

CICERO Working Paper 2006:03

CDM baseline methodologies and carbon leakage

Steffen Kallbekken, Line Sunniva Flottorp and Nathan Rive

March 2006

CICERO

Center for International Climate
and Environmental Research
P.O. Box 1129 Blindern
N-0318 Oslo, Norway
Phone: +47 22 85 87 50
Fax: +47 22 85 87 51
E-mail: admin@cicero.uio.no
Web: www.cicero.uio.no

CICERO Senter for klimaforskning

P.B. 1129 Blindern, 0318 Oslo
Telefon: 22 85 87 50
Faks: 22 85 87 51
E-post: admin@cicero.uio.no
Nett: www.cicero.uio.no

Tittel: CDM baseline methodologies and carbon leakage

Forfatter(e): Steffen Kallbekken, Line Sunniva Flottorp and Nathan Rive

CICERO Working Paper 2006:3 19 sider

Finansieringskilde: Swedish Foundation for Strategic Environmental Research (Mistra)

Prosjekt: ETIC 30044

Prosjektleder: Asbjørn Torvanger

Kvalitetsansvarlig: Gunnar S. Eskeland

Nøkkelord: Clean Development Mechanism, baseline methodology, carbon leakage, market leakage

Sammendrag: Karbonlekkasje er et viktig problem fordi det kan redusere den miljømessige effekten til internasjonale klimaavtaler. I gjennomføringen av Kyotoprotokollen har den grønne utviklingsmekanismen (CDM) potensial til å redusere karbonlekkasjen betydelig. I hvilken grad dette potensialet kan realiseres avhenger av hvordan baselinemetodologien tar hensyn til denne effekten. Vi bruker en generell likevektsmodell for å analysere virkningen av tre ulike metodologier, og finner ut at de gir resultater som avviker fra hverandre etter hvert som antallet CDM prosjekter øker. Vi finner imidlertid også at med realistiske antakelser om antallet prosjekter vil CDM redusere karbonlekkasjen betydelig uavhengig av hvilken metodologi som blir brukt.

Språk: Engelsk

Rapporten kan bestilles fra:
CICERO Senter for klimaforskning
P.B. 1129 Blindern
0318 Oslo

Eller lastes ned fra:
<http://www.cicero.uio.no>

Title: CDM baseline methodologies and carbon leakage

Author(s): Steffen Kallbekken, Line Sunniva Flottorp and Nathan Rive

CICERO Working Paper 19 pages

Financed by: Swedish Foundation for Strategic Environmental Research (Mistra)

Project: ETIC 30044

Project manager: Asbjørn Torvanger

Quality manager: Gunnar S. Eskeland

Keywords: Clean Development Mechanism, baseline methodology, carbon leakage, market leakage

Abstract: Carbon leakage is an important issue because it can reduce the environmental effectiveness of international climate agreements. Under the Kyoto Protocol, the Clean Development Mechanism (CDM) can potentially reduce carbon leakage significantly. To what extent this potential can be realized depends on how the CDM baseline methodology accounts for this effect. We use a Computable General Equilibrium model to analyze the impact of three different baseline methodologies, and find that they produce diverging results as the number of CDM projects increase. We do, however, find that under realistic assumptions on the level of CDM activity the CDM will significantly reduce carbon leakage irrespective of which baseline methodology is used.

Language of report: English

The report may be ordered from:
CICERO (Center for International Climate and Environmental Research – Oslo)
PO Box 1129 Blindern
0318 Oslo, NORWAY

Or be downloaded from:
<http://www.cicero.uio.no>

Contents

1	Introduction	1
2	Accounting for carbon leakage in the CDM baseline methodology	3
2.1	BASELINE METHODOLOGIES	5
2.2	HOW WILL CARBON LEAKAGE BE ACCOUNTED FOR IN PRACTICE?	8
3	The model.....	9
3.1	MODELLING THE CDM.....	10
3.2	SCENARIOS AND CASES	11
4	Results	12
4.1	RESULTS FOR THE CDM SCENARIO	12
4.2	SENSITIVITY ANALYSIS.....	16
5	Conclusions	17

Acknowledgements

Thanks to Asbjørn Torvanger and Gunnar S. Eskeland for valuable comments. This project received financial support from the Swedish Foundation for Strategic Environmental Research (Mistra), under the CLIPORE research programme.

1 Introduction

The Kyoto Protocol (United Nations Framework Convention on Climate Change (UNFCCC) 1997) establishes binding greenhouse gas (GHG) emission caps for a first commitment period (2008-2012). These emission caps apply to participating Annex B countries.¹ It is expected that implementation of measures to meet these caps will result in spillover effects in non-Annex B countries. One such effect is *carbon leakage* (or emissions leakage),² which means that the environmental benefits of mitigation in some countries are to some extent offset by higher emissions in countries without binding caps on emissions.

Carbon leakage occurs when there is a price differential (in actual prices or shadow prices) on GHG emissions between countries. In the case of the Kyoto Protocol, the price differential is brought about by abatement policies in Annex B countries that will create a significant and positive price on emissions, while the price on emissions in non-Annex B countries will be low (or zero, if no climate policies whatsoever are implemented). The imposition of emissions restrictions in Annex B countries therefore creates a relative price change that may provide sufficient incentives for industries (especially emissions intensive industries) to relocate from Annex B countries to non-Annex B countries, or that will reduce their competitiveness to the extent that their competitors in non-Annex B countries will increase their output (and emissions). As a result of this ‘leakage’, emissions in non-Annex B countries will be higher than they would have been without implementation of the Kyoto Protocol. The consequence of carbon leakage is that the overall environmental effectiveness of the Protocol is reduced (and could, in principle, even be negative). Carbon leakage can of course also be seen as a problem of loss of investments and jobs in Annex B countries, but in this paper the focus will be on the environmental effects.

Carbon leakage has been an important issue in the literature concerning the Kyoto Protocol as it implies that the environmental benefits of mitigation in some countries are offset by higher emissions in countries without binding caps (see for example Hourcade and Shukla 2001; Sijm et al. 2004; Manne and Richels 1999). Sijm et al. (2004, p.12) defines carbon leakage as “the ratio of policy-induced increase of emission from a non-abating country over the reduction of emission by an abating country.” For the purposes of this paper it is necessary to adopt a more specific version of this definition: We will take “policy-induced” to mean any changes brought about as a result of the implementation of the Kyoto Protocol, and by “increase of emissions” we will understand ‘net increase in global emissions as compared to business-as-usual emissions in the absence of the Kyoto Protocol less the committed emissions reductions of the Annex B countries’.³

Several studies have estimated the magnitude of carbon leakage using applied equilibrium models. Most of these studies estimate the global rate of carbon leakage to be between 5 and 20 percent of the emissions reductions projected to be required by Annex B countries to meet

¹ The Annex B countries are the 39 industrialized countries with a quantified emission limitation listed in Annex B of the Kyoto Protocol. Of these, only countries that have ratified the Kyoto Protocol will be bound by the emissions caps. The United States and Australia have decided not to ratify. Annex 1 countries are the 36 countries listed in Annex 1 of the UNFCCC. To avoid confusion we will always refer to Annex B and non-Annex B countries. Keep in mind that countries that have not ratified the Kyoto Protocol do not belong to either group.

² In this paper we use the term carbon leakage although some of the literature (e.g., reports produced by the IPCC) uses the term emission leakage. Because emissions are usually quantified in CO₂ equivalents, we find it most appropriate to use the term carbon leakage.

³ One important reason for choosing *net increase in global emissions* rather than just *increase in non-Annex B emissions* is that the CDM allows a relocation of emissions between Annex B and non-Annex B countries; i.e. a decrease in non-Annex B countries that has a zero net effect globally. Furthermore, project-specific leakage under the CDM is included in and unambiguously accounted for under this definition of carbon leakage.

their Kyoto commitments (for an overview see Hourcade and Shukla 2001 or Sijm et al. 2004). Some studies claim the global carbon leakage rate could be greater than 100%, in which case the Kyoto Protocol will lead to an overall *increase* in global emissions (see for example Babiker 2005). Studies that focus on endogenous technological development, on the other hand, find much lower – even negative – rates of carbon leakage (see Golombek and Hoel 2004; Di Maria and van der Werf 2005).

