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# Does the Clean Development Mechanism have a viable future?

**Abstract:**
The developed countries can meet part of their Kyoto commitments by investing in emission-reducing projects in developing countries (the Clean Development Mechanism, CDM). Since the developing countries have so far not been willing to accept binding emission commitments, the CDM has been the only mechanism available for ensuring emission-abatement measures in developing countries. We argue that the CDM is not an efficient tool for achieving deep cuts in global emissions and conclude that maintaining the CDM as an option for developing countries may in itself be a serious obstacle to more binding participation by these countries.

**Keywords:** Clean development mechanism, climate agreement, emissions trading, emissions reductions.

**JEL classification:** Q54, Q56

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# 1. Introduction

Under the Kyoto Protocol, the developed countries took on binding quantitative commitments to limit their greenhouse gas emissions for the period 2008-2012.[1] However, the US has subsequently withdrawn its support for the Kyoto Protocol.

Each country with a binding emission commitment has been allocated an emission quota called its assigned amount. The quota is divided into assigned amount units (AAU), which can be traded with other developed countries. This type of arrangement is called a cap and trade system. In addition to taking part in emissions trading, the developed countries can meet their commitments through domestic abatement, projects in other developed countries (Joint Implementation projects) and finally, through the Clean Development Mechanism (CDM).

The CDM allows developed countries to earn certified emission reduction units (CERs) through emission-reduction or emission-removal projects in developing countries. Examples include afforestation (i.e. planting *new* forest), switching to less polluting fuels or energy sources, and energy efficiency measures.

Since emissions reductions achieved through the CDM may be used in their entirety to offset emissions in developed countries, the mechanism is not designed to bring about an overall decrease in global emissions.[2] However, the CDM is important in reducing the costs of complying with the Kyoto Protocol, since it ensures that more countries cut their emissions, and there are many low-cost options for reducing emissions in developing countries. Moreover, the expectation that the CDM would result in lower costs may have made the developed countries willing to take on stricter commitments than they would otherwise have done. Thus, the CDM may well have resulted in global emissions reductions in practice, but we ignore this possibility in the following discussion.

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[1] See Annex B to the Kyoto Protocol for a complete list of countries that have quantitative emission commitments. The text of the Protocol is available at http://unfccc.int/kyoto_protocol/items/2830.php.

[2] According to the Kyoto Protocol, the purpose of the CDM is to assist the developed countries in meeting their commitments, and to assist developing countries in achieving sustainable development (see Article 12 of the Protocol). It can be argued that CDM projects result in technology transfers, so that new environmentally sound technology is deployed in developing countries. However, as long as there are no costs (tax or carbon price) associated with emissions in developing countries, significant transfers of new technology are unlikely if they result in higher production costs. Moreover, the CDM may encourage the introduction of new technology even if the most cost-effective measure would be to reduce production. This is because emission credits can be earned by introducing new technology, whereas it is difficult to define reductions in production as CDM activities. This issue is discussed by Fischer (2005) and Hagem (2009).

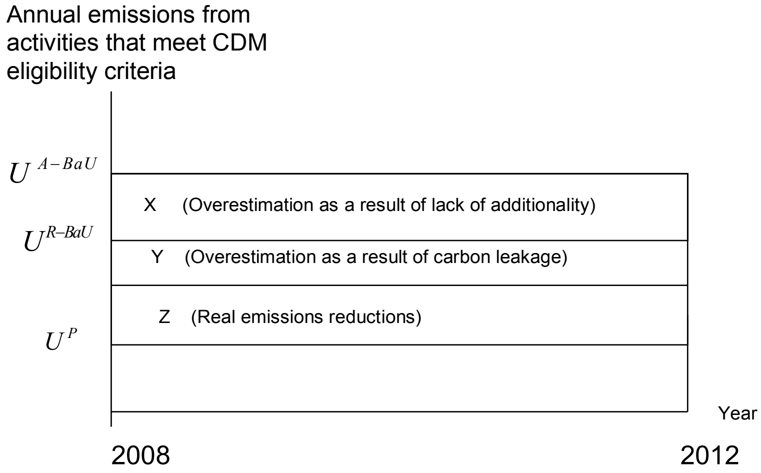
This paper discusses how the CDM functions and whether it is compatible with a future climate agreement designed to bring about deep cuts in emissions. We start by describing some of the fundamental weaknesses of the CDM in the next section. In section **0**, we illustrate numerically that an ambitious global target for emissions reductions cannot be achieved by reductions in the developed countries alone. Substantial cuts in emissions in developing countries will be needed as well. However, our conclusion is that the CDM is not a suitable mechanism for achieving such large cuts in emissions because transaction costs are high, it is not cost effective, and there is a high risk that emissions reductions will be overestimated. In section **0**, we show by the use of a numerical model that the developing countries can gain from participating in a cap and trade system even if their cap is substantially lower than their estimated emissions in the absence of any abatement efforts. Furthermore, we argue that as long as developing countries have risk-free opportunities to earn money on emissions reductions under the CDM, it will be difficult to persuade them to take on the kind of commitments that will be needed to achieve ambitious climate goals.

