose an equitable scheme that facilitates this decision of non Annex 1 countries. This short paper deals with this problem, by analysing the Kyoto scheme and proposing alternative solutions which could convince developing countries to join the Kyoto Protocol. In particular, which alternative permit allocation scheme (allocation by population or allocation by GDP) could force developing countries to join a global market of emission permits and if the Kyoto Protocol represents a good starting point.

Keywords: developing countries, climate policy, emission trading.
JEL Classification: H00, H2, H3

1. Introduction

This paper examines under which conditions developing countries will decide to take part to a global market of emissions trading. Starting by analyzing the Kyoto Protocol we try to find an alternative permit allocation scheme that guarantee a fair burden sharing.

The role of developing countries, which for historic and equity reasons are not expected to contribute to global emissions reduction in the short run, will be crucial in the future and whether they decide to take commitment to stabilising their carbon emissions will be one of the hottest issues in the following conferences on climate change.

In the last Conference of the Parties (COP-8), held in New Delhi at the end of 2002, developing countries reaffirmed development and poverty eradication as their overriding priorities and they accepted the importance of the implementation of UNFCCC commitments stressing that differentiated responsibilities, development priorities and circumstances are necessary. COP-8 was not a overall success because the usual division between developed and developing country did not disappear and will emerge in the future Conference of the Parties. Anyhow, even if USA repudiate the Kyoto Protocol and interfered in the progress of negotiations, Parties agreed on the rules and the procedures for CDM and provided additional guidance to the LDC Fund.

Despite this, in the long run it appears reasonable to convince developing countries to join the Kyoto Protocol or any other agreement, due to the fact that they are growing fast in terms of population and production and are increasing their consumption of energy. Moreover, their projected emissions will sharply increase in the near future.

The paper is organised as follows: in Section 2 we present a survey of the literature, in Section 3 we will focus the attention on the trend of population growth, the trends of CO_2 emissions. Section 4 concerns methodology; it details marginal abatement curves and the determination of an equilibrium in emissions permit market. In Section 5 three different emissions trading scenario are analysed, in particular we focus our attention on the issue of "hot air" and on the role of USA in environmental worldwide agreements. In Section 6 we define two alternative permit allocation schemes (permit allocation by population and permit allocation by GDP) and evaluate the costs and the benefits of these alternative schemes of emissions trading. The final section summarizes the main conclusions.

2. Review of the literature

Different authors have discussed and analysed the Kyoto Protocol and its economic implications. In particular, the introduction of a market for emissions permit would lower the cost of meeting the Kyoto target, being economically efficient (Buonanno et al. (2001), Ellerman and Decaux (1998, 2000), Ciorbi et al. (2001). Emission trading, and more generally the application of flexibility mechanisms, can reduce overall abatement cost without reducing the effectiveness of climate policy. (Manne and Richels (2000)).

Larsen and Shah (1994) evaluate the feasibility of alternative emissions permit allocations in a global permit regime for stabilization of world emissions at 1987 levels by the year 2000. In their paper they analysed which alternative allocations scheme would have been preferable in inducing broad participation in an international agreement for reducing carbon emissions.

Shin (1998) review the Kyoto Protocol and consider major driving forces and indicators of climate change negotiation. He analyses and proposes possible solutions for burden sharing in

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order to involve developing countries in participating to the treaty, underlying that "considering the fast growth and increasing share in GHG emissions from developing countries, it is necessary to take some measures to mitigate the emissions without damaging economic development in these countries".

Both papers deal with the issue regarding the involvement of less developed countries.

In our paper we will follow the methodology used by Larsen and Shah for analysing the Kyoto Protocol.

3. Data

3.1 Data Source

The data for carbon emissions are taken from Carbon Dioxide Information Analysis Center (CDIAC) and cover the period from 1990 to 1998. The data are available for countries and they have been aggregated by the author into 12 regions (see Table 1 for the composition of regions) in order to conduct the analysis using the abatement marginal curves estimated by Ellerman and Decaux. For projecting emissions until 2010 emissions growth rate by World Energy Outlook - March 2001 have been used.

The data for income and population have been collected from World Bank Development Indicator. The data are from 1990 to 1998 and have been projected until 2010 using the population growth assumptions published in World Energy Outlook 2000.