In principle, any activity that reduces the price differential on emissions between Annex B and non-Annex B regions will decrease the magnitude of carbon leakage. The Kyoto Protocol allows use of three flexibility mechanisms to reduce the cost of meeting the emissions caps: International Emission Trading (IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM) (UNFCCC 1997). To the extent that use of these flexibility mechanisms reduces the cost of emissions in Annex B countries, they should also reduce carbon leakage to some extent (as this would reduce the price differential). Importantly, while IET between Annex B countries in principle equalizes carbon prices between the trading countries, the CDM will likely only *reduce* the price differential between the trading countries (Annex B and developing countries). See Kallbekken 2006 for a more comprehensive treatment of this issue.⁴

The CDM allows Annex B countries or firms in Annex B countries to generate Certified Emission Reduction units (CERs) by investing in projects that reduce emissions in non-Annex B countries (UNFCCC 2005a). CERs generated under the CDM can be used by Annex B countries towards meeting their quantified emission reduction commitments under the Kyoto Protocol.

The CERs generated by the project are calculated as the difference between a *baseline* and the (projected) actual emissions – adjusted for any leakage that may occur. UNFCCC (2005a, §44) defines the *baseline* for a CDM project activity as “the scenario that reasonably represents the emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity”.

The CDM rules state that leakage should be taken into account when establishing the baseline estimates (UNFCCC 2005a: §59). Leakage is defined as “the net change of anthropogenic emissions by sources of greenhouse gases which occurs outside the project boundary, and which is measurable and attributable to the CDM project activity” (UNFCCC 2005a: §51). Several different types of leakage have been identified in the literature – though the focus is largely on positive leakages (i.e. increases in emissions).

Receiving credits for emissions reductions that would have taken place even in the absence of the project constitutes *project-specific leakage*. Geres and Michaelowa (2002) present a framework to calculate project-specific leakage.

In addition, there are two types of economic leakage (Vöhringer et al. 2006). *Direct economic leakage* relates to emissions associated with the production factors and intermediate deliveries demanded by the project. *Market leakage* refers to the indirect effects transmitted through price changes; for example that the project changes the relative prices of fossil fuels and thus cause other economic agents to change their production decisions (and emissions). In particular, the *aggregate* effect of the full portfolio of CDM projects on market prices can be significant enough to merit accounting for them.

Vöhringer et al. (2006) claim that project-specific approaches fail to take account of *market leakage*, as they have been considered either unmeasurable or insignificant for individual projects. Vöhringer and his colleagues argue that the attribution of market leakage to projects

⁴ The CDM will reduce rather than equalize the price of emissions because not all profitable projects will be implemented (participation will not be 100%), and because transaction costs are expected to be significantly higher for the CDM than for IET.

requires a theory that establishes a link between a project and the changes in GHG emissions that occur outside the project boundary.⁵ They argue that aggregated market leakage effects can be attributed proportionally to individual projects.

Carbon leakage is an important issue because it may to some extent compromise the environmental effectiveness of the Kyoto Protocol. The magnitude of carbon leakage is determined by the price differential on emissions. The CDM has the potential to significantly reduce this differential. Given this, the CDM should have a potential to significantly reduce carbon leakage (Kallbekken 2006). While most studies focus on the positive leakage effects of CDM projects, this mechanism suggests that the overall (market) effect of CDM projects may in fact result in *negative* leakage. To what extent this potential can be realized depends, however, on the baseline methodology. Specifically, it depends on how the methodology accounts for the overall effect of all CDM projects on carbon leakage. This should be accounted for as the baseline is supposed to represent what emissions would have been in the absence of the specific project; but not in the absence of other CDM projects. The research question we attempt to answer in this paper is: Whether - and how - the aggregate market leakage effects of other CDM projects should be accounted for in the CDM baseline methodology.

In Section 2 of this paper we provide a theoretical analysis of the influence of different baseline methodologies on the potential for the CDM to reduce carbon leakage, highlighting the intuition behind this study. These interactions are then examined quantitatively using a computable general equilibrium (CGE) model with different cases representing the different baseline methodologies. The model is described in section 3, and we report our findings in Section 4. Section 5 concludes the paper.

2 Accounting for carbon leakage in the CDM baseline methodology

Carbon leakage is caused by the price differential on emissions that will arise between the Annex B and the non-Annex B countries with implementation of the Kyoto Protocol. This dynamic is illustrated in Figure 1. In the business-as-usual (BAU) scenario with no Kyoto Protocol, global emissions are assumed to be 100 units. 70 of these units are emitted in Annex B countries, while 30 are emitted in non-Annex B countries. Assume that under the Kyoto Protocol (without the CDM) the Annex B countries are committed to reducing their emissions to 60 units. This reduction of 10 units will be the basis for calculating carbon leakage throughout all the examples. Because of carbon leakage emissions in non-Annex B countries rise to 35 units (as shown in the second set of bars). Global emissions are then 95 units. This would correspond to carbon leakage of 50% (an increase of 5 units in non-Annex B countries over a decrease of 10 units in Annex B countries).

⁵ According to UNFCCC (2005: §52) a project boundary “shall encompass all anthropogenic emissions by sources of greenhouse gases under the control of the project participants that are significant and reasonably attributable to the CDM project activity”.

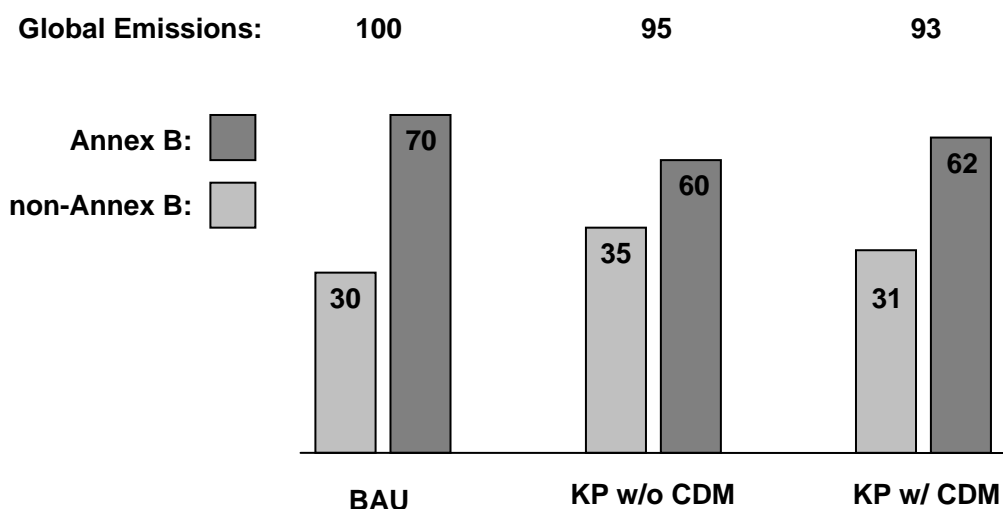


Figure 1: Emissions levels in Annex B and non-Annex B countries in 2010 under BAU and the Kyoto Protocol with and without CDM implementation.

The actual magnitude of carbon leakage will stand in some direct relationship to the size of the price differential: a higher differential will increase the competitive advantage of non-Annex B countries and thus also increase carbon leakage. The CDM, by reducing the price of emissions in Annex B countries (and slightly increasing the price in non-Annex B countries), will reduce also the magnitude of carbon leakage to non-Annex B countries, and improve the environmental effectiveness of the Kyoto Protocol. In the example in Figure 1, the introduction of the CDM means that some Annex B countries purchase emissions credits from CDM projects. In the figure we assume this allows the Annex B countries to increase their emissions by 2 units as compared to the situation without the CDM. The emissions are reduced correspondingly in the non-Annex B countries through CDM projects.⁶ But, beyond this relocation of emissions, emissions in non-Annex B countries are reduced by a further 2 units because, as the CDM project has decreased the international permit price, the price differential is smaller. Carbon leakage is now reduced to only 3 units (30%).

The issue we are interested in is how (and whether) this effect will be accounted for in CDM project baselines. We will consider three alternative ways of accounting for leakage in order to examine the issue in detail. First, however, it is necessary to say a little more about how the CDM rules on baseline methodology (and accounting for leakage) should be interpreted in this context.