# 2. How does the CDM function?

The CDM Executive Board, which is accountable to the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol, is responsible for approving all CDM projects and issuing CERs. Like one AAU, one CER gives the right to emit one ton of $CO_2$ equivalent ($CO_2$e).[3] The number of emission credits issued corresponds to the calculated emissions reduction from the CDM project, which is the difference between the level of emissions without the CDM project (the business-as-usual or BaU level) and emissions after the project has been carried out.

[3] The Kyoto Protocol regulates emissions of several greenhouse gases, of which $CO_2$ is the most important. Quantities of the other gases, including methane and nitrous oxide, are measured in terms of their global warming potential, in $CO_2$ equivalents.

**Figure 1. Illustration of the different sources for overestimation of annual emissions reductions from CDM-projects**




For illustrative purposes, assume that a developing country's estimated aggregate BaU emissions have been set at $U^{A\text{-}BaU}$ during a relevant period, for example the Kyoto period, 2008–2012. The observed level of emissions after completion of a number of CDM projects, that meet the CDM eligibility criteria, is given by $U^P$ in Figure 1. If all the projects are approved, they will generate CERs corresponding to the difference between $U^{A\text{-}BaU}$ and $U^P$, in other words the sum of the areas of rectangles X, Y and Z in Figure 1. These credits can be used in their entirety by developed countries to offset corresponding increases in their emissions.

However, there is a high probability that the real emissions reductions generated by the projects will be lower than the estimated figures that are used as a basis for issuing CERs.[4] This is because of problems related to the *additionality criterion* and to *carbon leakage*. A CDM project is only approved if it meets the additionality criterion, i.e. if it can be substantiated that it would not have been financially viable to carry out the project if it did not generate CERs and thus extra funding. Since there are substantial profits to be made by acquiring CERs, the parties involved in CDM project

[4] We have focused on the case where the emissions reductions generated by a CDM project are systematically overestimated, since this results in the greatest profits for all actors with a financial interest in the project. Because of the high level of uncertainty, there may also be cases where the real abatement from a CDM project is larger than the estimated figure used as a basis for issuing CERs.

activities have an incentive to present profitable projects as unprofitable, so that projects that would have been carried out in any case are approved as CDM projects and generate CERs.[5] Furthermore, the CDM gives incentives for increasing production of emissions generating goods to gain a profit on emission reduction through the CDM at a later stage.[6] The parties also have a financial interest in overestimating the BaU emissions from projects that meet the additionality criterion, since this will generate more CERs. Moreover, even if a specific investment project is unprofitable unless it can be used to generate CERs, there may be alternatives that are profitable and that would also reduce emissions.[7] In such cases, the true BaU emission level is not equal to emissions before the start of the CDM project, as the investors may claim, but the emission level that would have been achieved through the alternative profitable investment.

The effects of CDM projects in developing countries are overestimated by these types of miscalculation, since the estimated BaU emissions from activities that meet CDM eligibility criteria ($U^{A\text{-}BaU}$) are higher than the true BaU emissions, $U^{R\text{-}BaU}$. The difference corresponds to area X in Figure 1.

