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Should developing countries take on binding commitments in a climate agreement?

A cost-benefit analysis

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Sammendrag:. Denne artikkelen vurderer kostnader og nytte for alle parter til en framtidig klimaavtale ved at utviklingsland påtar seg bindende forpliktelser. Slike forpliktelser ville gi utviklingsland muligheten til å delta i kvotehandel, som har betydelig lavere transaksjonskostnader enn dagens grønne utviklingsmekanisme (CDM). Vi vurderer hvorvidt effektivitetsgevinsten fra å delta i kvotehandel kan være stor nok til å utligne den økonomiske risikoen som følger av å påta seg bindende forpliktelser (som skyldes at størrelsen på framtidige utslipp er ukjent). Vi bruker en dynamisk likevektsmodell for å utføre denne analysen. Vi finner at effektivitetsgevinsten som utviklingsland kan oppnå ikke nødvendigvis er spesielt stor sammenlignet med den risikoen de pådrar seg. Utviklingsland kan derfor ha gode grunner til å ikke gå inn for en avtale som setter et tak på deres utslipp.

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Abstract: This paper explores the costs and benefits for all parties to a future climate agreement of developing countries taking on binding commitments. Such commitments would allow developing countries to participate in emissions trading, which has significantly lower transaction costs than the present Clean Development Mechanism (CDM). Thus we analyse whether the efficiency gains obtained by participating in emissions trading can offset the economic risk (due to the fact that future emissions cannot be known) incurred by taking on binding commitments. We use a dynamic computable general equilibrium model to carry out the analysis. We find that the efficiency gains that can be obtained by developing countries might not be very large compared to the risks they incur. Developing countries might therefore have good reasons not to embrace "cap and trade" emissions trading.

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1 Introduction

An important question when discussing a regime for regulating greenhouse gas emissions beyond the first Kyoto commitment period is: On what terms would developing countries be willing to join a climate agreement with binding commitments to reduce emissions? At present, developing countries take part in the climate agreement by being parties to the United Nations Framework Convention on Climate Change (UNFCCC) and through the Clean Development Mechanism (CDM) under the Kyoto Protocol. The CDM is one of the flexibility mechanisms[1] and offers Annex B parties (i.e., participating developed countries) the opportunity to obtain cheap emission reduction credits. The Annex B country invests in a greenhouse gas abatement or sequestration project in a developing country and receives emission credits in return that can be used to meet its Kyoto targets.

The economic gain from getting developing countries to take on binding commitments is connected to the gain from replacing the CDM with ordinary ("cap and trade") emissions trading. The CDM is a system for trading emission reductions (or rather credits) instead of emission allowances, as with emissions trading. The form of trading used in the CDM is often referred to as "credit trading," and most authors argue that it implies higher transaction costs compared to emissions trading. For example, Jotzo and Michaelowa (2002) estimate that transaction costs will be \$0.65[2] per ton of carbon-dioxide equivalent (t CO_2e) higher for the CDM than for the emissions trading mechanism, while in a different study by Michaelowa and Jotzo (2003) they find a difference in transaction costs of \$0.17/t CO_2e. The differences between these two studies stem from the differences in the assumptions used. Stavins (1995) identifies three components of the transaction costs in a tradable permit market: search for information, bargaining and decision, and monitoring and enforcement. The CDM would probably involve higher transaction costs in all three components, but this would of course depend on the institutional framework chosen for the flexibility mechanisms. In our study we will therefore assume higher transaction costs for the CDM than for emissions trading (discussed further in section 2).

Emissions trading would require the developing countries to participate in a climate agreement with binding commitments for emissions of climate gases, and hence would permit them to trade the allowances obtained from the binding commitments that they have agreed to. However, taking on binding commitments might cause developing countries to incur higher risks through higher than expected costs of "business-as-usual" (BAU) emissions. There is uncertainty regarding developments such as income growth, meaning that a cap might become binding in a costly way if, for example, growth rates turn out to be higher than expected. If developing countries were to be given a cap that is too low compared to their actual BAU emissions, they would risk being worse off under an emissions trading scheme than with the CDM. With the CDM this risk is eliminated since it does not rely on setting any limit on emissions from developing countries; instead it allows them to sell "abatement" projects in which emission reductions are calculated based on a project-specific baseline.