3.2 Emissions Scenario

In 1990 (Table 2) the major part of carbon emissions was produced by industrialised countries and transition economies. The United States, the European Union (EEU) and the FSU (FSU) accounted for more than 50% of World emissions, while Developing Economies produced 32% of overall emissions and the main contribution was due to China with 11%. Industrialised countries has a carbon emissions per capita more than twice the LDCs average. The picture changes when we consider carbon emissions in relation to GDP. In this case developing countries produce more emissions per GDP unit compared with developed regions. The scenario will slightly change in 2010. Developing countries will produce more than 45% of all carbon emissions. China's share of world emissions is forecasted to increase form 11% to 15%, India's share from 3% to 5%, DAE from 2.6% to 4,5% and EEX countries from 6.6% to 9.6%. The share of emissions of the US, Japan and other OECD countries will remain roughly constant, while it will decrease from 13.8% to 11.5% for the European Union and will be reduced by 50% in FSU and EET because of the reform of the energy sector and the economic recession. The ratio of emissions per capita will remain constant, with the exception of FSU and

EET, even if it will increase in developing countries. Carbon emissions per GDP will generally decrease.

Summarising: the world CO_2 emissions will increased by more than 34% in the 20 years from 1990 to 2010. In particular China, India and Brazil will almost double their emissions. The FSU and the Transition economies will have a sharp decrease due to the reform of the energy sector. Developed countries will increase carbon emissions between 10% for the European Union and 34% for the US.

Indicators such as carbon emissions per GDP and carbon emissions per capita show that industrialised countries are characterised by high carbon emissions per capita and low carbon emission per GDP, while developing countries are characterised by low carbon emissions per capita and relative high carbon emissions per GDP. This means that in terms of energy efficiency industrialised economies are more efficient, even if they present differences.

4. Marginal abatement cost functions

In order to analyse the global market of emission permits we use marginal abatement cost function, In particular, the ones derived by Ellerman and Decaux (1999) by using a CGE model. The marginal abatement cost functions are used to work out the equilibrium in the market of emissions permits. Marginal abatement costs vary across countries, then for a given reduction the cost of meeting it will be different, but in presence of a market of emission permits each country is assumed to reduce emissions until its marginal abatement cost is equal to the emissions permit price. In other words, a country will buy emission permits if its marginal abatement cost is higher then the price of permits, otherwise it will domestically reduce emissions.

The cost of emission reduction is described by the marginal abatement cost (MAC). Using MAC curves, demand and supply of emission permits can be derived. In principle, in order to minimise costs, each country's reduction will be such that the MAC corresponding to that reduction will be equal to the price of the permits. If the reduction so obtained is higher than the requirement, the countries will sell permits, contributing to the supply in the permits market. Conversely, if the reduction is lower than that required, the country will contribute to the demand of permits. The market clearing condition determines the market price of emission permits.

The abatement emissions cost functions are of the form:

$$P = aQ^2 + bQ$$

where Q is the abatement amount in million tons of carbon (Mton) and P is the marginal cost of abatement, or shadow price, of carbon in 1985 US$ as in the Ellerman and Decaux paper (multiplication by 1.5 converts all price and cost data in the Ellerman-Decaux paper and in this paper into current (1998) US dollars).

By integration, the total cost of abatement is:

$$C = \frac{1}{3}aQ^3 + \frac{1}{2}bQ^2$$

the coefficient a and b are different for each country and they are presented in table 3.

5. Emissions Trading and Equilibrium Permit Price

Three different emissions trading scenarios are analysed in this section. First, global emissions trading under the Kyoto Protocol. In this scenario (named Kyoto) all regions are supposed to take part in the trading. Annex1 countries are committed to meet the Kyoto target limit, that is -7% respect to 1990 emission level for United States, -6% for Japan, - 8% for Europe, - 4,5% in aggregated for other OECD countries, - 5% for Eastern Europe countries and 0% for FSU, while Non-Annex1 countries do not have any commitment to meet. An anomaly of the Kyoto Protocol is represented by the fact that for the FSU and the EET emissions are predicted to be below the Kyoto target in 2010. The reform of the energy sector and the economic recession caused a reduction in emissions to a level below the emissions limit imposed by the Kyoto Protocol. The difference between their commitment and predicted emissions is called "hot air", in other words both FSU and EET can export "right to emit" without undertaking any abatement in emissions level. The second scenario (named Kyoto-No hot air) will set a different commitment for the FSU and the EET. In particular their emissions target will be set equal to the projected level of emissions in the year 2010. This will lead to a decrease in the supply of permits and consequently to an increase in the prices. The third scenario (named Kyoto-No Usa), assumes the same limitations on the FSU and the EET as in the second scenario. Further, it assumes that the US will participate in the Kyoto Protocol and reduce their emissions to the level of 1990 without undertaking any further reduction and that developing countries will symbolically reduce emissions by 2% respect to the projected emissions in 2010.