Another problem that arises when trying to determine the abatement achieved by CDM investments is that of *carbon leakage*. Emissions reductions in one part of the economy may be partly counterbalanced by higher emissions in other parts of the economy. One example of a CDM project with potential leakage is the partial replacement of coal by biofuel as energy source in a production process. It is reasonable to assume that the replacement of polluting forms of energy with green energy is not the only result of investing in green energy: such investments increase the energy supply, which will also reduce market energy prices and is likely to result in a higher overall level of energy use. If this happens, the reduction in the use of polluting energy resulting from a CDM project will be partly counteracted by an increase in the use of polluting energy elsewhere in the country. As long as there is no constraint on aggregate national emissions in developing countries, it is difficult to avoid this effect, which is known as carbon leakage. Such leakages are not taken into account when calculating

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[5] If a project does not meet the additionality criterion, the true volume of BaU emissions is equal to the observed volume after completion of the project. In this case, the project does not result in a real reduction in emissions.

[6] An example of this kind of perverse incentives created by CDM is given in Wara (2007). He shows that manufactures in developing countries have stepped up their production of HCFCs in order to profit by cutting back on the greenhouse gas HFC, which is produced as a by product.

[7] The possibility of earning money on future CDM projects may also discourage actors in developing countries from investing in alternative, profitable energy efficiency projects today. The effect of this on global emissions is discussed in Hagem (1996).

the number of CERs earned by a project.[8] In Figure 1, the overall carbon leakage effect is shown by area Y. Figure 1 thus illustrates a case where the additionality and carbon leakage problems result in the overestimation of the effects of CDM projects in a developing country by Y+X tons $CO_2$, corresponding to the same number of CERs. Since CERs can be used to offset emissions in developed countries, the global rise in emissions as a result of the CDM projects in this example is Y+X tons $CO_2$.

It is difficult to estimate the severity of these types of overestimations. Calculations of both Y and X must be based on counterfactual figures, i.e. the estimated emission levels if the CDM projects had not been carried out. This means that it is never possible to calculate a precise figure for the global rise in emissions that can be attributed to the CDM. Michaelowa and Umamaheswaran (2006) have assessed the documentation of additionality for 54 CDM projects, and concluded that additionality was only well documented for a minority of these. Calculations based on general equilibrium models also show that there may be substantial carbon leakage effects. For example, a study by Glomsrød and Taoyuan (2005) showed that approval of coal cleaning as a CDM project activity in China could result in a rise in $CO_2$ emissions instead of a decrease. This is because the greater energy efficiency of cleaned coal would reduce the demand for raw coal and thus its price, leading to a rise in consumption in other parts of the economy. The rise in energy efficiency and reduction in the cost of transporting coal would also boost economic growth and lead to a rise in energy use and emissions. Using a general equilibrium model for the Chinese economy, carbon leakage was found to exceed 100 per cent, that is, the increase in emissions outside the border of the projects more than offset the emissions reductions within the border of the project. Böhringer, Conrad and Löschel (2003) showed that if Germany meets its Kyoto commitment partly by means of investments in the power sector in India, this will lead to a rise in emissions in other parts of the economy equivalent to 56 per cent of the emissions reduction in the power sector. On the other hand, the CDM may reduce global carbon leakage by lowering the international price of carbon and thus weakening the incentives to relocate manufacturing from developed to developing countries.[9,10]

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[8] In principle, the number of CERs is calculated on the basis of the difference between the estimated BaU emissions and the actual emissions after the project is completed, corrected for any carbon leakages that are measurable and attributable to the CDM project. However, leakage effects resulting from general equilibrium effects in the economy are not taken into account. The rules for CDM project activities may be found here: http://cdm.unfccc.int/Reference/COPMOP/08a01.pdf, See also http://cdm.unfccc.int/Reference/Guidclarif/glos_CDM_v04.pdf

[9] Global carbon leakage describes a situation where emissions reductions funded by countries that have binding emission caps (developed countries) are partly offset by rises in emissions in countries without quantified commitments (developing countries). This may be explained both by leakage effects transmitted through global energy markets (because the prices of fossil energy drop as a result of lower demand in developed countries), and by the relocation of energy-intensive manufacturing from developed to developing countries.