Hence, in this paper we analyse whether the efficiency gains obtained by participation in emissions trading could offset the economic risks that would be incurred by taking on binding commitments without knowing what future emissions might be.

Several other authors have analysed the issue of developing countries participating in a climate agreement. The paper by Peck and Teisberg (1999) explores the incentives for

[1] The other two flexibility mechanisms are emissions trading (which is discussed later in the paper) and joint implementation – which allows credits from emissions reduction projects to be transferred between Annex 1 parties.

[2] All prices are given in US dollars.

participating in international CO_2-control agreements using tradable emission permits. In their model, damages from climate change are included. They conclude that the Kyoto Protocol transfers wealth from the Annex I countries to the non-Annex I countries, but that the protocol fails to realize the hoped-for efficiency gains from an agreement to control CO_2 emissions. Their study is based on the CETA model, which is a partial equilibrium model focusing on the energy sector and global warming. Two other numerical studies that analyse the importance of developing country participation are Zhang (2001) and Manne and Richels (1996). Bohm (2002) discusses ways in which the next climate agreement could be made more effective by facilitating early participation from developing countries. He focuses on the design of the compensation rule, the need to regulate the use of the CDM, the effect of allowing borrowing and the implications of a Commitment Period Reserve.

Our study departs from these earlier studies in some significant ways. We employ a dynamic computable general equilibrium model, and take into account the transaction costs of the CDM. We focus on the possibilities for developing countries to join a post-Kyoto agreement with binding commitments, while most other numerical studies of this kind have concentrated on the Kyoto agreement itself. Our model also takes into account the costs (the increased economic risk) of replacing the CDM with emissions trading.

Our study shows that there is a considerable gain to be achieved from getting developing countries to join an agreement that includes emissions trading in a second commitment period after Kyoto, as compared to the gains that would be obtained through their continued participation in the CDM. However, the economic gains for developing countries from joining an agreement that includes emissions trading are quite low compared to the economic costs of having higher BAU emissions than expected. Developing countries might therefore have good reasons not to embrace the cap and trade emissions trading, even if they could do so with constraints equal to their expected BAU emissions. We conduct sensitivity analyses that confirm the robustness of these findings.

2 The model

The DEEP model used in this study is a multi-sectoral, multi-regional, multi-gas dynamic CGE model. The production and demand structures are based on the GTAP-EG model (Rutherford and Paltsev 2000), with some modifications in the production structure for fossil fuels. Non-CO_2 emissions are modelled as in the EPPA model (Hyman et al. 2002). The trade data used is from the GTAP (v5) database, while the emissions data is from the GTAP/EPA Project "Towards an Integrated Data Base for Assessing the Potential for Greenhouse Gas Mitigation." The model is fully described in Kallbekken (2003). The growth[3] and technological change parameters in the model are based on the IPCC SRES A1B scenario (Nakicenovic and Swart, 2000)[4]. Table 1 lays out the regional aggregation of the model.

In the model, we assume that the Kyoto Protocol is implemented with emissions trading among the Annex B regions. Furthermore, we assume that the protocol is extended for a second five-year period, with emission constraints remaining the same for the second commitment period. Each Annex B region is given an endowment of tradable emission permits equal to its Kyoto commitment. The emissions trading market is modelled as an international trading pool (where all regions initially sell all their permits, before the sectors in each region purchase – at a world price – the permits that they need). The Annex B regions can bank their permits from the first to the second commitment period.

[3] Note that in the model, growth is determined through an exogenous growth rate for consumption.

[4] The SRES A1B scenario assumes "rapid and successful economic development," whereby the global economy grows at an average annual rate of 3%, and whereby technological progress is rapid.

Table 1 Regions in the model, region code and full region name.