Using the marginal abatement cost functions presented in the previous paragraph we determine the price and the flow of permit in all three scenario. In the Kyoto scenario the price is 6.9 1985 US$/ton of carbon (10.35 in 1998 US$). The price will increase to 15 US$/ton (22.5 in 1998 US$) for the second scenario and to 14.5 US$/ton (21.75 in 1998 US$) in the last scenario. (see tables 6,7,8 for a detailed view of the results).

The enlargement of the market of permits to developing countries will reduce the costs of meet the Kyoto target for industrialised countries. Tables 6, 7 and 8 show that a full global trading will massively reduce total abatement costs for developed countries in all three scenarios, the total abatement cost would be higher in the Kyoto-No hot air and then the net gain from trade slightly lower than in the other two scenarios. A full global trading system would lower total abatement cost for industrialised countries and at the same time would permit developing countries and transition economies to have revenues from the trading.

6. Alternative permit allocation

A crucial aspect of alternative permit allocation schemes is represented by the international support that these alternative schemes might expect to receive. It is reasonable to think that an international agreement, such as the Kyoto Protocol, will be operative only if all countries can benefit from it. The Kyoto Protocol says nothing about the way in which emission permits should be allocated among countries participating in the treaty. In this section we analyses how, and if, an alternative permit allocation scheme would improve the situation of the countries participating in the Kyoto Protocol, and in particular which permit allocation scheme would be preferable in order to induce developing countries to commit themselves to an emissions reduction.

We define the net costs or benefits (in 1985 US dollars) of alternative permit allocation as (following the procedure used in Larsen and Shah 1994):

$$C_j = P\left[E_j^P - \left(E_j - E_j^R\right)\right] - TC_j$$

where P is the price of permit, E_j^P is the allocated volume of permits in tons of carbon for region j, E_j is the level of emissions in the year 2010 for region j, E_j^R is the emissions reduction in region j and finally TC_j is the total cost of reduction for country j. The term in parenthesis on the right hand side represents the costs or revenues from the purchases or sales of permits, while the second term is the total cost of emission reduction. Thus the net cost or the net benefit will be determined by the permit allocation scheme used.

In the following section we consider two different allocation schemes: by population and by GDP. We will work out the analysis for the three different scenarios presented in section 5.

6.1 Permit allocation by population

In this section we will define and analyse the permit allocation by population.

The permit allocation by population is defined for the year 2010 in the following way:

$$E_j^P = E^P\left(\frac{POP_j}{POP_w}\right)$$

where E^P is equal to the world permit level ($E^P = \sum_j E_j^P$). The value that E^P will assume is different according to the considered scenario. It will be equal to the sum of the level of emissions allowed by the Kyoto Protocol for Annex1 countries and of the forecasted level of emissions for Non Annex1 countries in the first scenario. In the second scenario it is equal to the sum of Kyoto Protocol level of emissions without including "hot air" and of the projected emissions level and finally in the third scenario it is equal to sum of emissions for the Annex1 regions (Kyoto targeted emissions for Japan, EEU and OOE, level of emissions of 1990 for USA and forecasted emissions in the year 2010 for FSU and EET) and of forecasted emissions in 2010 reduced of the 2% for Non Annex1 countries.

Permit allocation per capita E^P/POP_w is the same in all countries for each scenario, it is 1.09 tons of carbon in the first scenario and 1.035 tons of carbon both in the second and in the third scenario.

Ratio of permit allocation with respect to carbon emissions in 2010 is presented in table 5.

The ratio is greater than one for developing countries and low income countries, in particularly China, India and DAE will benefit from an allocation by population in term of assigned emissions. It is lower than one for developed countries, transition economies and middle income countries (Brazil). An allocation by population will guarantee a larger amount of permits to developing countries. This result is confirmed in all three scenarios. Industrialised economies such as the US, Japan and the EEU will only receive an amount of permit equivalent to between 18% and 40% of their projected emissions in 2010.