[10] A study by Kallbekken (2007) showed that the CDM reduces global carbon leakage, whereas Bollen, Gielen and Timmer (1999) drew the opposite conclusion.

Thus, there is a great deal of evidence that, under the current rules, the net effect of the CDM is an increase in global emissions. To counteract this, various ways of tightening up the rules have been discussed. One possibility is to award each project fewer CERs than the number corresponding to the estimated emissions reductions – for example, emission credits could be issued for only half the estimated abatement. This would make the CDM more expensive for developed countries and less profitable for developing countries, but would prevent a global rise in emissions and would address much of the criticism that has been levelled against the system. On the other hand, such a strict regime might be less cost-effective.

Another option is to introduce stricter requirements for documenting additionality. Unfortunately, the stricter the requirements for documentation and control, the more transaction costs will rise (meaning administration, documentation and control costs). There is also a risk that the cheapest and thus most cost-effective projects will not be approved because it will not be possible to substantiate that they meet the additionality criterion by a good margin, even if they do in fact satisfy this criterion. It is paradoxical that the most cost-effective CDM projects that meet the additionality criterion are by definition only additional by a very small margin, and are therefore unlikely to pass the additionality test under a stricter regime.

Another weakness of the CDM is that it can only apply to a certain proportion of emissions in developing countries. Certain types of activities, such as conservation of forests, are explicitly excluded. Moreover, policy reforms designed for example to reduce emissions from transport through higher end-user prices for petrol and diesel, and low-cost energy efficiency measures such as removal of subsidies, are not approved as CDM project activities, and there is little prospect of their inclusion. To reduce the degree of uncertainty associated with the emission-reduction effects of CDM projects, the mechanism only applies to emissions reductions achieved through concrete investment projects. This means that the CDM can never ensure that all cost-effective emission-reduction measures are carried out, whereas an international carbon price can do this through a global emissions trading scheme or taxation system. Nor does the CDM solve the problem of relocation of emission-intensive manufacturing from developed to developing countries. Thus, the CDM results in higher costs than a global cap and trade system, both because it does not necessarily result in the lowest-cost emissions reductions, and because the transactions costs can be very high.

Even though the CDM could be improved, it will never be able to ensure both that all carbon credits issued correspond to real abatement of emissions, and that abatement takes place where it is cheapest (global cost effectiveness).

## 3. Is the CDM compatible with an ambitious climate agreement?

In this section, we discuss whether the CDM, despite its weaknesses mentioned in the previous section, is viable if the world really implements an ambitious global climate agreement.

It is a matter of debate exactly what is meant by an ambitious climate agreement. The EU has adopted the goal of limiting the average rise in global temperature to no more than 2°C above the pre-industrial level. Stern (2006) (the Stern Review) proposes a less ambitious target, since the costs may otherwise become excessive. The Stern Review recommends that the atmospheric concentration of greenhouse gases should not exceed 550 ppm, which would mean that projected global warming does not exceed 3° C.[11] This target can be achieved by following a recommended emissions path in which emissions peak in the next 10–20 years, and are at least 25 per cent below the 2004 level in 2050. In the longer term, emissions must be cut to more than 80 per cent below the current level.[12] We have used this path for global emissions reductions as a basis, but have only considered the reduction of $CO_2$ emissions from fossil fuels. In the numerical examples of the costs of a climate agreement, we have considered the year 2050 only[13].