	Region code	Full region name
Annex B	EU	European Union
	SEL	Permit exporting regions (Former Soviet Union, Eastern and Central Europe)
	RAB	Rest of Annex B (Japan, EFTA, Canada, New Zealand)
(Annex B)	USA	Kyoto Rejecting Countries (USA and Australia)
CDM regions	BRA	Brazil
	CHN	China
	IND	India
	OPE	OPEC countries
	ROW	Rest of World (Asia, Africa, Latin America, Pacific)

CDM credits can be generated by any non-Annex B country (hereafter called CDM countries) that undertakes emission reduction projects that reduce emissions below the estimated baseline emissions. If we regard the BAU emissions of these countries as the baseline, then any reductions in emissions below this level can be regarded as generating CDM credits. Conceptually, this is the same as the CDM countries having an emission constraint that is exactly equal to their BAU emissions.

We have chosen to include “carbon leakage” in the BAU emissions. “Carbon leakage” is the term used to describe the fact that when one region imposes an emission constraint, this will reduce the competitiveness of its emission-intensive industries, and some of the activity in these industries will be shifted to regions without such constraints. The reason for including carbon leakage emissions is that in the absence of the CDM, these additional emissions would actually take place as Annex B countries implement the Kyoto Protocol. Compared to the option of excluding carbon leakage, this will give developing countries larger allowances, and therefore lower the permit prices in the model.

The CDM credits are sold to Annex B countries, which use these credits to meet their Kyoto commitments. Because it is expected that a credit and baseline system such as the CDM would have higher transaction costs than a cap and trade system such as emissions trading, we impose transaction costs on these trades in the model; when a CDM credit is sold, we impose a tax of $0.50 per ton of Ce (carbon equivalent). This amount is supposed to reflect the *difference* in transaction costs between the CDM and emissions trading, and the amount we use lies between the two estimates by Jotzo and Michaelowa (2002 and 2003). Introducing a difference in transaction costs would have the effect of increasing the price of CDM projects relative to emissions trading, thus reducing the scope for efficiency-enhancing trades (and the number of profitable CDM projects).

In the scenarios where developing countries take part in (cap and trade) emissions trading, they do so in the same way as any other Annex B country and without any transaction costs.

3 Basic scenarios

3.1 Description of the scenarios

We begin by running the model for specific scenarios that have different assumptions regarding the use of the Kyoto flexibility mechanisms. These scenarios are called *no trade,* *CDM* and *ET* (emissions trading) in reference to the assumptions we make about the period following the first commitment period of the Kyoto Protocol (assumed to be the period 2013-2017). For all these scenarios we assume that the United States and Australia stick to their decision not to ratify the protocol.

In the *no trade* scenario, the Kyoto Protocol is implemented as intended, with full emissions trading between Annex B regions, but the developing countries do not participate either through the *CDM* or *ET*. Hence they do not carry out any abatement. This scenario is introduced as a basis for comparing the *CDM* and *ET* scenarios, and also in this section as a means to compare our study to other studies. In the *CDM* scenario, the CDM regions generate and sell permits as intended under the Kyoto Protocol. Finally, in the *ET* scenario, CDM regions take part in emissions trading on an equal footing with Annex B regions in the second commitment period, with an emission constraint that is equal to their BAU emissions.

Using scenarios that differ on the basis of the flexibility mechanisms in the Kyoto Protocol is useful in exploring the economics of moving from *no trade* to *CDM* to *ET*. Economic theory predicts that when transaction costs are removed, efficiency will increase in the emissions trading market, and so might also overall welfare.

In running the three scenarios in the model, and comparing our results with those of other studies, we are primarily interested in the impacts on permit prices and permit trading since these elements are the easiest ones to compare between studies. In our discussion we will focus on the welfare effects (costs and benefits).

3.2 Permit prices and estimates in literature

The results of going from *no trade* to *CDM* to *ET* are not very surprising: The permit price in Annex B countries decreases as we move from the *no trade* to the *CDM* scenario. More specifically, the prices drop from $13.00 to $2.08 (always stated as per ton carbon equivalent). When we move from the *CDM* to the *ET* scenario, the permit price falls by a further $0.20. These results are shown in table 2.