In table 4 we quantify the cost of this scheme of allocation in terms of GDP ratio, by calculating the ratio between the cost of alternative permit allocation scheme as defined in equation 3 and the GDP in year 2010.

China and DAE would slightly benefit under this permits allocation scheme (between 0.1% and 0.5% of GDP). India would gains a net benefit of more than 2% of its GDP.

Developed regions, transition economies and Brazil would be worse off. The net cost would be considerably high for FSU, more than 1.5% of its GDP, whereas for all other countries it would be between 0.2% and 0.3% of their GDP. The permit allocation by population would affect negatively developed regions, even if the amount of cost in terms of GDP would be relatively small, while developing regions would benefit from that or al least not be worse off.

Given the net costs for developed regions, these countries are unlikely to participate in a full global trading scheme based on a permit allocation by population. In the next paragraph we analyse allocation by GDP.

6.2 Allocation by GDP

The permit allocation by GDP is defined for the year 2010 in the following way:

$$E_j^P = E^P \left(\frac{GDP_j}{GDP_w} \right)$$

where GDP_j is country's j GDP in year 2010 US dollars, GDP_w is world aggregate GDP in year 2010 and E^P is equal to the world permit level as defined in the previous paragraph.

Permit allocation per dollar of GDP E^P/GDP_W is the same in all countries for each scenario, it is 0.167 tons of carbon in the first scenario and 0,159 tons of carbon both in the second and in the third one.

Ratio of permit allocation with respect to carbon emissions in 2010 is presented in table 5.

Using an allocation by GDP the ratio is greater than one or very close to one for developed countries and for DAE, while is lower than one for less developed countries, transition economies and middle income countries (Brazil). Brazil and DAE would have more or less the same amount of permit both in allocation by population and in allocation by GDP. An allocation by population would guarantee a larger amount of permits to developed countries. This result is confirmed in all three scenario. Japan, European Union and the other OECD countries would receive an amount of permit between one and two times bigger compared to the case in which no allocation permit scheme are used.

In table 4 it is possible to quantify the cost of this scheme of allocation in terms of GDP ratio. We simply calculate the ratio between the cost of alternative permit allocation scheme as defined in equation 3 and the GDP in year 2010.

It's important to underline the role of hot air in the meeting of Kyoto commitment. In fact "hot air" will guarantee less efforts for developed countries in meeting the constraints, because these countries will benefit from buying reductions units at low cost. In the so called Kyoto scenario, including hot air, the relative costs of a different allocation scheme would be low in terms of GDP, whereas in the Kyoto-No hot air and in the Kyoto-No Usa scenarios, that do not allow for "hot air", the cost of alternative emissions scheme will increase for all developed regions and transition economies and in particularly for FSU (more than 2% of GDP). Developing regions, except for DAE, would be worse off. The net cost would be larger than 0.7% of GDP for India and 0,9% for China.

The permit allocation by GDP would affect mainly developing regions, while industrialised economies would slightly benefit from it.

The two allocation schemes, although presenting different results in terms of net costs and net benefit, show how the Kyoto Protocol appears to be equitable. In fact, the net costs or benefits deriving from alternative permit allocation schemes are relatively small.

7. Conclusion

The first part of the paper focuses on the increasing importance of dealing with the issue of global warming. In the light of the projection of future emissions it seems to be particularly urgent to reach an international agreement that will allow a significant reduction in world carbon emissions. The role of developing countries will be crucial in the future and it's important whether they decide to take commitment to stabilise or reduce their carbon emissions. Recently at the last Conference of the Parties (COP-8), held in New Delhi, developing countries reaffirmed that they will not consider reductions in their emissions if undifferentiated responsibilities will not take in consideration, so that the issue has been postponed to future climate change debate.

As analysed in section 2 the projected emissions would increase by 34% at the world level, but they would almost double in developing countries, which are less efficient from the energetic point of view. In fact carbon emissions to GDP are definitely lower in industrialised economies than in developing countries.

The analysis of a full global trading scheme based on the use of marginal abatement cost allow us to conclude that a full global trading this would reduce the cost of achieving the Kyoto constraints for Annex 1 countries and it would create a new source of export earnings for Non Annex 1 countries, which would be net sellers of permits.