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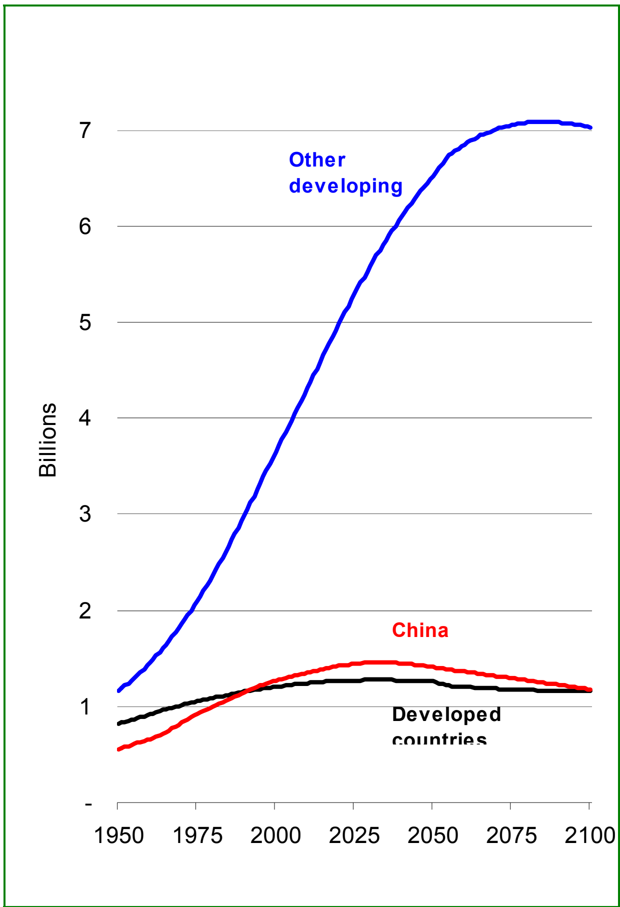
[11] See Stern (2006), Executive Summary, pages xv and xvii.

[12] See Stern (2006), Executive Summary, page xi.

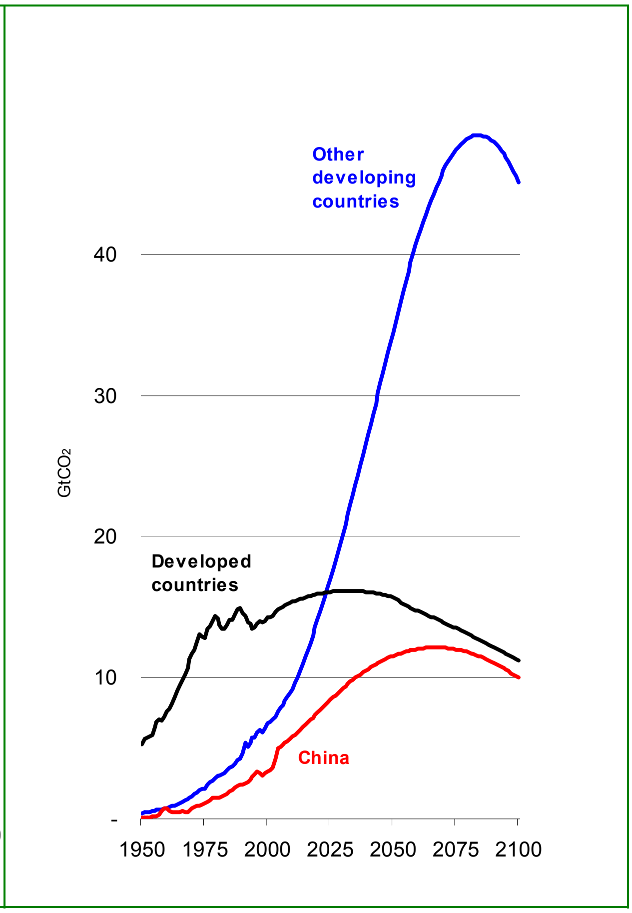
[13] We consider $CO_2$ emissions from fossil fuels only. The Stern Review includes all greenhouse gas emissions. We have used a $CO_2$ emissions scenario with the same percentage reduction as the Stern Review. As a result, we estimate somewhat higher greenhouse gas concentrations than those calculated by the Stern Review. Nevertheless, we assume that the cost will be 1% of GDP, as does the Stern Review.

**Figure 2. World population growth 1950 – 2100. UN projections, medium scenario. Billion people**




Source: UN (2004) and UN (2006)

**Figure 3. Global emissions, historical figures and projections from IPCC reference scenario A1, in developed countries, China and other developing countries**




Source: IPCC (2000)[14]

Cutting emissions by 25 per cent relative to 2004 by 2050 may appear to be a modest target, but involves a dramatic cut relative to the projected level in 2050 in the reference scenario. As a result of rapid population growth (see Figure 2) and a rise in per capita energy use in developing countries, projected emissions in the reference scenario are more than twice as high in 2050 as in 2004, see Figure 3 and Table 1. Both the emissions figures and the GDP figures in Table 1 are from IPCC's SRES scenario MESSAGE 1 (see IPCC (2000)).