Table 2 Permit prices ($ per ton Ce) and banking* for the different scenarios of the use of the flexibility mechanisms

	No trade	*CDM*	*ET*
ET price	$13.00	$2.08	$1.86
CDM price	$0.61	$1.58	$1.36
Banking	7.02%	5.69%	4.10%

*Banking is measured in % of total Annex B endowment banked.

If we look at the Annex B countries as a block in the *CDM scenario*, they meet 7.6% of their commitments through purchases of CDM permits in the first commitment period, and 11.4% in the second commitment period. They also bank 5.7% of their permits to the second commitment period.

Our results are broadly consistent with results from other studies, though towards the lower end of the range in terms of permit prices. The IPPC Third Assessment Report (IPCC, 2001) provided estimates on marginal abatement costs with global trading for 15 models. The marginal abatement costs ranged from $1.40 to $33.00 per ton CO_2. Apart from two studies, all of these models come up with a marginal abatement cost estimate below $15.00. These results depend crucially on a number of assumptions and model characteristics. Most of these models do not include gases other than CO_2, and this results in a higher permit price. Also, leaving out the CDM increases the price (because fewer cheap abatement options are available).

A particularly relevant comparison is Lucas et al. (2002). The model used in their paper includes all six Kyoto Protocol greenhouse gases, the CDM and banking of permits, and it also uses the SRES A1B scenario. It is, however, a partial equilibrium model that includes market power (we do not include market power in our model, something which would have increased the ET permit price). Within this framework they find a permit price of $3.00. This set-up is comparable to our *CDM* scenario price of $2.08.

The study by Jotzo and Michaelowa (2002) includes the CDM (with transaction costs), but CO_2 is the only Kyoto Protocol gas that is included. They find an international permit price of $3.78.

3.3 Welfare effects

As we move from the *no trade* to the *CDM* scenario and from the *CDM* to the *ET* scenario, we expect to see global welfare gains, and this is indeed what our results show. Global welfare increases as we move from *no trade* to *CDM* and to *ET*.[5]

The Annex B "permit sellers" region experiences a welfare loss in moving from the *no trade* scenario to *CDM* and to *ET*. This is because this region receives significant profits from sales of "hot air," and these profits are hurt when the permit price decreases. All other regions gain by moving from *no trade* to *CDM* or *ET* with the exception of Brazil, which experiences a small welfare loss in both the *CDM* and the *ET* scenarios as compared to the *no trade* scenario. Among the CDM regions, India gains the most from moving towards more unrestricted trade (from *no trade* to *CDM*, and from *CDM* to *ET)*, while the "rest of the world" (ROW) region experiences very meagre gains. The welfare effects are listed in table 3.

Table 3 Welfare changes (% change in equivalent variation (EV) compared to the *no trade* scenario).

	CDM	**ET**
EU	+0.046	+0.060
SEL	-0.450	-0.449
RAB	+0.051	+0.065
USA	+0.008	+0.014
BRA	-0.019	-0.015
CHN	+0.022	+0.037
IND	+0.095	+0.135
OPE	+0.023	+0.036
ROW	+0.001	+0.013
Global	**+0.009**	**+0.021**

[5] Welfare is measured as percent change in equivalent variation for the 20-year duration of the scenarios. When we discuss the welfare changes, and do not provide absolute numbers, then changes are always measured relative to the *no trade* scenario.

The variation in welfare effects between regions can largely be explained by the different economic structures of the regions, and the price changes that accompany changes in the permit price. One main effect is that, in our model, permit sellers lose, and buyers gain when the permit price decreases. This is the main reason behind the welfare losses that the "Seller" region experiences when moving from the *no trade* to the *CDM* and to the *ET* scenario. CDM regions experience a welfare gain for two different reasons: As we move from the *no trade* to the *CDM* scenario, the CDM regions find themselves in a position to sell a number of their profitable abatement projects. As we move from the *CDM* to the *ET* scenario, the CDM regions are able to sell more permits at the same Annex B permit price, as the difference in transaction costs (between CDM and Annex B regions) is removed in the second commitment period.