Paragraph 46 of UNFCCC (2005a) states that the baseline “may include a scenario where future anthropogenic emissions by sources are projected to rise above current levels, due to the specific circumstances of the host Party.” This is interpreted here as implying that the baseline may first of all account for expected increases in emissions in the BAU scenario (economic growth), and secondly may also account for how carbon leakage increases these BAU emissions. It might not be obvious at first that the second type of accounting should be allowed, but consider that *in the absence of the proposed CDM activity* (which is the definition of the baseline); emissions would indeed increase due to carbon leakage (as compared to a world with no Kyoto Protocol). Thus, the positive carbon leakage induced by emissions restrictions in Annex B countries can be accounted for.

⁶ In our illustrations we will for simplicity not include emissions in countries that are not parties to the Kyoto Protocol.

Paragraph 47 (UNFCCC 2005a) states that “[t]he baseline shall be defined in a way that CERs cannot be earned for decreases in activity levels outside the project activity or due to force majeure.” This means that no CDM project should be able to claim credits for having reduced the carbon leakage through market prices.

The combined effect of paragraph 46 and 47 is that the CDM should reduce carbon leakage as (1) projects are allowed to increase their baseline due to positive carbon leakage, but (2) are not allowed to claim credits for reductions in carbon leakage that they may induce by reducing the price differential between Annex B and non-Annex B countries.

It is, however, not obvious that the full potential of this reduced carbon leakage will be realized in practice. The UNFCCC definition of the baseline implies that CDM projects should account for how their BAU emissions change as a result of other CDM projects being implemented. We will refer to the baseline that does account for such market leakage effects *of other projects* as the ‘correct’ baseline (i.e. what emissions would have been in the absence of this specific CDM project, but not in the absence of all CDM projects).

However, none of the three allowed baseline methodologies that project participants can currently choose from seem to account for this effect, cf. UNFCCC 2005a §48: (a) Existing actual or historical emissions. (b) Emissions from a technology that represents an economically attractive course of action. (c) The average emissions of similar project activities undertaken in the previous five years.

If the baseline methodology fails to account for how the aggregate market effects of other CDM projects can reduce carbon leakage, the result will be a type of project-specific leakage: Some proportion of the CERs generated are received for emissions reductions that occur thanks to the aggregate market effects of *other* CDM projects – and thus would have taken place even in the absence of the specific project. This in turn means that *some* of the potential for the CDM to reduce carbon leakage will not be realized. It is important to point out that irrespective of how the baseline methodology accounts for it, carbon leakage to firms or industries that do not participate in the CDM will be reduced as the price differential is reduced. The issue of baseline methodologies therefore becomes more important the larger the share of firms that participate in the CDM.

2.1 Baseline methodologies

We will present three alternative baseline methodologies. These methodologies will be analyzed numerically in the modeling exercise in section 3. The first represents a baseline methodology that is fully consistent with the CDM rules. The other two are baselines that fail to account for the market leakage of other projects in different ways; one will produce project-specific leakage as discussed above, while the other baseline methodology will produce greater actual emissions reductions than the number of CERs received.

(1) The first baseline methodology accounts for how *other* CDM projects reduce carbon leakage, and therefore uses the ‘correct’ baseline. With this methodology we expect that carbon leakage will be reduced more the higher the participation rate (when more firms participate) in the CDM. The reason is that the more CERs generated the lower the permit prices in the IET – the lower the carbon leakage. If this effect is accounted for, the baselines will be set at a lower level than otherwise, and the potential to reduce carbon leakage will be realized.

This is not to say that this baseline methodology is straightforward.⁷ To find the baseline we need to consider what emissions would have been if all projects – individually but simultaneously – took into account how their baseline depends on the other CDM projects that are implemented. This emissions level corresponds closely to what emissions would have been if all market prices were *as if* the CDM projects had been implemented.⁸ CERs are calculated as reductions below this baseline.

An example is illustrated in Figure 2. In the example, total emissions in non-Annex B countries would be 3 units lower if all market prices were *as if* CDM projects had been implemented, than they would be under the Kyoto Protocol without the CDM. This is the amount by which the CDM reduces carbon leakage. This lower level of emissions should then be used as the baseline for CDM projects. Assume the participating firms reduce emissions from the baseline of 13 units to 11 units, and generate 2 CERs. If the effect of other projects on baseline emissions had not been accounted for, they would have received 4 CERs (compare emissions to 15 units under Kyoto Protocol without CDM). But because they do account for this effect, the CDM reduces carbon leakage from 50% (in the initial example) to 20%.

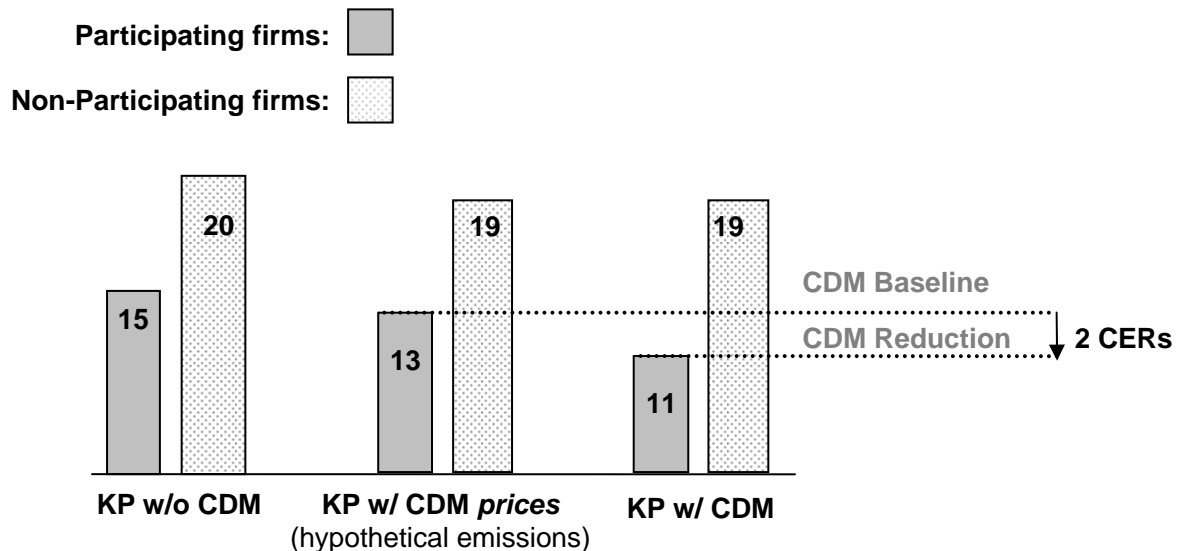


Figure 2: Non-Annex B emissions levels in firms participating and not participating in the CDM, and CER credits generated from ‘correct’ baseline methodology.

(2) Our second baseline methodology represents a case where the carbon leakage induced by emissions restrictions in Annex B countries is accounted for in the baseline, but where how other CDM projects can offset this effect to some extent is not accounted for. The baseline for any given project is therefore fixed at some level that is independent of how many other CDM projects are carried out (and thus independent of how they may reduce carbon leakage). Figure 3 illustrates an example where firms participating in CDM generate 4 CERs by reducing their emissions from a baseline of 15 units to 11 units. Emissions in the

⁷ To find the appropriate baseline emissions we need to consider the case where the baseline for each project takes into account how the overall effect of all other CDM projects has changed market prices and thus changed market leakage and what the emissions for each activity would have been without the CDM project. The baseline is then endogenous with respect to the number of CERs generated overall - and the baseline influences the number of CERs generated.

⁸ The correspondence is close but not perfect: The influence of other projects on the baseline of each project is accounted for, but so is the influence of the project on its own baseline. The latter influence will be minimal though if we can assume that each project is relatively small in proportion to the total volume of CDM projects.

non-participating firms are reduced by one unit due to less carbon leakage. This baseline methodology represent project-specific leakage as some of the credits are received for emissions reductions that would have taken place even without the project (the baseline used is higher than the ‘correct’ baseline). Carbon leakage is still reduced, from 50% to 40% – but it would have been reduced by a further 20% if the correct baseline had been used (where only 2 CERs would have been granted).