This short paper has evaluated alternative tradable permit allocation, following the procedure used in Larsen and Shah 1994. An allocation by population and an allocation by GDP were analysed. Developing countries would benefit from an allocation by population, and industrialised economies would be worse off, conversely an allocation by GDP made developed countries better off. Even if neither allocation by GDP nor allocation by population appears not to benefit countries overall, the allocation by population appears slightly preferable as it induces developing countries to take part in a full global trading regime. It seems important to convince developing countries to take some measure to mitigate their emissions, but to ensure at the same time it is indispensable to define a fair and equitable burden sharing.

A close related issue is represented by the role played by the level of technology and technological progress. Flexible mechanisms, as international emissions trading, could create incentives for technology transfer between developed countries and developing countries. In fact, the introduction of a global market of permits may foster investment in R&D and force inefficient countries to renew their energy/production system.

The transfer of environmental friendly technology to developing countries could represent an important policy in dealing with reductions of carbon emissions.

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Table 1 – Countries and Regions

Annex 1* United States (USA), Japan (JPN), European Union (EEC), Other OECD Countries (OOE), Eastern Europe (EET), Former Sovier Union (FSU) **Non Annex 1 Countries**** China (CHN), Brazil (BRA), India (IND), Energy Exporting Countries (EEX) (Middle East, Mexico, Venezuela, Indonesia, Andean Pact Countries), Dynamic Asian Economies (DAE) (South Korea, Philippines, Thailand, Singapore,Hong Kong and Taiwan), Rest of the World (ROW) * Developed countries and transition economies ** Developing countries

Table 2: Statistics for years 1990 (base year of the Kyoto Protocol) and 2010

	Carbon Emissions (000 tons)		GDP per capita (US $)		Percent of World Emissions		Carbon Emissions per capita (ton/cap)		Carbon Emissions to GDP (ton/US $)	
	1990	***2010***	***1990***	***2010***	***1990***	***2010***	***1990***	***2010***	***1990***	***2010***
Usa	1,314,318	1,767,757	22,266	36,027	22.52%	22.48%	5.26907	6.03004	0.23663	0.16738
Jpn	292,212	358,485	24,041	36,254	5.01%	4.56%	2.36538	2.80637	0.09838	0.07741
Eec	807,785	903,345	18,825	27,608	13.84%	11.49%	2.35308	2.49960	0.12499	0.09054
Ooe	289,813	388,581	14,156	19,213	4.97%	4.94%	2.11697	2.57966	0.14955	0.13427
Eet	267,499	201,747	1,528	3,069	4.58%	2.57%	2.23450	1.55976	1.46241	0.50828
Fsu	1,011,473	695,185	2,860	1,640	17.33%	8.84%	3.54132	2.51847	1.23827	1.53608
Eex	385,222	758,656	1,893	2,006	6.60%	9.65%	0.82199	0.87350	0.43425	0.43547
Chn	655,497	1,201,591	312	1,311	11.23%	15.28%	0.57745	0.89427	1.84834	0.68192
Ind	184,296	422,793	380	679	3.16%	5.38%	0.21694	0.37621	0.57103	0.55378
Dae	156,596	358,839	2,713	6,840	2.68%	4.56%	0.74835	1.47245	0.27583	0.21526
Bra	55,298	123,972	3,143	5,546	0.95%	1.58%	0.37379	0.65696	0.11892	0.11845
Row	416,545	684,175	756	4,249	7.14%	8.70%	0.35137	0.42785	0.46400	0.10068
World	5,836,554	7,865,132	4,076	6,366	100%	100%	1.111	1.17288	0.26700	0.18424

Table 3: Coefficients of MACs Curves ($P = aQ^2 + bQ$)

Region	a	b	Region	a	b
United States	0.0005	0.0398	EEC	0.0032	0.3029
Japan	0.0255	1.816	China	0.00007	0.0239
European Union	0.0024	0.1503	India	0.0015	0.0787
Other OECD	0.0085	-0.0986	DAE	0.004	0.3774
Eastern Europe	0.0079	0.0486	Brazil	0.5612	8.4974
FSU	0.0023	0.0042	Rest of the World	0.0021	0.0805

*source: Ellerman and Decaux (1999b)

Table 4: Net costs (-) or benefit (+) as percentage of GDP (year 2010)