However, the gains and losses experienced by different countries in the permit market cannot fully explain the welfare effects. The changes in permit prices will also influence the prices of energy and other goods. In general, the changes in the prices of energy goods and other goods are small, typically less than 1% as one moves from *no trade* to *CDM* to *ET*. As permit prices decline in Annex B countries, and increase in CDM countries, one would expect an increased demand (and hence an increased price) for "dirty" goods, and a decreased demand for "clean" goods in Annex B countries, and the opposite in CDM countries. To some extent this is what happens: The price of crude oil increases in all Annex B regions, and decreases in all CDM regions (where there is any change). The price changes for natural gas, which is a relatively clean fuel, are in the opposite direction; the price increases in China, OPEC and the ROW region, while it decreases in all Annex B regions.

4 Uncertainty about BAU

When developing countries take part in emissions trading instead of the CDM, it produces an economic gain. This gain can, in principle, be used in different ways; it can be distributed to regions that are reluctant to join the agreement, or to countries that take an economic risk by signing the agreement. Global gains amount to $6.2 billion (table 4).[6] Developing countries receive a little more than half the total gain. The global gains are estimated by comparing the welfare in the different scenarios with what we assume would happen if developing countries were to choose not to join a climate agreement with binding commitments.

Table 4 Gain in US$ million from moving from *CDM* to *ET*

EUU	2021
SEL	12
RAB	1318
USA	--
BRA	122
CHN	646
IND	684
OPE	272
ROW	1090
Total	**6163**

[6] These estimates are in line with what one would expect. As a rough estimate of the expected gain from replacing CDM with emissions trading for developing countries, we could multiply the reduction in the permit price ($0.50), by the total emission endowments of the developing countries (10.3 billion tons), and get a value of $5.2 billion.

Now assume that developing countries would be willing to join an agreement under which they would be at least as well off as they would be if they were to continue the current agreement (Kyoto Protocol) with no changes.

An emissions trading system requires, however, that each country take on binding emission constraints. So far we have assumed that caps have no costs for developing countries, as they each would be given a cap equal to their respective BAU emissions. In our model we can know these emissions with certainty. In reality, if developing countries were to accept a cap, there would be uncertainty regarding developments such as income growth, meaning that a cap might become binding in a costly way if, for example, growth rates turn out to be higher than expected. If developing countries are given a cap that is too low compared to their respective actual BAU emissions, they risk being worse off with emissions trading than with the CDM. The uncertainty concerning the growth in actual (BAU) emissions would be an important consideration in the negotiation of a climate agreement, and could be a reason for developing countries to demand more compensation.[7]

To examine this question we have considered to what degree the actual emissions of developing countries can differ from their estimated BAU emissions before they would experience an actual loss (compared to their continuing in a CDM agreement). In our calculations, we use the efficiency gains that are obtained to compensate the developing countries for the loss incurred by "incorrect" estimates of BAU. The extent to which actual emissions can be different from estimated BAU emissions without developing countries experiencing a loss is referred to as the "buffer for uncertainty" in BAU emissions.

We find that developing countries have an average buffer of 4.1%[8] (table 5). We also consider the case in which, as an added incentive for joining an agreement, the developed countries redistribute to developing countries the gains that they obtain from the participation of developing countries in emissions trading. With such redistributions, the buffer size increases to 9.0% on average.

Table 5 Buffer size (% of emissions)

Brazil	3.7
China	2.9
India	5.3
OPEC	3.8
ROW	4.7
Average	4.1
With all gains	9.0

However, the buffers afforded by the gains are very small compared to what a different assumption about growth implies. If we take the SRES A1B scenario as a basis and increase the annual growth rate by 1%, this would result in 23.8% higher emissions by developing countries in the second commitment period. If we instead reduce the growth rate by 1%, the

[7] This would mean that when they negotiate in the first period, they would take into account the option value of getting new information in the next period. The option value of new information argument and its implications are discussed by Fisher and Hanemann (1986).