[14] The IPCC decided not to develop new emissions scenarios for its Fourth Assessment Report, published in 2007, but to use those presented in the Special Report on Emissions Scenarios (IPCC 2000). We have therefore also based our calculations on IPCC (2000).

**Table 1. $CO_2$ emissions, GDP and population in 2004 and 2050 in the reference scenario***

| | 2004 | | | 2050 | | |
|---|---|---|---|---|---|---|
| | Emissions | GDP** | Population | Emissions | GDP** | Population |
| | $GtCO_2$ | Billion USD | Billions | $GtCO_2$ | Billion USD | Billions |
| Developing countries | 12.6 | 22 950 | 5.2 | 45.9 | 136 394 | 7.9 |
| Developed countries | 14.9 | 32 146 | 1.2 | 15.8 | 89 024 | 1.3 |
| World | 27.5 | 55 096 | 6.4 | 61.7 | 225 419 | 9.2 |

* These emission figures do not include emissions from land use, land use change and forestry (LULUCF). The emissions shown in Figures 1 and 3 do include emissions from LULUCF and are therefore somewhat higher.
** The GDP figures are measured in purchasing power parities.

Table 1 shows that in the reference scenario, emissions are estimated to rise by 125 per cent by 2050. If we are to cut global emissions by 25 per cent relative to the 2004 level by 2050, they should not exceed approximately 21 $GtCO_2$. This means that they would have to be cut by 66 per cent relative to the 2050 level in the reference scenario. This cannot be achieved by reductions in the developed countries only. Even if all the developed countries reduced their emissions to 0 in 2050, global emissions would still rise by 67 per cent. Thus, an ambitious global target for emissions reductions cannot be achieved without substantial cuts in emissions in developing countries as well.

We must therefore ask whether the CDM can bring about large enough cuts in emissions from developing countries in the long term. If we assume that only developed countries have binding emission caps, and that the target is to reduce global emissions by 25 per cent relative to 2004, the overall quota for all the developed countries must be *negative*, corresponding to about -25 $GtCO_2$, or approximately -160 per cent of the reference level in 2050. This means that the developed countries must purchase 25 billion CERs per year, to be cancelled, before they can purchase further credits to offset the emissions they in fact generate.

It is expected that 1.34 billion CERs will be generated by registered CDM projects by the end of the first Kyoto commitment period. This corresponds to an average of 0.27 billion CERs per year[15]. Under an ambitious climate agreement, the CDM market would thus have to be at least 90 times this size. And this figure does not take into account the additionality and carbon leakage problems described in the previous section.

[15] http://cdm.unfccc.int/Statistics/index.html

Given a climate agreement with this level of ambition, the price of carbon would be considerably higher than the present level for CERs (EUR 14 – 15 in mid-November 2008, see www.nordpool.no). A high carbon price would in turn result in a larger volume of CDM projects.

However, to expand the volume of CDM projects to the extent described here, it would be necessary to include relatively small projects in the portfolio – and the small projects have high transaction costs per unit of emissions reduction. For example, Michaelowa, Stronzik, Eckermann and Hunt (2003) estimated that the transaction costs for very small projects (200–2000 $tCO_2$ per year) are about EUR 100 per ton $CO_2$.

According to the literature, even an ambitious global climate agreement (to achieve the 550 ppm target) may involve relatively modest costs, generally of the order of 0–3.5 per cent of GDP in 2050 (see IPCC (2007). The Stern Review estimates that the annual costs of stabilising the concentration of greenhouse gases in the atmosphere at 550 ppm will not exceed one per cent of global GDP per year[16]. In this case, it would be possible for the developed countries to meet all the costs, which would be equivalent to about 2.5 per cent of the developed countries' GDP (see Table 3, which is discussed further in the next section). However, these estimates assume that emissions reductions are distributed cost-effectively, and that the developed countries do not pay the developing countries more than the cost of the emissions reductions. In a situation where all emissions reductions in the developing countries take place through the CDM, the costs incurred by the developed countries may be considerably higher, both because the CDM is not cost effective, as explained earlier, and because it involves financial transfers to developing countries.