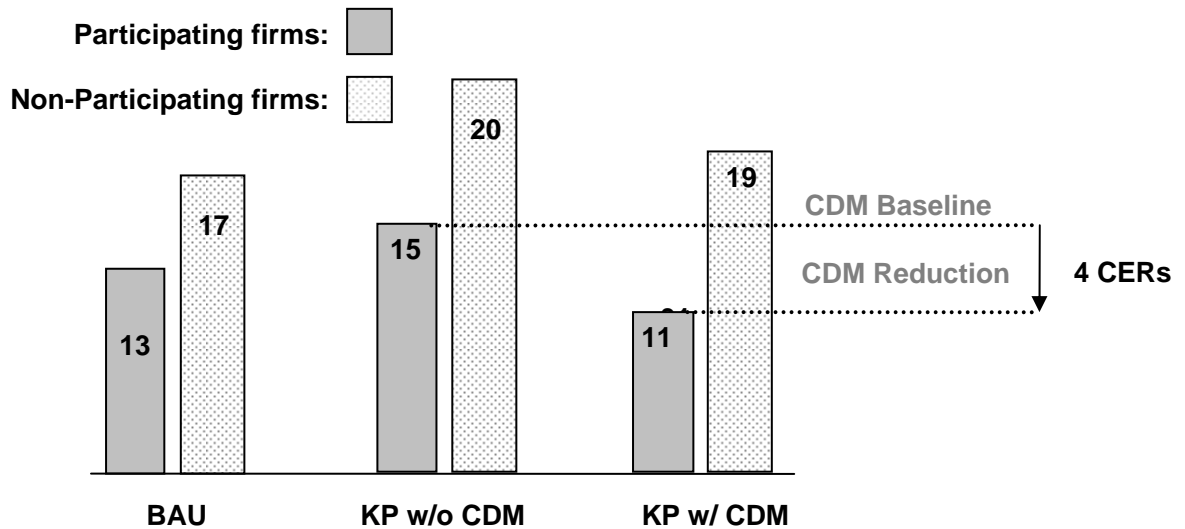


Figure 3: Non-Annex B emissions levels in firms participating and not participating in the CDM, and CER credits generated from a fixed baseline accounting for carbon leakage from Annex B.

With this baseline methodology we expect the level of carbon leakage to be lower at higher rates of participation in the CDM: The emissions permit price in the international market will fall as a result of the increased generation of CERs, and this will in turn drive the reduction in carbon leakage. However, at some participation rate the trend will reverse and carbon leakage begin to increase as a function of increasing participation. This is because the CDM activity is reducing carbon leakage only in firms that do not participate in CDM projects themselves: once an activity implements a CDM project, the baseline is fixed to what it would have been *in the absence of all CDM projects* (as shown in Figure 3). As the subset of the economy participating in CDM grows, the share of the total emissions that are ‘locked-in’ to this fixed baseline grows, and the number of remaining non-participating firms (for whom carbon leakage can be reduced) shrinks. In the limit, where the participation rate in CDM countries is 100%, there can be no reduction in carbon leakage in the CDM host country: only carbon leakage to countries not participating in the Kyoto Protocol will then be reduced.

(3) The third and final case considers a baseline methodology with a fixed baseline, as in case 2, but where the baseline is equal to what the emissions would have been in the absence of the Kyoto Protocol (see Figure 4). In other words, how carbon leakage will increase the BAU emissions (the correct baseline) is not taken into account. In this case, CDM projects are in a sense required to ‘compensate’ for carbon leakage before being credited for emissions reductions. The example in Figure 4 illustrates that firms participating in the CDM receive only 1 CER credit when they reduce their emissions by 3 units (as compared to what they would have been with implementation of the Kyoto Protocol without the CDM). This ‘shortfall’ is due to the fact that their baseline is set at 2 units lower than their emissions under the Kyoto Protocol without the CDM. In this example carbon leakage is reduced from 50% to 20%.

This baseline methodology represents an overall failure to account for carbon leakage: The positive carbon leakage resulting from implementation of the Kyoto Protocol is not accounted for in the first place, and (consequently) neither are offsets in this carbon leakage resulting from implementation of other CDM projects. With this baseline methodology we again expect carbon leakage to be a uniformly decreasing function of an increasing participation rate: Increased participation will reduce the permit price and carbon leakage, and also, with increasing participation a greater share of emissions become locked-in to a baseline that is too low (lower than the correct baseline).

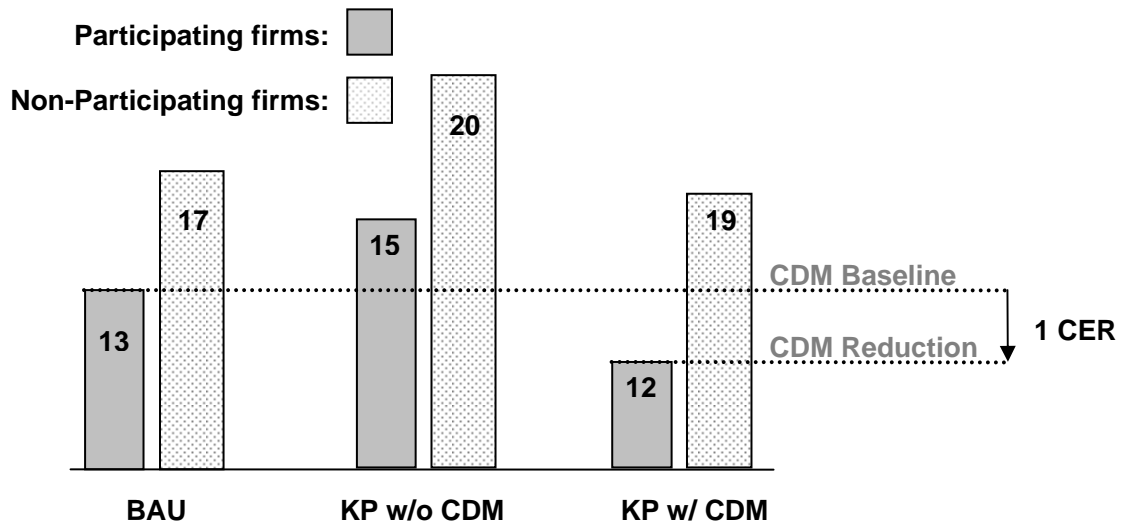


Figure 4: Non-Annex B emissions levels in firms participating and not participating in the CDM, and CER credits generated using a fixed baseline not accounting for any carbon leakage

2.2 How will carbon leakage be accounted for in practice?

It is relatively straightforward to show how market leakage effects on the baseline should be accounted for in principle – or in a CGE model (as we will do soon). How to do it in practice is a far more complicated issue though. In our three idealized baseline methodologies we assume that we have perfect information – not only about the price elasticity in all relevant markets, but also about what all prices would have been in those hypothetical realities where there is no Kyoto Protocol or no CDM projects. The more relevant issue is – what information relevant to leakage is it likely that CDM project developers will have available, or will expend costs to obtain?

It is difficult to account for the market leakage impact on baselines without employing some sort of partial or general equilibrium model. The first baseline methodology – which is consistent with the CDM rules - assumes that each project takes into account how changes in market prices brought about by all other CDM projects will influence their BAU emissions. Such an analysis would not necessarily have to be carried out by each project developer: It could also be done by the CDM Executive Board, which could then provide price estimates to project developers, or themselves make adjustments to the baselines of all projects. Vöhringer et al. (2006) argue that while project partners normally propose the baseline methodologies to the Executive Board, this would result in excessive transaction costs in this case. The leakage projections provided by the Executive Board would have to be updated if the assumed volume of CERs generated should deviate too far from the actual volume, thus ex-post adjustments might be required if one is to account for market leakage to the greatest extent possible and have a correct baseline.

Still, this would be a complex and potentially costly method for accounting for carbon leakage. One alternative – which would bring us somewhere between the two fixed price methodologies – would be to update baseline estimates using observed prices at regular intervals. This could be a practical alternative, and could potentially be an improvement on the CGE modelling approach (as CGE models will always be imperfect representations of the market).

The other two baseline methodologies are strictly speaking not consistent with the UNFCCC definition of the baseline. They are incorrect because they do not reflect what emissions actually would have been in the absence of each specific CDM project; instead they reflect what emissions would have been with the Kyoto Protocol but without the CDM, and in the complete absence of the Kyoto Protocol, respectively. In other words neither baseline methodology takes into account how the CDM (as a whole and the project on its own) would have changed emissions (and thus the correct baselines) through market interactions.

