

The costs of green house gas emission reductions in the European and Japanese economies under alternative emission trading regimes.

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Abstract

Following the successful outcomes of the COP6 meeting in Bonn in July 2001, it is likely that the path to the adoption of the Kyoto Protocol may still be well alive, despite the withdrawal of the US from the Protocol in March 2001. Among the remaining parties, the European Union and Japan are major players. In this paper, we look at the costs of achieving the Kyoto Protocol targets for the EU and Japanese economies under various assumptions. First we consider the case where the US remains committed to the Kyoto targets, with and without emission trading with the rest of the Annex 1 countries. Although this scenario is unrealistic, it serves to highlight the gains and losses from US participation in international emission trading. Next we consider the case when the US withdraws from its Kyoto targets altogether. Clearly, this will have a direct and significant effect on the overall Kyoto aggregate. The 'indirect' effects on Annex 1 countries, however, are relatively small. Finally, we also experimented with various emission trading regimes within the Annex 1 countries, where the total level of international emission trading is subject to an overall limit to satisfy the so-called supplementary provisions. It turns out that these provisions will have a significant effect on the macroeconomic and international trade variables of these countries but will have only a small effect the marginal cost of emission abatement as expected. We use the latest GTAP version 5 data base and the latest GTAP-E model for our experiments.

Keywords: CO₂ emissions; Abatement costs, Kyoto Protocol, Emission trading, Computable general equilibrium model, Japan, European Union.

1. Introduction

Following the successful outcomes of the COP6 meeting in Bonn in July 2001, it is likely that the path to the adoption of the Kyoto Protocol may still be well alive, despite the withdrawal of the US from the Protocol in March 2001. Among the remaining parties, the European Union and Japan are major players. In this paper, we look at the costs of achieving the Kyoto Protocol targets for the EU and Japanese economies under various assumptions. First we consider the case where the US remains committed to the Kyoto targets, but will not participate internationally in emission permits trading with the

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rest of the Annex 1 countries. Although this scenario is unrealistic, it serves to highlight the gains and losses from US participation in international emission trading. Next we consider the case when the US withdraws from its Kyoto targets altogether. Clearly, this will have a direct and significant effect on the overall Kyoto aggregate. The ‘indirect’ effects on Annex 1 countries, however, are relatively small. Finally, we also experimented with various emission trading regimes within the Annex 1 countries, with the level of international emission trading be subject to an overall limit to satisfy the so-called supplementary provisions. It turns out that these provisions will have a significant effect on the macroeconomic and international trade variables of these countries but will have only a small effect the marginal cost of emission abatement. We use the latest GTAP-E model and data base aggregation for this investigation¹ The outline of this paper is as follows. Section 2 gives details of the experiments. Section 3 describes the results. Section 4 gives some conclusions.

2. Design of the experiments

We conduct two sets of experiments. In the first set, we started with the Burniaux and Truong (2002) “Annex 1 trade” case as a ‘reference’ case. This is the case where unrestricted emission trading among Annex 1 countries is assumed. The case approximates the idealised situation where not only are international emission trading (IET) and Joint Implementaion (JI) mechanisms used to equalise the marginal cost of emission reduction across Annex 1 countries, but domestic emission trading schemes (and / or domestic carbon taxes)² are also used within Annex 1 countries to equalise the marginal cost of emission reduction across all sectors within the domestic economy. Next, we assumes the USA withdraws from international emission trading with other Annex 1 countries, but still keeps its Kyoto commitments and will try to achieve this unilaterally. These assumptions are unrealistic, but the case useful for comparison with the full “Annex 1 trade” case. This will help to highlight the main gainers and losers from Annex 1 trading. Next, we consider the case when the US will not commit to its Kyoto targets and will pursue a policy which is equivalent to imposing no additional carbon tax on domestic users. Again, this assumption may be unrealistic, but it serves to highlight the importance of the US role in the overall Kyoto targets.

In the second set of experiments, we examine the effects of the so-called

¹ For more details on this, see Burniaux and Truong (2002).