[8] That is, they can be given an allowance that is 4% lower than their actual emissions, and still be as well off as with the CDM.

emissions in the second commitment period would be 16.5% lower for the developing countries as a group. This could mean that the compensation available through the efficiency gains obtained by developing countries for going from the CDM to emissions trading could be too small to sufficiently compensate them for the risk involved in joining an agreement with binding commitments[9].

5 Sensitivity analysis

We have carried out sensitivity analyses for some of the key parameters in the model. First, we have run the model with growth rates that are 1% above and below the rates in the SRES A1B scenario (reported as *grow-less* and *grow-more*). We have run the model with discount rates of 3% and 7% (reported as dis3 and dis7), as compared to the rate of 5% used in the main scenarios, and we have also tested the effect of assuming different transaction costs – $0.10 and $0.80 (reported as trans1 and trans8). Finally, we have tested the effect of changing policy assumptions – by letting the United States and Australia take part in the Kyoto Protocol in the second period. Tables 6, 7 and 8 summarise some of the results.

The greatest effects are caused, unsurprisingly, by changing the growth rates. The extent of the effects is surprising though (at least initially): When growth is reduced by 1%, the permit price in the *no trade* scenario falls to $1.00. When growth is increased by 1%, the price increases to $34.50. The changes in welfare are the result of many different effects. First of all, the changes are not merely scale effects; abatement cost curves are exponential and higher growth rates will therefore affect abatement costs more than reducing growth by the same percentage. See table 6 for details of the welfare effects.

On average, welfare changes by about twice as much in the *grow-more* scenario than in the *grow-less* scenario. The size of the buffer for uncertain BAU emissions is as high as 8.8% on average (ranging from 5.7 to 10.9% for individual regions) with low growth, and it is reduced to as little as 1.1% with higher growth. With all available gains redistributed, the buffer is 13.1% and 4.6% for *grow-less* and *grow-more*, respectively.

Changing the discount rate has a small effect on permit prices (5% lower and 2% higher for the 3% and 7% discount rates in the *ET* scenario, respectively). The buffer is lower with a 3% discount factor and higher with a discount factor of 7% - when we only take the developing countries' gains into account (table 8). The explanation is simply that developing countries have smaller gains with which to purchase the extra permits that they would need. If we also take into account the gains of going from the CDM to emissions trading for the Annex B regions, the opposite is be true; the buffer is higher with a lower discount rate and lower with a higher rate. This is because Annex B countries gain more from a lower discount rate than developing countries lose by it, and hence the total sum available for buying permits is greater – and increases the buffer.

Changing the transaction costs will, for obvious reasons, change the permit prices. When we reduce the transaction costs by $0.40, the ET permit price goes down by $0.13, and when we increase the transaction costs by $0.30, the price goes up by $0.11 (table 7). If we look at the welfare effects as we move from the *CDM* to the *ET* scenario, the changes between the analyses are almost perfectly proportional to the ratio of the transaction costs (1 to 5 and 8 to 5) – with smaller welfare changes coupled to lower transaction costs.

The buffer is reduced with lower transaction costs and increased with higher transaction costs *both* for the case in which we only take the developing countries gain into account, *and* for the case in which we include all gains. Such a pattern is what we would expect:

[9] This would of course depend on developing countries' attitude to risk and the probability of emissions being higher or lower than in our scenarios.

Lower/higher transaction costs decrease/increase the gain of moving from the CDM to emissions trading, and hence the buffer decreases/increases (table 8).

When we include the United States and Australia in the second commitment period, it is not surprising to find that permit prices increase. In the *no trade* scenario the price is $22.10, while it drops to $3.43 in the *CDM* scenario, and $3.22 in the *ET* scenario. The welfare of the developing countries increases in this policy scenario. However, we also find that the buffer for uncertainty in the BAU emissions decreases when the United States joins the climate agreement. The reason for this is that the permit price increases, and hence the cost of obtaining the extra permits needed to meet the commitments during the second commitment period would increase, and the buffer would decrease. The buffer size is 2.6% on average, and 5.6% if all gains were to be redistributed.