Yet, these other two methodologies are arguably realistic representations of the baseline methodologies actually being used: (1) Neither of these two baseline methodologies requires sophisticated analysis of leakage effects. (2) If current prices are being used to create a baseline, without any forecasting of how emissions trading and/or the CDM will change prices, project developers are using some sort of *fixed* baseline. (3) If current prices reflect implementation of the Kyoto Protocol without the CDM (because emissions trading schemes are already in operation while relatively few CDM projects have been implemented), this baseline is equivalent to our second baseline methodology. (4) If current prices do not reflect how implementation of the Kyoto Protocol will change prices, because preparations for implementation have only just begun, then this baseline is equivalent to our third baseline methodology. The latter case might seem to be the most realistic as most Annex B countries have not yet implemented policies that are sufficiently strong to put them on a trajectory to meeting their commitments (thus current prices are closer to reflecting this reality).

3 The model

We use the DEEP CGE model to analyze the influence of the CDM on carbon leakage, and the implications of using different baseline methodologies. By using a CGE model we forego the opportunity of studying the CDM at the project level in favour of capturing the full global market effects of Kyoto Protocol implementation with the CDM.

The DEEP model is a multi-sector and multi-region intertemporal computable general equilibrium model. The model was used in Kallbekken and Westskog (2005). A full description of the DEEP model, including assumptions on elasticities and the dynamics of the model, can be found in Kallbekken (2004). The model builds on the GTAP-EG model (Rutherford and Paltsev 2000), and uses the GTAP data base (Dimaranan and McDougall 2006).

For the purposes of this paper we use the time horizon 2001-2012 (annual steps). The sectors and regions are listed in table 1. Economic and emissions growth is assumed to follow the International Energy Outlook 2005 projections (EIA 2005). Both economic and emissions growth is moderate in mature market economies in this projection (though significantly higher for North America than for Europe and Asia), and high in emerging economies.

We assume that IET will be an important measure for the Annex B countries in meeting their commitments under the Kyoto Protocol. More specifically, we assume that the current EU Emissions Trading Scheme will be extended to include the aluminium and chemical sector by 2008. We assume that Russia will implement a somewhat more comprehensive

scheme than the EU in that it will also include other manufacturing and services.⁹ For the other Annex B countries we assume an emissions trading system similar to the EU ETS, but with emissions from the gas sector also included (such as Canada's Large Final Emitters system does). For all Annex B countries we assume that only CO₂ emissions are part of IET. Furthermore we assume that no hot air is sold on the market.^{10,11} For emissions not covered by the IET we assume other, but less stringent measures will be implemented. In the model this is done by establishing national 'shadow' emissions trading systems with an emissions reduction requirement only half as stringent as the IET (ratio of required cuts to BAU emissions is half as large as for sectors in the IET).

Table 1: Regions and sectors in the model

Region	Sector
Russia	Refined petroleum
Rest of Annex B	Crude oil
China	Gas
India	Agriculture
Brazil	Energy intensive sectors
Africa and Latin America	Other manufacturing and services
Asia	Electricity
Non-participating regions*	Capital good

- Predominantly the USA and Australia

3.1 Modelling the CDM

We have chosen to model the CDM as a mechanism conceptually equivalent to an emissions trading scheme: If we regard the BAU emissions of the non-Annex B countries as their baseline, then any reduction in emissions below this level can be regarded as generating CDM credits (see Kallbekken and Westskog 2005). The CDM does, however, differ from IET in three important respects; transaction costs, the *participation rate*, and having to establish a baseline. The cases representing different baseline methodologies are discussed in section 4.2. Finally, we assume that CDM projects can reduce emissions of CH₄ and N₂O as well as CO₂.

Many studies argue that the CDM is likely to entail larger transactions costs than emission trading (see for instance de Gouvello and Coto 2003, Jotzo and Michaelowa 2002, Michaelowa and Jotzo 2005 and Michaelowa et al. 2003). These larger costs are due to the fact that a credit trading mechanism, like the CDM, depends on a project specific analysis and

⁹ Whether Russia will actually implement an emissions trading system or whether Russia will instead focus on promoting JI projects in the same sectors has no numerical impact on our estimates (given our other assumptions).

¹⁰ Hot air is the term used to describe the "excess" credits granted to economies in transition as a result of their actual emissions already being significantly below the agreed upon emissions cap when the Kyoto Protocol was negotiated.

¹¹ When the USA withdrew from the Kyoto Protocol in 2001 "the EU, Japan and Canada declared that for environmental or other reasons they were not interested in buying up Russian "hot air"." (Egenhofer 2003).

a rigorous process of approval. In our model we impose CDM transaction costs of 20% – following Michaelowa and Jotzo (2005) where transaction costs account for 20% of the permit price for the marginal projects.¹² In the sensitivity analysis we will show that using a fixed transaction cost, rather than a percentage premium, does not significantly change our conclusions.

There are several barriers to CDM project development. These include very basic barriers such as lack of capacity to identify and assess potential projects in host countries, and lack of awareness of the CDM and its benefits amongst potential financiers. Ellis et al. (2004) argue that these barriers also include financial and institutional barriers, risk and uncertainties associated with generating CERs, delays in approving CDM project activities and methodologies, and other barriers such as difficulties in matching potential projects with potential investors, or barriers for investment by non-domestic entities. In addition, Ellis and co-authors claim that capacity and institutional issues are significant barriers to a more widespread use of the CDM.

Participation rate is the term we use to reflect the fact that, due to these various barriers, only some share of the potentially profitable CDM projects will be implemented. We define participation rate as the share of potentially profitable projects that is actually implemented. In the model we do this in a manner equivalent to how Jotzo and Michaelowa (2002) scale back their abatement cost curves (while we vary the percentage, they scale the curves back to 10% of their economy-wide estimate).¹³

3.2 Scenarios and cases

We created three *scenarios* for this project. The first scenario, which we call *No-Kyoto*, is used to find what emissions would have been without implementation of the Kyoto Protocol (i.e. to determine the magnitude of carbon leakage as a basis for calculations). The *IET-only* scenario is used to find the magnitude of carbon leakage with implementation of the Kyoto Protocol (with international emissions trading), but without any CDM projects. The last scenario is the *CDM scenario* consisting of three different cases representing the three baseline methodologies introduced in the previous section:

- In the *updating* case the baseline is updated with respect to how other projects affect the baseline for each project.¹⁴ This case is fully consistent with the CDM rules.
- In the *fixed baseline* case the baseline for CDM projects is fixed with respect to what emissions would have been in the absence of all CDM projects. In other words there is no accounting for CDM leakage in this case, and there will thus be project-specific leakage.

¹² 20% transaction costs is a relatively high estimate. A high estimate was chosen because other assumptions in the model may exaggerate the potential for CDM (having entire shares of the economy participation in the CDM implies that even the very smallest potentials will be made use of).

¹³ As abatement costs are implicit in our model, we do not as such scale back abatement cost curves, but vary the share of total emissions that can participate in the CDM.

¹⁴ In the model this is implemented through a stepwise procedure: In each step we increase the participation rate by 1% to find out how this changes the business-as-usual emissions of the activities not taking part in the CDM. This emissions level is then used as the baseline in the next step for those firms that did not participate in the CDM in the previous step, but which are now assumed to participate.

- In the *fixed no-Kyoto* case the baseline is again fixed, but this time with respect to what emissions would have been in the absence of the Kyoto Protocol (and not just CDM projects). This baseline methodology fails to account for carbon leakage as such.

4 Results

Under the *No-Kyoto* scenario the emissions covered in the model are projected to grow to 11.9 Gt Ce per year during the first commitment period.^{15,16} The Annex B countries are committed to reducing their emissions by a total of 445 Mt Ce per year, which corresponds to a 3.7% cut in global emissions as compared to the *No-Kyoto* scenario.

In the *IET-only* scenario the permit price is \$27.2/t Ce. This increase in the cost of emissions in Annex B countries results in an increase in emissions in non-Annex B and non-participating countries of 28 Mt Ce per year. This corresponds to carbon leakage of 6.3%. Compared to other estimates in the literature (typically 5-20%) this is a relatively low estimate. There are two important reasons for this. First, our estimated permit price is relatively low – thus producing small incentives to shift production (IPCC 2001 reported a range of permit prices for Annex B only emissions trading of \$14-224/t Ce, with an average of \$77/t Ce). Second, capital is region specific in our model and this might result in some underestimation of carbon leakage.

4.1 Results for the CDM scenario

Under all three cases with CDM activities the volume of CDM sales increase and the IET permit price decreases significantly as the participation rate increases (see figures 5 and 6). The permit price that is \$27.2 with 0% participation (equivalent to the *IET-only* scenario) is roughly halved if the participation rate is 10% instead. CDM volumes climb from 0 to 100 Mt Ce/year as the participation rate increases from 0 to 10%, and levels off around 250 Mt Ce/year as the participation rate approaches 100%. Thus our scenarios suggest a theoretical potential for CDM sales (unrealistic though it may be) where the CDM would be responsible for more than half of the emissions reductions under the Kyoto Protocol.