² Note that the effects of domestic carbon taxes and the effect of domestic emission trading scheme will be different, especially in terms of income distribution. In the current version of the GTAP-E model (Burniaux and Truong (2002), it is the former rather than the latter that is used to equalise the marginal cost of emission reduction across all sectors within a domestic economy.

supplementary provisions when they are imposed on Annex 1 countries. We first consider the case where only 50% of the full Kyoto targets are allowed to be achieved through international emission trading. We then reduce the limit to 20% and then 10%. Of course, when the limit is 100%, this is equivalent to the reference ‘Annex 1 trading’ case. When the limit reaches 0%, this is equivalent to the ‘no trading’ case as described in Burniaux and Truong (2002).

3. Results

3.1. The effects of US participation in International Emission Trading on Annex 1 countries

Table 1 shows the marginal costs of achieving the Kyoto targets with International Emission Trading with and without the US participation. It can be seen from this Table that the US benefits from Annex 1 trading in the sense that its marginal cost of emission reduction will be reduced from \$124/ton³ of carbon (USA – no trading) to \$78/ton of carbon (USA-trading). The actual reduction in CO₂ emissions in the US is also lower, from –35.6 percent (Kyoto target) to –26.6 per cent. The rest of the reduction is achieved through international permit purchase. As a result of this purchase, household regional income in the US is reduced (from 1.17% increase in the ‘USA no-trading’ case to 0.76% in the ‘USA-trading’ case (see Table 3). Gross domestic production growth in the US, however, is improved as a result of this international trading: it improves from –0.33% in the ‘USA no-trading’ case to –0.17% in the ‘USA-trading’ case. Similarly for inflation (1.47% increase in the price level in the ‘USA no-trading’ case is reduced to just 1.06% increase in the ‘USA-trading’ case).

Among the Annex 1 countries, the EEFSU is the region which benefits the most out of this international emission trading regime. This can be seen from EEFSU’s welfare gains (\$US 10.5 billion in the ‘USA no-trading’ case increased to \$US 20.8 billion in the ‘USA trading’ case). The terms of trade of the EEFSU is also seen to be improved from 0.26% in the ‘USA no-trading’ case to 0.92% in the ‘USA trading’ case (see Table 2), and regional income is also increased (from 3.18% in the ‘USA no-trading’ case to 5.89% in the ‘USA trading’ case - see Table 3). Only GDP growth in the EEFSU seems to suffer from the switch to a ‘specialisation’ in ‘emission reduction’ activities (a kind of ‘Dutch Disease’ as applied to emission trading). The percentage change in GDP in the EEFSU is reduced from a –0.29 % (in the USA no-trading case) to a –0.59 % (in the USA-trading case).

US participation in international emission trading, however, will bring some costs to the EU and Japan: This is because there will be an increase in the price of emission permits as a result of US participation in the market: from \$49.3/ton of carbon (in the case of ‘USA no-trading’ case to \$78/ton of carbon in the case of ‘USA-trading’ case). Since both the EU

³ These are 1997 US dollars.

and Japan are purchasers of emission permits, they will have to pay a higher price for the international permits, as well as, at the domestic level, have to incur higher marginal costs of emission reductions because they cannot afford to buy as much of the emission reduction from the international market as before US participation. Both of these effects will reduce the welfare GDP growth in both the EU and Japan as can be seen from Tables 2 and 3. In Table 3, GDP growth in the EU and Japan are seen to worsen from -0.07% to -0.22% (for the EU) and from -0.09% to -0.19% (for Japan) as a result of the US participation in international emission trading. Welfare level also decreases, from -\$7.3 billion to -\$19 billion for the EU, and from -\$5 billion to -\$9.7 billion for Japan. This implies that when the US withdraws from the Kyoto commitments (the last three columns in Table 3), the effects on the EU and Japan are actually positive: GDP growth performance improves (from a -0.22% to -0.17% for the EU, and from -0.19% to -0.12% for Japan). The effect of US withdrawal from the Kyoto commitments on the EEFSU is also positive in terms of GDP performance. This is the result of the reversal of the 'Dutch Disease' effect. GDP growth in the EEFSU improves from -0.59% to -0.24% when the US withdraws from the Kyoto commitments. Of course, all these 'positive effects' come at the 'expense' of the world environment: the aggregate Kyoto commitments for all Annex 1 regions now stands at only -7.8 percent in emission reduction, as compared to -22.1% emission reduction if the US commits.