Table 6.A Welfare changes compared to *no trade* scenario (% change in EV)

	dis3		**dis7**	
	CDM	*ET*	*CDM*	*ET*
EUU	+0.095	+0.128	+0.037	+0.045
SEL	-0.278	-0.270	-0.485	-0.487
RAB	+0.103	+0.136	+0.040	+0.048
USA	+0.037	+0.053	+0.000	+0.003
BRA	-0.035	-0.031	-0.013	-0.010
CHN	-0.010	-0.002	+0.030	+0.046
IND	+0.004	+0.039	+0.110	+0.149
OPE	-0.018	-0.011	+0.035	+0.049
ROW	-0.032	-0.024	+0.009	+0.021

Table 6.B Welfare changes compared to *no trade* scenario (% change in EV)

	trans1		**trans8**	
	CDM	*ET*	*CDM*	*ET*
EUU	+0.048	+0.051	+0.045	+0.068
SEL	-0.456	-0.455	-0.445	-0.444
RAB	+0.052	+0.055	+0.050	+0.072
USA	+0.008	+0.010	+0.008	+0.018
BRA	-0.018	-0.018	-0.019	-0.012
CHN	+0.025	+0.028	+0.021	+0.045
IND	+0.105	+0.113	+0.088	+0.154
OPE	+0.026	+0.029	+0.021	+0.043
ROW	+0.003	+0.005	-0.001	+0.019

Table 6.C Welfare changes compared to *no trade* scenario (% change in EV)

	grow-less		**grow-more**		**US joins**	
	*CDM**	*ET*	*CDM*	*ET*	*CDM*	*ET*
EUU	0	+0.005	0.349	+0.380	+0.015	+0.026
SEL	0	-0.017	-0.451	-0.438	-1.002	-1.004
RAB	0	+0.004	0.374	+0.402	+0.038	+0.048
USA	0	+0.002	0.041	+0.050	+0.011	+0.016
BRA	0	+0.003	-0.131	-0.131	+0.021	+0.025
CHN	0	+0.008	-0.047	-0.045	+0.121	+0.139
IND	0	+0.022	-0.007	+0.028	+0.343	+0.386
OPE	0	+0.009	-0.127	-0.123	+0.117	+0.132
ROW	0	+0.007	-0.176	-0.170	+0.071	+0.084

* With a permit price less than $0.50 above the CDM price, there is no CDM trading in the *grow-less* scenario, and therefore no differences between the *no trade* and *CDM* scenarios.

Table 7. Sensitivity analysis: Prices (US$/t Ce) and banking

	Scenario	**Emissions trading price**	**CDM price**	**Banking**
dis3	*No trade*	$12.93	$0.61	7.34 %
	CDM	$1.99	$1.49	5.96 %
	ET	$1.77	$1.27	4.28 %
dis7	*No trade*	$12.95	$0.61	6.89 %
	CDM	$2.12	$1.62	5.59 %
	ET	$1.90	$1.40	4.03 %
trans1	*No trade*	$13.00	$0.61	7.02 %
	CDM	$1.77	$1.67	5.64 %
	ET	$1.73	$1.63	5.34 %
trans8	*No trade*	$13.00	$0.61	7.02 %
	CDM	$2.32	$1.52	5.71 %
	ET	$1.97	$1.17	3.10 %
grow-less	*No trade*	$1.02	$0.61	5.29 %
	CDM	$1.02	$0.61	5.29 %
	ET	$0.66	$0.61	3.95 %
grow-more	*No trade*	$34.50	$0.61	8.65 %
	CDM	$3.58	$3.08	6.72 %
	ET	$3.34	$2.84	5.56 %
US joins	*No trade*	$22.09	$0.61	7.82 %
	CDM	$3.43	$2.93	9.05 %
	ET	$3.22	$2.72	8.39 %