The *fixed no-Kyoto* and *updating* cases follow each other very closely both in terms of permit prices (the difference is never more than \$0.1) and CDM sales (the difference is never more than 1%). Furthermore these differences diminish with an increasing participation rate (see Figure 5 and 6). The reason is that the *fixed no-Kyoto* baseline corresponds to BAU emissions at a permit price of zero, and the *updating* baseline corresponds to BAU emissions at a permit price that is declining fast and reaching very low levels with an increasing participation rate.

The results for the *fixed baseline* case diverge only marginally from the other two. With low participation rates the differences are minor. At higher participation rates the differences become more pronounced: With a 20% participation rate the permit price is more than 3% lower in the *fixed baseline* case than in the other two (that have identical permit prices at this participation rate). The volume of CERs generated is about 1.5% greater. The most dramatic differences between this and the other two cases are, however, in their impact on carbon

¹⁵ Ce is short for carbon equivalents; i.e. emissions of all gases converted to equivalent emissions of carbon using Global Warming Potentials (GWPs) with a 100-year time horizon.

¹⁶ Whenever emissions are reported on a per year basis this refers to the annual average of the five years of the first commitment period under the Kyoto Protocol.

leakage: At 20% participation carbon leakage is reduced to 1.85% under the *fixed baseline* case, versus around 0.9% in the other two cases. At a 95% participation rate carbon leakage has climbed back up as high as 5.1% for the *fixed baseline* case, while it is virtually eliminated at 0.14% in the *updating* case and 0.38% in the *fixed no-Kyoto* case (see figure 7).

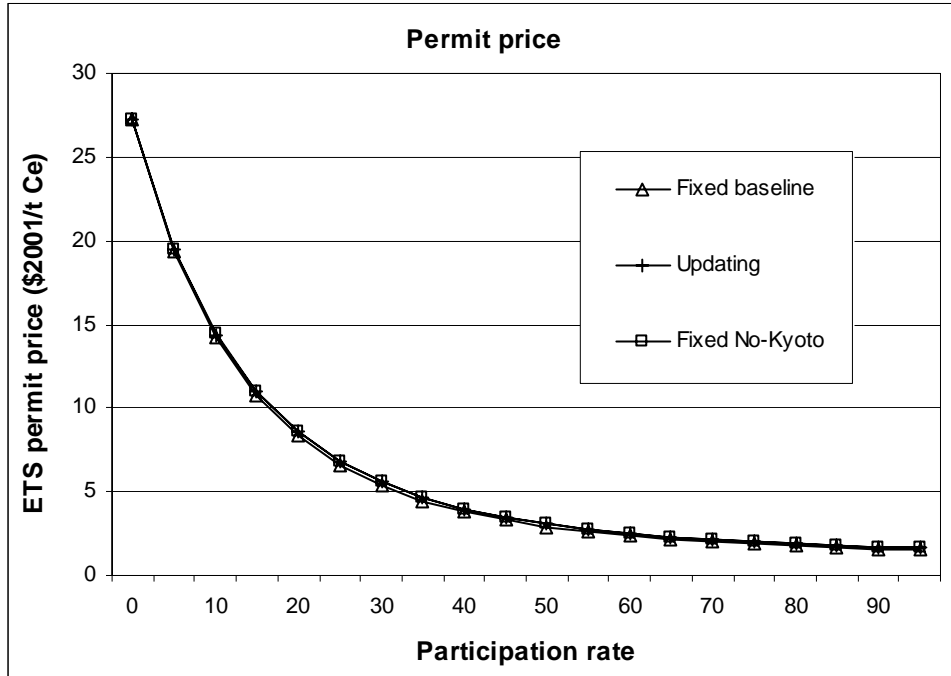


Figure 5: Permit price (\$2001/t Ce by participation rate)

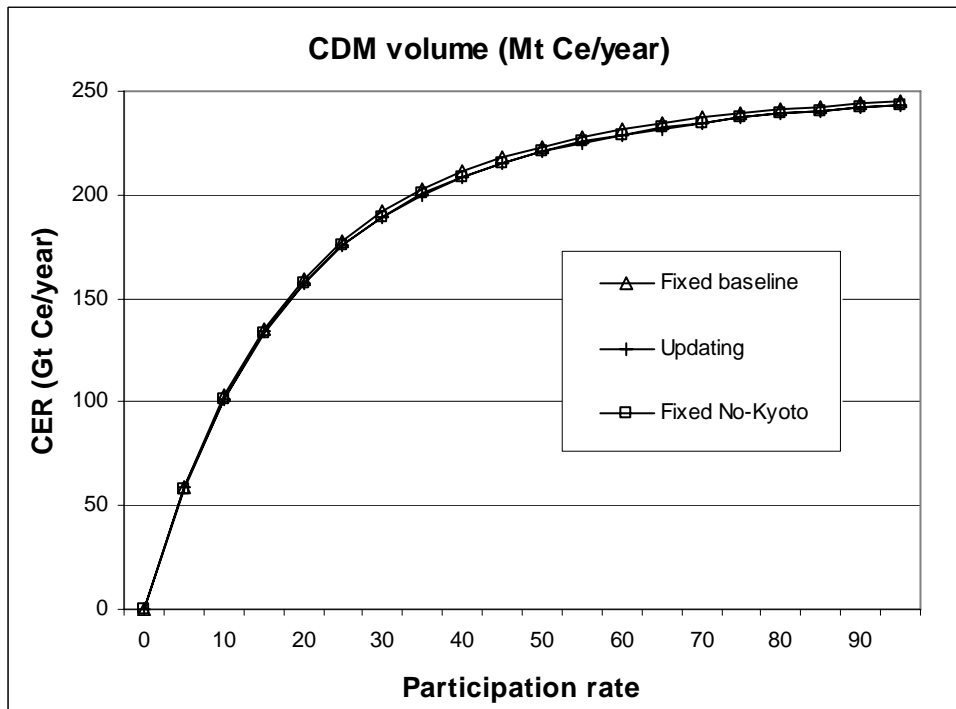


Figure 6: CDM volume (Mt Ce/year by participation rate)

In all three cases a higher participation rate will produce lower permit prices and generate more CDM credits. As we have already seen, carbon leakage does also change with the participation rate, but these results are not quite as straightforward – as figure 7 shows. The different ways of setting the baseline produce diverging estimates of carbon leakage. In section 2.1 we discussed briefly why and how we expected each type of market leakage accounting to influence the carbon leakage depending on the participation rate.

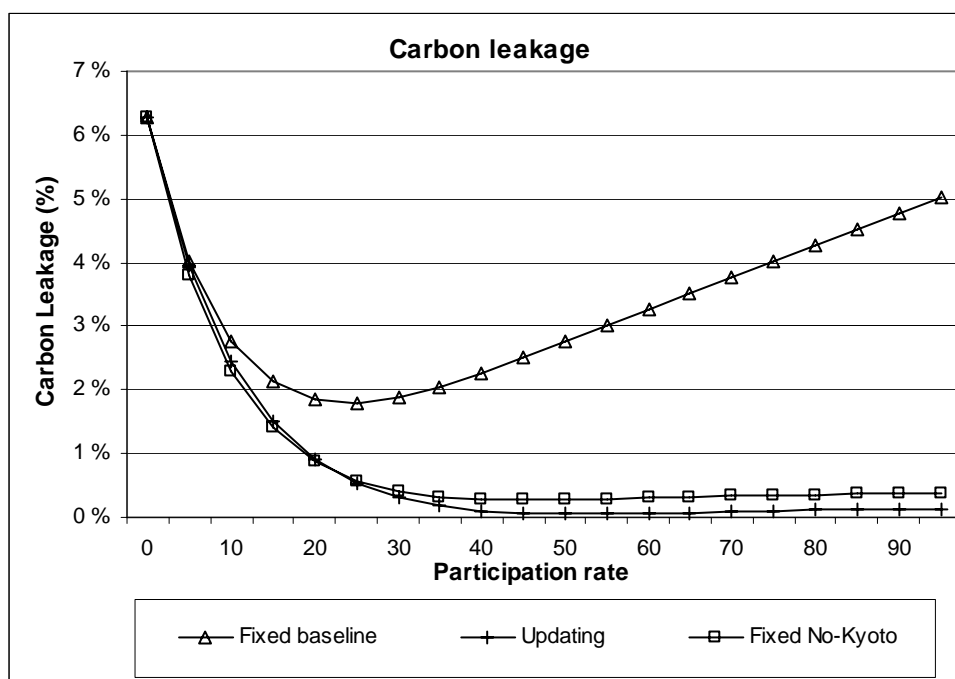


Figure 7: Carbon leakage (per cent by participation rate)