	Allocation by Population			Allocation by GDP		
	Kyoto	Kyoto No hot-air	Kyoto No-Usa	Kyoto	Kyoto No hot-air	Kyoto No-Usa
United States	-0,137%	-0,295%	-0,284%	0,009%	0,008%	0,008%
Japan	-0,049%	-0,108%	-0,104%	0,098%	0,195%	0,188%
European Union	-0,051%	-0,113%	-0,109%	0,085%	0,171%	0,164%
Other OECD	-0,071%	-0,154%	-0,149%	0,048%	0,092%	0,088%
Eastern Europe	-0,115%	-0,237%	-0,231%	-0,304%	-0,630%	-0,610%
Fsu	-0,770%	-1,675%	-1,618%	-1,328%	-2,833%	-2,734%
Eex	-0,014%	-0,065%	-0,063%	-0,267%	-0,400%	-0,568%
China	0,214%	0,483%	0,460%	-0,466%	-0,678%	-0,902%
India	1,120%	2,325%	2,238%	-0,359%	-0,527%	-0,720%
DAE	0,093%	0,195%	0,188%	0,105%	0,142%	0,213%
Brazil	-0,151%	-0,351%	-0,338%	-0,177%	-0,270%	-0,389%
Rest of the World	0,198%	0,405%	0,391%	0,077%	0,100%	0,149%

Table 5: Ratio of permit allocation to CO_2 emissions (year 2010)

	Allocation by Population			Allocation by GDP		
	Kyoto	Kyoto No hot-air	Kyoto No-Usa	Kyoto	Kyoto No hot-air	Kyoto No-Usa
United States	0,18	0,17	0,17	1,02	0,97	0,97
Japan	0,39	0,37	0,37	2,22	2,11	2,11
European Union	0,44	0,41	0,41	1,89	1,80	1,80
Other OECD	0,42	0,40	0,40	1,28	1,21	1,21
Eastern Europe	0,70	0,66	0,66	0,34	0,32	0,32
FSU	0,46	0,44	0,44	0,11	0,11	0,11
EEC	0,95	0,91	0,91	0,39	0,37	0,37
China	1,22	1,16	1,16	0,25	0,24	0,24
India	2,89	2,75	2,75	0,31	0,29	0,29
DAE	2,14	2,03	2,04	2,31	2,19	2,19
Brazil	0,57	0,54	0,54	0,50	0,48	0,48
Rest of the World	2,87	2,73	2,73	1,70	1,62	1,62

Table 6: Results of Trading in the Kyoto scenario

	USA	JPN	EEC	OOE	EET	FSU	EEX	CHN	IND	DAE	BRA	ROW
Emissions 1990 (Mton)	1,314	292	808	290	267	1,011	385	655	184	157	55	417
Projected Emissions 2010 (Mton)	1,768	358	903	389	202	695	759	1,202	423	359	124	684
Kyoto Target (Mton)	1,222	275	743	274	249	1,011	-	-	-	-	-	-
Kyoto commitment/1990	93%	94%	92%	95%	93%	100%	-	-	-	-	-	-
Reduction/ Projected Emissions	545	84	160	115	-47	-316	-	-	-	-	-	-
Reduction/ Projected (%)	31%	23%	18%	30%	0%	0%	-	-	-	-	-	-
Hot Air (Mton)	0	0	0	0	47	316	-	-	-	-	-	-
Market Price of Permit (US$)	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Cost of Reduction ($ billion)	0.24	0.01	0.09	0.06	0.07	0.13	0.06	0.57	0.13	0.05	0.00	0.12
Permit imp(+)/exp(-) (Mton)	461	80	129	80	-71	-370	-19	-186	-46	-15	-1	-41
Permit imp(+)/exp(-) ($ billion)	3.17	0.55	0.89	0.55	-0.49	-2.55	-0.13	-1.28	-0.32	-0.11	-0.01	-0.28
Permit/Kyoto target	38%	29%	17%	29%	-28%	-37%						
Permit/ Projected Emissions	26%	22%	14%	21%	-35%	-53%	-2%	-16%	-11%	-4%	-1%	-6%
Total Cost ($ billion)	3.41	0.56	0.99	0.61	-0.42	-2.42	-0.07	-0.72	-0.18	-0.06	0.00	-0.17
Total Cost in No trade Case ($ billion)	32.83	9.42	5.22	3.63	-	-	-	-	-	-	-	-
Gain from trade ($ billion)	29.42	8.85	4.23	3.02	-0.42	-2.42	-0.07	-0.72	-0.18	-0.06	0.00	-0.17