Table 8 Sensitivity analysis of buffer size (% of emissions)

	dis3	dis7	trans1	trans8	grow-less	grow-more	US joins
Brazil	3.48	3.33	0.81	5.77	8.73	-0.13	2.25
China	1.48	3.26	0.62	4.48	5.73	1.16	2.03
India	4.36	5.40	1.13	8.10	10.56	2.00	3.28
OPEC	1.90	4.15	0.81	5.80	9.29	0.49	2.32
ROW	3.00	4.92	1.00	7.25	10.86	0.92	2.92
Average	2.71	4.30	0.87	6.29	8.79	1.13	2.61
With all gains	11.77	7.46	1.94	13.68	13.05	4.63	5.59

6 Conclusions

6.1 Main findings

In this paper we have analysed the costs and benefits obtained when developing countries take on binding emission constraints in order to take part in emissions trading in a future climate agreement. We have analysed whether or not, and under what circumstances, the benefits could be large enough to outweigh the costs. We have shown the following:

The CDM is assumed to have high transaction costs, and developing countries are assumed to have low-cost abatement projects to offer. We find that developing countries could obtain substantial welfare improvements by making the transition from the CDM to emissions trading.

Industrialized countries would also obtain welfare gains from this transition, since they would get more efficient access to low-cost abatement options in developing countries. These gains would increase, both for developing and industrialized countries, if the United States were to participate in the climate agreement.

The welfare gains in developing countries, however, would not be large compared to the costs if the emission constraints were to actually become binding. Developing countries might therefore have good reasons not to embrace the cap and trade emissions trading, even if they could do so with constraints equal to their expected BAU emissions. In fact, we find that the incentives to join might not be strong enough even if the industrialized countries were to redistribute all or most of their welfare gains to the developing countries as an incentive to attract their participation. The participation of the United States in a new Kyoto-like agreement in the next commitment period (2013-2017), would have the effect of decreasing the buffer available to compensate for the uncertainty in the BAU emissions.

The sensitivity analyses we conducted confirm this picture. Both the size of the transaction costs and the assumptions about the growth rates would influence the size of the available buffer.

6.2 Limitations of the study

In the approach taken in this paper we look only at the economic gains obtained by moving from the CDM to an agreement under which the developing countries participate with binding commitments and with emissions trading. Obviously, it is questionable that this would be the only approach taken by the developing countries when they take part in negotiating a new agreement. From the negotiations of the Kyoto Protocol we know that the issue of moral obligations was important to many developing countries. They thought that the developed countries should be obliged to reduce their emissions first since they were responsible for most of the greenhouse gas emissions up to that time (see for instance Grubb et al 1999). Furthermore, the negotiation of climate agreements will take place in a wider policy context. For instance, developing countries might be willing to join a climate agreement with binding commitments if it were linked to the negotiation of a profitable trade agreement (Carraro and Marchiori 2003).

Moreover, our analysis only takes into account one side of the climate problem, the cost side. We have not included an analysis of the benefits of reducing climate gases. Such an analysis would show that the willingness of the developing countries to join an agreement would be even greater because of their realization that they would likely experience the most serious (negative) consequences of climate change. One additional factor, the ancillary benefits of reducing climate gases, is not included in our analysis, either. Since emissions of greenhouse gases are, to a large extent, connected to the use of energy, reducing them would also mean a reduction in the emissions of other polluting gases, such as SO_2, that have local effects. Hence, taking ancillary benefits into account would give developing countries a stronger incentive to join a new agreement, or alternatively, they would require less compensation to do so (Aunan et al 2003 and Aaheim et al 1999).

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List of acronyms

CETA	Carbon Emission Trajectory Assessment (energy-economic model)
DEEP	Dynamic analysis of the Economics of Environmental Policy
EPA	Environmental Protection Agency (United States)
EPPA	Emissions Prediction and Policy Analysis
GTAP	Global Trade Analysis Project
GTAP-EG	GTAP-Energy in GAMS
IPCC	Intergovernmental Panel on Climate Change
SRES	Special Report on Emissions Scenarios