For the updating case we expected to see a uniformly decreasing rate of carbon leakage. We do see a strong decrease, from 6.3% to a minimum of less than 0.06% (where emissions in developing countries are actually lower than they would have been in absence of the Kyoto Protocol). However, the leakage is not uniformly decreasing with an increasing participation rate as the leakage does start to climb slowly at higher rates. This is possibly an artefact of how the updating case is implemented in the model.¹⁷

In the *fixed baseline* case the carbon leakage initially drops rapidly, from 6.3% at 0% participation to a minimum of 1.8% leakage at 25% participation. This is the result of a decreasing price differential. But – for higher participation rates carbon leakage increases slowly with an increasing participation rate. The reason for this is that while the ever decreasing permit price will always tend to reduce carbon leakage, there is also more project-specific leakage as the share of emissions participating in CDM projects increases: At 100% participation all emissions in developing countries are tied to a baseline that does not account for carbon leakage (thus a baseline that is too high), CDM projects then simply relocate

¹⁷ In the step-wise procedure only the emissions for the share of emissions that is not taking part in the CDM can actually be updated for each step. This means that as this share gets ever smaller at higher participation rates, a larger share of emissions get “locked in” and are not updated from step to step.

emissions between Annex B and non-Annex B countries, and only emissions in non-participating countries will be reduced as a result of the CDM.

In the *fixed no-Kyoto* case carbon leakage decreases rapidly with increasing participation as an increasing share of emissions becomes ‘locked-in’ to a low baseline - and as the increasing number of CERs generated brings down the permit price and hence also carbon leakage. At 100% participation all emissions in developing countries would in effect be capped with no carbon leakage (total leakage stays above 0% only because of leakage to non-participating countries). This is the result that was predicted and explained in section 2.1 (case 3).

It is difficult to assess up front what would be a realistic participation rate. A rate of 10% gives a volume of CDM sales (102-113 Mt Ce/year across cases) roughly consistent with the estimate by Michaelowa and Jotzo (2005) (99 Mt Ce/year).¹⁸ This might seem high in light of the number of CDM projects currently in the pipeline - reported by CDM Watch (2005) to be 18-29 Mt Ce/year.¹⁹ The participation rate that is consistent with such a volume of CDM sales is below 2%. It is, however, possible that this just indicates a slow start for the CDM. New rules adopted by COP/MOP1 in Montreal (UNFCCC 2005b) that open the door for a broader range of CDM projects that are not strictly project based can be expected to increase the participation rate.

In table 2 we present emissions (Mt Ce/year) for all our scenarios and cases, using a 10% participation rate for the three CDM cases. The numbers show that at what might be a realistic participation rate (realistic number of CERs generated), carbon leakage can be reduced by more than one half from what it would have been without the CDM.

Table 2: Annual emissions and carbon leakage (Mt Ce) under the five scenarios and cases (with 10% participation rate in the three cases).

Region	BAU	No CDM		CDM cases	
	No-Kyoto	IET-only	Updating	Fixed baseline	Fixed no-Kyoto
Annex B	3653.7	3209.2	3209.2	3209.2	3209.2
China	2160.7	2166.9	2159.7	2160.4	2159.8
India	668.5	670.0	669.4	669.4	669.3
Brazil	164.8	165.4	165.4	165.4	165.3
Asia	1451.8	1457.8	1454.7	1455.0	1454.4
Africa and Latin America	1770.2	1777.8	1773.4	1773.8	1773.1
Non-participating regions	2426.2	2432.3	2430.4	2430.4	2430.5
Change from no-Kyoto	-	-416.6	-433.5	-432.1	-434.2
Total carbon leakage	-	27.9	10.9	12.3	10.2
Leakage (%)	-	6.3 %	2.5 %	2.8%	2.3%

¹⁸ In their study Michaelowa and Jotzo scaled back the abatement cost curves to 10%. Thus, in one sense this might not have any significance beyond showing that we arrive at the same volume of CDM sales when we use a similar participation rate even if we use a rather different model.

¹⁹ CDM Watch (2005) provides a low estimate of 328 million CERs in pipeline, and a high estimate of 530 million CERs. These numbers were converted to Ce and divided by the 5 years of the first commitment period.

4.2 Sensitivity analysis

There are many assumptions that need to be made to undertake any CGE analysis, and these can potentially have a significant bearing on the results. Results already presented show that changes in the assumptions on participation rate and baseline methodology can have a significant influence. A sensitivity analysis conducted on two other important assumptions seems to indicate that the main results are robust across other assumptions:

We use transaction cost of 20% of total cost of CDM permits in the standard scenarios. It is not clear whether using a fixed share of costs or whether using a fixed cost is the most appropriate way to represent transaction costs. We have therefore run two of our cases (*fixed baseline* and *updating*) with a fixed \$1/t CO₂ (or \$3.7 per t Ce) transaction cost (Chen 2003). The effect this has on carbon leakage can be seen in figure 8 (where the results for the standard assumption also appear for comparison). For both cases using the \$3.7 transaction costs results in slightly lower leakage rates for low participation rates (less than 0.1% lower), and somewhat higher carbon leakage for higher participation rates. The intuition behind this is simple: Carbon leakage is determined by the international permit price. \$3.7 is less than 20% of the permit price as long as permit prices are higher than \$18, thus making CDM credits cheaper and thus reducing carbon leakage somewhat more. For permit prices below \$18 a fixed \$3.7 premium on CDM credits increases the permit price (quite substantially at high participation rates).

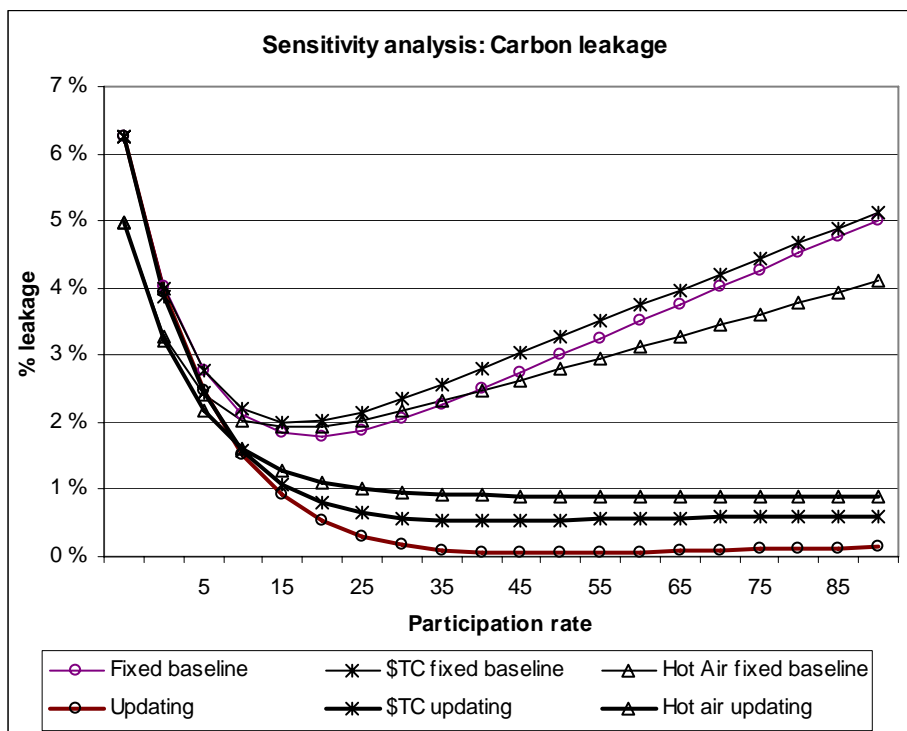


Figure 8: Carbon leakage under sensitivity analysis and with standard assumptions

The assumption regarding how much hot air is sold could also have a significant influence on the results. If we relax the assumption that *no* hot air is sold by instead assuming that Russia will sell 50% of its hot air, this results in a dramatic drop in permit prices (to \$14.1 as compared to \$27.2 at 0% participation in the standard scenarios). The volume of CDM sales stays at around 2/3 of the level for the standard assumptions. This means that the initial carbon leakage is much lower, and it is reduced even further as permit prices are extremely low. However, the shape of the curves is the same as in the standard scenarios.