3.2. The effects of Supplementary Provisions on Annex 1 Trading

Tables 4-6 show the results of experiments which seek to quantify the effects of the imposition of 'supplementary provisions' on Annex 1 trading of emissions. Firstly, we observe that the provisions may not have any effect on Annex 1 trading (even with US participation)⁴ unless the limit is set below 50%. Table 5 shows that with a 50% limit, only Japan is affected, and only slightly (Japan needs to reduce emission by at least -15.9 percent domestically to satisfy this condition, and this is just slightly below the result reached without any restrictions: -15.2%). As a result, the case of 50% emission trading limitation is very close to the 'reference' case of full annex 1 trading without restrictions. Next, we assume the limit is lowered to 20% of the quota level. In this case, all Annex 1 countries are affected. As a result, the marginal cost of emission reduction is now higher for all Annex 1 countries (with the exception of the EEFSU which is a seller of emission permits, and hence it will have to reduce the 'supply' of emission reductions, and this leads to lower cost). The marginal cost of emission reduction is now almost doubled for the EU, and more than doubled for Japan, but increased only slightly for the US. Given that this is the case, it is interesting to note that it is the EU rather than the US which wants to impose the supplementary provisions on international emission trading (for reasons other than economics). Imposing limits on international emission trading reduces the welfare of all trading countries (with the exception of the USA, which benefits slightly from this emissions trade restriction) (see Table 5). The reduction in welfare primarily comes from an increase in allocative inefficiency which comes from emission trading restrictions. This negative welfare effect, however, is balanced to some extent by the positive effects of an

⁴ We expect that with the US participation the amount of emission trading will be greater and hence the supplementary provisions or 'limits' are more likely to become binding than if the US did not participate.

improvement in the terms of trade which resulted from a reduced volume of emission trade. In most cases, the (negative) allocative inefficiency effect overwhelmed the (positive) terms of trade effects. As a result, most Annex 1 countries experienced a decrease in welfare when the limits on emission trading is increased (from 50% to 80%, i.e. the 'ceiling' on trading is lowered, from 50% to 20% of the Kyoto targets). One exception is the US, which experienced some small net gains in welfare when this limit on trading is increased (see Table 5, columns 1 and 3, row 1). International emission trade restriction will bring less benefits to the EEFSU in terms of regional income changes because the regions earns a substantial amount of its regional income from this trade. Other regions, however, will experience the reverse (see Table 6). In terms of the effect on GDP growth, however, emission trade restrictions will cause inefficiencies in those countries which easily achieve the Kyoto targets within the domestic economies such as the EU and Japan, (and to some extent, the US), but it will benefit the EEFSU domestic economy, because there will now be less of the 'Dutch Disease' effect.

Finally, if the cap on emission trading is reduced still further from 20% to 10% of the Kyoto targets, then this approaches the situation of 'no Annex 1 trading' (as examined in more details in Burniaux and Truong (2002)).

4. Conclusion

We have shown in this paper that the withdrawal of the US from the Kyoto Protocol will have a significant adverse effect on the Kyoto aggregate, and hence on the world environment as a whole, but within Annex 1 countries, this does not alter significantly the basic picture of the flow of benefits and costs associated with emission trading between the remaining Annex 1 countries. With the exception of the EEFSU, which stands to gain substantially from the participation of the US in Annex 1 emission trading, the rest of the Annex 1 countries do not suffer any substantial losses from the US withdrawal. In fact, in some cases, they may even stand to gain from the US withdrawal. But of course, this must be balanced against the potential losses from deterioration in the world (economic and natural) environment when the US withdraws from its Kyoto 'obligations'. Secondly, the paper also shows that by imposing limits on emission trading between Annex 1 countries, the EU and Japan may stand to lose a great deal from its potential benefits (as compared to the US which does not suffer greatly from the imposition of these limitations), unless, of course, the limits are non-binding. Fortunately, it may look like any limits on international emission trading which allows for up to 50% of the Kyoto targets to be traded internationally may be non-binding, and hence they can survive both politically as well as economically.