Table 7: Results of Trading in the Kyoto-No hot air scenario

	USA	JPN	EEC	OOE	EET	FSU	EEX	CHN	IND	DAE	BRA	ROW
Emissions 1990 (Mton)	1,314	292	808	290	267	1,011	385	655	184	157	55	417
Projected Emissions 2010 (Mton)	1,768	358	903	389	202	695	759	1,202	423	359	124	684
Kyoto Target (Mton)	1,222	275	743	274	202	695	-	-	-	-	-	-
Kyoto commitment/1990	93%	94%	92%	95%	75%	69%	-	-	-	-	-	-
Reduction/ Projected Emissions	545	84	160	115	0	0	-	-	-	-	-	-
Reduction/ Projected (%)	31%	23%	18%	30%	0%	0%	-	-	-	-	-	-
Hot Air (Mton)	0	0	0	0	47	316	-	-	-	-	-	-
Market Price of Permit (US$)	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04	15.04
Cost of Reduction ($ billion)	0.82	0.06	0.34	0.20	0.22	0.41	0.25	2.04	0.47	0.20	0.01	0.40
Permit imp(+)/exp(-) (Mton)	407	76	106	66	-41	-80	-36	-323	-77	-29	-2	-68
Permit imp(+)/exp(-) ($ billion)	6.11	1.14	1.60	1.00	-0.61	-1.20	-0.54	-4.86	-1.16	-0.44	-0.02	-1.02
Permit/Kyoto target	33%	28%	14%	24%	-20%	-12%	-	-	-	-	-	-
Permit/ Projected Emissions	23%	21%	12%	17%	-20%	-12%	-5%	-27%	-18%	-8%	-1%	-10%
Total Cost ($ billion)	6.94	1.20	1.94	1.20	-0.39	-0.80	-0.30	-2.82	-0.70	-0.24	-0.01	-0.62
Total Cost in No trade Case ($ billion)	32.83	9.42	5.22	3.63	-	-	-	-	-	-	-	-
Gain from trade ($ billion)	25.89	8.22	3.28	2.43	-0.39	-0.80	-0.30	-2.82	-0.70	-0.24	-0.01	-0.62

Table 8: Results of Trading in the Kyoto-No Usa scenario

	USA	JPN	EEC	OOE	EET	FSU	EEX	CHN	IND	DAE	BRA	ROW
Emissions 1990 (Mton)	1,314	292	808	290	267	1,011	385	655	184	157	55	417
Projected Emissions 2010 (Mton)	1,768	358	903	389	202	695	759	1,202	423	359	124	684
Kyoto Target (Mton)	1,314	275	743	274	202	695	743	1,178	414	352	121	670
Kyoto commitment/1990	100%	94%	92%	95%	75%	69%	193%	180%	225%	225%	220%	161%
Reduction/ Projected Emissions	453	84	160	115	0	0	15	24	8	7	2	14
Reduction/ Projected (%)	26%	23%	18%	30%	0%	0%	2%	2%	2%	2%	2%	2%
Hot Air (Mton)	0	0	0	0	47	316	-	-	-	-	-	-
Market Price of Permit (US$)	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49
Cost of Reduction ($ billion)	0.77	0.05	0.32	0.19	0.21	0.38	0.23	1.92	0.44	0.19	0.01	0.38
Permit imp(+)/exp(-) (Mton)	318	76	108	67	-40	-78	-20	-291	-67	-21	1	-52
Permit imp(+)/exp(-) ($ billion)	4.60	1.11	1.56	0.97	-0.58	-1.14	-0.29	-4.22	-0.97	-0.31	0.01	-0.76
Permit/Kyoto target	24%	28%	14%	25%	-20%	-11%	-3%	-25%	-16%	-6%	1%	-8%
Permit/ Projected Emissions	18%	21%	12%	17%	-20%	-11%	-3%	-24%	-16%	-6%	1%	-8%
Total Cost ($ billion)	5.38	1.16	1.88	1.17	-0.37	-0.75	-0.06	-2.30	-0.53	-0.12	0.02	-0.38
Total Cost in No trade Case ($ billion)	32.83	9.42	5.22	3.63	-	-	-	-	-	-	-	-
Gain from trade ($ billion)	27.45	8.26	3.33	2.46	-0.37	-0.75	-0.06	-2.30	-0.53	-0.12	0.02	-0.38