The sensitivity analysis indicates that our main results are relatively robust. The exact estimates for the permit prices or CDM volumes may change, but the structure of the interaction between baseline methodologies, participation rate and carbon leakage remains the same (all curves still have the same basic shapes).

5 Conclusions

The CDM has the potential to significantly reduce international emissions trading permit prices and thus also to significantly reduce the magnitude of carbon leakage under realistic assumptions (Kallbekken 2006). In this paper we have analyzed how the choice of CDM baseline methodologies can influence to what extent this potential will be realized. This paper does not analyse the role of technology spillovers due to CDM projects. Also, we have not considered how incentives by both host and investor to overstate the emissions reductions achieved by a CDM project might pull the results in the opposite direction (see for example Michaelowa and Dutschke 1999).

Our estimate of carbon leakage (without CDM) is relatively low (estimates in the literature typically range from 5 to 20%). If carbon leakage is small, the problem is not critical with respect to environmental effectiveness - or competitiveness effects - and the issue of to what extent the CDM can reduce it becomes less relevant. If, however, carbon leakage should turn out to be a significant issue, then the CDM – and how baselines are established – becomes a concern. In fact, most other studies find higher rates of carbon leakage than we do.

The contribution of this paper is to show how important it is to account for market leakage effects in the CDM baseline methodology; the CDM has the potential to reduce carbon leakage significantly, but this potential *may not* be realized unless carbon leakage is accounted for appropriately.²⁰ Using the methodology most consistent with the CDM rules (the *updating* baseline), carbon leakage is reduced significantly with increasing participation rates. It is, however, not clear that this is the methodology that will be used in practice: It requires at least regular updating of observed market prices – possibly CGE modelling tools, while the two alternative baseline methodologies are much less demanding as current prices can be used to estimate the baseline. However, unless the amount of CERs generated should be significantly greater than expected today, carbon leakage will be reduced under all three baseline methodologies considered here: At a 10% participation rate carbon leakage is reduced by between two thirds and one half.

References

- Babiker MH (2005) Climate change policy, market structure, and carbon leakage. *Journal of International Economics* 2(65): 421-45.
- CDM Executive Board (2005) CDM – Project activities. <http://cdm.unfccc.int/Projects/registered.html>. Cited 16 Dec 2005.
- CDM Watch (2005) CERs claimed to 2012 by CDM projects 11 March, 2005. <http://www.cdmwatch.org/quick-stat/quick%20stats%20march%2011%202005.pdf>. Cited 16 Dec 2005.
- Chen W (2003) Carbon quota price and CDM potential after Marrakesh. *Energy Policy* 31: 709-719.
- Dimaranan BV, McDougall RA (eds.) (2006 forthcoming) *Global Trade, Assistance, and Production: The GTAP 6 Data Base*. Center for Global Trade Analysis, Purdue University. West Lafayette, Indiana.

²⁰ At low - but perhaps realistic – participation rates the reductions in carbon leakage are less dependent on the baseline methodology than it is for higher rates of participation.

- De Gouvello C, Coto O (2003) Transaction Costs and Carbon Finance Impact on Small-Scale CDM Projects. *PCFplus Report 14*, PCFplus Research, Washington DC.
- Di Maria C, van der Werf E. (2005) Carbon leakage revisited: Unilateral climate policy with directed technical change. Discussion Paper Tilburg University No. 2005-68, Tilburg University, Tilburg.
- Egenhofer C (2003) What can the EU do to encourage Russia to ratify the Kyoto Protocol? Centre for European Policy Studies. http://www.ceps.be/Article.php?article_id=124&. Cited 31 Mar 2006.
- EIA (2005) International Energy Outlook 2005. Official Energy Statistics from the US Government. <http://www.eia.doe.gov/oiaf/ieo/pdf/tbl2.pdf>. Cited 31 Mar 2006.
- Ellis J, Corfee-Morlot J, Winkler H (2004) Taking stock of progress under the Clean Development mechanism (CDM). In: OECD Environmental Directorate and International Energy Agency (eds.), OECD and IEA Information Papers, Paris, pp 1-51.
- Geres R, Michaelowa A (2002) A qualitative method to consider leakage effects from CDM and JI projects. *Energy Policy* 30: 461-63.
- Golombek R, Hoel M (2004) Unilateral Emission Reductions and Cross-Country Technology Spillovers. *Advances in Economic Analysis & Policy* 4 (2), article 3.
- Hourcade JC, Shukla P (2001) Global, Regional, and National Costs and Ancillary Benefits of Mitigation. In: IPCC, Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, New York, pp. 499-560.
- Jotzo F, Michaelowa A (2002) Estimating the CDM market under the Marrakech Accords. *Climate Policy* 2 (2-3): 179-196.
- Kallbekken S. (2004) A description of the Dynamic analysis of Economics of Environmental Policy (DEEP) model. CICERO Report 2004:01, CICERO, Oslo.
- Kallbekken S (2006) Why the CDM can reduce carbon leakage. CICERO Working paper 2006:02, CICERO, Oslo.
- Kallbekken S, Westskog H (2005) Should Developing Countries Take on Binding Commitments in a Climate Agreement? An Assessment of Gains and Uncertainty. *Energy Journal* 26 (3): 41-60.
- Manne AS, Richels RG (1998) The Kyoto Protocol: a Cost-Effective Strategy for Meeting Environmental Objectives. *Energy Journal* (Kyoto Special Issue): 1-23.
- Michaelowa A, Dutschke M (1999) Economic and Political Aspects of Baseline in the CDM Context. In: Goldemberg J, Reid W (eds) (1999) Promoting development while limiting greenhouse gas emissions: trends & baselines. United Nations Development Programme and World Resources Institute, New York: pp 115-134.
- Michaelowa A, Fages E (1999) Options for Baselines of the Clean Development Mechanism. *Mitigation and Adaptation Strategies for Global Change* 4: 167-85.
- Michaelowa A, Jotzo F (2005) Transaction costs, institutional rigidities and the size of the clean development mechanism. *Energy Policy* 33: 511-23.
- Michaelowa A, Stronzik M (2002) Transaction costs of the Kyoto Mechanisms. HWWA Discussion Paper 175, Hamburg Institute of International Economics, Hamburg.
- Michaelowa A, Stronzik M, Eckermann F, Hunt A (2003) Transaction Costs of the Kyoto Mechanisms. *Climate Policy* 3: 261-278.
- Millock K (2002) Technology transfers in the Clean Development Mechanism: an incentives issue. *Environment and Development Economics* 7: 449-66.
- Rutherford TF, Paltsev SV (2000) GTAP-Energy in GAMS: The Dataset and Static Model. Working Paper No. 00-2, Department of Economics, University of Colorado.
- Sijm JPM, Kuik OJ, Patel M, Oikonomou V, Worrell E, Lako P, Annevelink E, Nabuurs GJ, Elbersen HW (2004) Spillovers of Climate Policy - An assessment of the incidence of carbon leakage and induced technological change due to CO₂ abatement measures. Scientific Assessment and Policy Analysis, Netherlands Research Programme on Climate Change, Amsterdam.

Silayan A. (2005) Equitable Distribution of CDM Projects Among Developing Countries. HWWA-Report 255, Hamburg Institute of International Economics, Hamburg: 1-88.

UNDP (2003) The Clean Development Mechanism: a User's Guide. UNDP, New York.

UNFCCC (1997) *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. http://unfccc.int/essential_background/kyoto_protocol/items/1678.php. Cited 31 Mar 2006.

UNFCCC (2005a) Decision -/CMP.1 Modalities and procedures for a clean development mechanism as defined in Article 12 of the Kyoto Protocol. In: UNFCCC secretariat (ed), COP11/MOP1 (Advanced Unedited Version), Montreal.

UNFCCC (2005b) Decision -/CMP.1 Further guidance relating to the clean development mechanism. In: UNFCCC secretariat (ed.), COP11/MOP1 (Advanced Unedited Version), Montreal.

Vöhringer F, Kuosmanen T, Dellink R (2006) How to attribute market leakage to CDM projects. *Climate Policy* 5(5).