4.1. Reference

Burniaux J.M., and Truong P. Truong. 2002. "GTAP-E: an Energy-Environment Version of the GTAP Model" GTAP Technical Paper No 16 (Revised), Center for Global Trade Analysis, Purdue University, West Lafayette, Indiana, USA. January.

Table 1 Marginal Costs of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA.

	Kyoto with Emission Trading (trading includes the USA)		Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)		Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)	
	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)
USA	-26.6	77.9	-35.6	123.9	0.5	0
EU	-13.9	77.9	-9.0	49.3	-9.7	43.8
EEFSU	-26.6	76.4	-19.4	48.9	-18.4	43.3
JPN	-15.2	78.0	-10.0	49.3	-10.5	43.8
RoA1	-20.9	78.3	-14.2	49.5	-14.5	43.9
Eex	2.0	0	2.1	0	0.5	0
CHIND	-0.5	0	-0.3	0	-0.6	0
RoW	3.7	0	3.4	0	1.4	0
Annex 1 (with USA)	-22.1		-22.1		-7.8	
Annex 1 (without USA)	-19.2		-13.3		-13.3	
Non-Annex 1	1.3		1.4		0.2	
Leakage rate (%)	3.7		3.9		4.4	
Leakage rate (%) (excl. USA)	na		na		2.0	

Note that the marginal costs are expressed in real terms (i.e. deflated by the GDP deflator of each country/region). Therefore, slightly different marginal costs in case of emission trading are consistent with a common trading price of nominal terms

Table 2 Macroeconomic effects of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA (welfare change and terms of trade)

	Kyoto with Emission Trading (trading includes the USA)		Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)		Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)	
	EV (*)	Terms of trade	EV (*)	Terms of trade	EV (*)	Terms of trade
USA	-18.8	0.54	-17.5	0.96	0.3	0.03
EU	-19.0	0.20	-7.3	0.18	-16.5	0.07
EEFSU	20.8	0.92	10.5	0.26	9.9	0.57
JPN	-9.7	0.66	-5.0	0.63	-7.3	0.23
RoA1	-11.4	-0.56	-9.3	-0.71	-6.3	-0.14
Eex	-15.3	-2.19	-16.2	-2.34	-4.4	-0.62
CHIND	0.6	-0.01	0.8	0.06	0.0	-0.06
RoW	3.3	0.22	3.6	0.25	0.7	0.04

(*) Equivalent Variation (EV), in \$US billion.

Table 3 Macroeconomic effects of Achieving the Kyoto Targets with International Emission Trading, With and Without the USA (regional income, GDP quantity and price level changes)

	Kyoto with Emission Trading (trading includes the USA)			Kyoto with Emission Trading (trading does not include the USA but the USA unilaterally commits)			Kyoto with Emission Trading (trading does not include the USA and the USA does not commit)		
	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)
USA	0.76	-0.17	1.06	1.17	-0.33	1.47	0.21	0.00	0.21
EU	0.77	-0.22	1.07	0.70	-0.07	0.84	0.23	-0.17	0.46
EEFSU	5.89	-0.59	3.10	3.18	-0.29	1.69	2.81	-0.24	1.50
JPN	0.66	-0.19	0.97	0.67	-0.09	0.85	0.17	-0.12	0.38
RoA1	-0.10	-0.39	0.55	-0.09	-0.21	0.37	-0.14	-0.22	0.27
Eex	-0.84	-0.02	-0.71	-0.95	-0.01	-0.83	-0.19	-0.01	-0.15
CHIND	0.66	0.05	0.60	0.63	0.06	0.57	0.23	0.01	0.22
RoW	0.80	0.04	0.74	0.75	0.04	0.70	0.28	0.01	0.26

(a) percentage change in regional household income; (b) percentage change in GDP quantity index; (c) percentage change in GDP price index.

Table 4 Marginal Costs of Achieving the Kyoto Targets for Annex 1 countries with International Emission Trading and with Supplementary Provisions

	Kyoto with Emission Trading (trading includes the USA)					
	Up to 50 per cent of Kyoto targets are allowed for trading		Up to 20 per cent of the Kyoto targets are allowed for trading		Up to 10 per cent of the Kyoto targets are allowed for trading	
	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)	% Reduction of Emissions	(1997 USD per Ton of Carbon)
USA	-26.6	78.0	-28.5	87.2	-32.0	105.0
EU	-13.9	78.4	-20.2	124.4	-20.2	124.4
EEFSU	-26.3	74.3	-6.1	16.5	0.8	4.1
JPN	-15.9	82.5	-28.6	190.4	-28.6	191.1
RoA1	-20.9	78.5	-32.1	147.2	-32.1	147.4
Eex	2.0	0	2.1	0	2.3	0
CHIND	-0.5	0	-0.9	0	-0.8	0
RoW	3.7	0	3.9	0	3.9	0
Annex 1 (with USA)	-22.1		-22.1		-22.1	
Non-Annex 1	1.3		1.2		1.3	
Leakage rate (%)	3.7		3.5		3.7	

Note that the marginal costs are expressed in real terms (i.e. deflated by the GDP deflator of each country/region). Therefore, slightly different marginal costs in case of emission trading are consistent with a common trading price of nominal terms

Table 5 Macroeconomic Impacts of Implementing the Kyoto Protocol for Annex 1 countries with International Emission Trading and with Supplementary Provisions (welfare change and terms of trade)

	Up to 50 per cent trading allowed		Up to 20 per cent trading allowed		Up to 10 per cent trading allowed	
	EV (*)	Terms of trade	EV (*)	Terms of trade	EV (*)	Terms of trade
USA	-12.6	0.62	-10.6	0.73	-13.2	0.85
EU	-14.9	0.22	-28.6	0.29	-27.7	0.29
EEFSU	6.3	0.29	-2.2	-0.64	-2.7	-0.76
JPN	-7.0	0.75	-18.7	1.16	-18.3	1.19
RoA1	-9.7	-0.54	-14.6	-0.54	-14.6	-0.59
Eex	-15.5	-2.21	-18.0	-2.56	-18.8	-2.69
CHIND	0.6	0.00	0.7	0.00	0.8	0.02
RoW	3.3	0.22	3.9	0.25	3.8	0.25

(*) Equivalent Variation (EV), in \$US billion.

Table 6 Macroeconomic Impacts of Implementing the Kyoto Protocol for Annex 1 countries with International Emission Trading and with Supplementary Provisions (regional income, GDP quantity and price level changes)

	Up to 50 per cent trading allowed			Up to 20 per cent trading allowed			Up to 10 per cent trading allowed		
	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)	y (a)	qgdp (b)	pgdp (c)
USA	0.92	-0.17	1.14	1.17	-0.20	1.36	1.27	-0.26	1.51
EU	0.80	-0.22	1.05	0.90	-0.44	1.34	0.93	-0.43	1.36
EEFSU	3.08	-0.72	2.06	0.28	-0.10	0.33	0.03	-0.07	0.14
JPN	0.80	-0.19	1.04	1.04	-0.55	1.61	1.07	-0.55	1.64
RoA1	0.07	-0.38	0.60	0.07	-0.79	0.94	0.08	-0.79	0.93
Eex	-0.86	-0.02	-0.73	-0.99	-0.03	-0.85	-1.06	-0.03	-0.91
CHIND	0.65	0.05	0.60	0.76	0.06	0.70	0.78	0.06	0.72
RoW	0.79	0.04	0.73	0.95	0.05	0.89	0.93	0.05	0.87

(a) percentage change in regional household income; (b) percentage change in GDP quantity index; (c) percentage change in GDP price index