In a well-functioning market, the international price of CERs is equal to the cost per unit emission reduction from the most costly CDM project. This means that the developing countries will make a profit on all except the most costly project, and the costs incurred by the developed countries will rise above 2.5 per cent of GDP. It is precisely the prospect of gaining from the transactions that can provide an incentive for developing countries to take part in a cap and trade regime, provided that they are allocated a large enough volume of emissions. Thus, a global cap and trade regime could be a win-

[16] See Stern (2006), Executive Summary, page xiii.

win situation for developed and developing countries, and pave the way for an ambitious climate agreement[17]. This is illustrated further in the next section.

# 4. Developing countries under a cap and trade system

To provide a numerical illustration of the possible scale of global emissions trading and income transfers in a cap and trade system, we have made some calculations based on the target for the atmospheric concentration of greenhouse gases (550 ppm) and the estimate of total annual costs (1 per cent of global GDP) from the Stern Review, and a model of the costs of climate measures, which is described in the appendix**.**

As mentioned above, the emissions path used in the Stern Review is based on the assumption that emissions in 2050 are reduced to 75 per cent of the 2004 level. In our model, this requires a carbon price of USD 115 per ton $CO_2$ in 2050. This is in reasonably good agreement with the estimates obtained from other climate models, see the discussion in the appendix. If developing country emissions are to be capped at the BaU level (46 $GtCO_2$ in 2050), the developed countries must receive an overall negative quota of 25.5 $GtCO_2$. The optimal strategy for the developed countries will then be to purchase emission credits corresponding to 30.7 billion $GtCO_2$ from the developing countries. They must surrender 25.5 billion emission credits for cancellation to correspond to the initial negative quota, and can use 5.2 billion emission credits to offset annual emissions of 5.2 $GtCO_2$.

[17] Taking part in a cap and trade regime does not preclude developing countries from obtaining funding from the types of projects that currently come within the scope of the CDM. Such projects would correspond to those known as Joint Implementation (JI) projects under the Kyoto Protocol. However, in a cap and trade regime, the developing countries are responsible for their overall national emissions. Any carbon leakage effects associated with JI projects would therefore have to be offset by emissions reductions in other parts of a country's economy.

**Table 2. Emissions are reduced to 75 per cent of the 2004 level in 2050, and developing country emissions are capped at the BaU level**

| | | Developing countries | Developed countries | World |
|---|---|---|---|---|
| National emissions quota | % of BaU | 100 | -162 | 33 |
| | $GtCO_2$ | 46 | -25.5 | 20.5 |
| Simulated emissions | $GtCO_2$ | 15.3 | 5.2 | 20.5 |
| Export of emissions units | $GtCO_2$ | 30.7 | -30.7 | 0 |
| Emissions reduction | $GtCO_2$ | 30.7 | 10.5 | 41.3 |
| Cost of emissions reduction | USD billion | 1 770 | 607 | 2 377 |
| Net cost of purchasing emission units | USD billion | -3 540 | 3 540 | 0 |
| Net cost | USD billion | -1 770 | 4 147 | 2 377 |
| | % of GDP | -1.3 | 4.7 | 1.1 |

Given a carbon price of USD 115 per ton, sales of 30.8 billion emission credits will give a gross sales income of a little more than USD 3540 billion. According to our calculations, this gives the developing countries a net income of USD 1770 billion, corresponding to 1.3 per cent of their GDP. The annual costs for the developed countries correspond to 4.7 per cent of their GDP.

Even if developing countries' emissions are capped at 66 per cent of the BaU level (30.4 $GtCO_2$), these countries incur no net costs in a cap and trade regime, see Table 3. In this case, the developed countries must receive an overall negative quota of 10 $GtCO_2$, and their costs correspond to 2.5 per cent of GDP in 2050.

Even though estimates of this kind are always open to criticism, the main conclusion is robust: the developing countries will make a considerable profit from an emissions trading scheme if their emissions are capped at the BaU level.

**Table 3. Emissions are reduced to 75 per cent of the 2004 level in 2050, and developing country emissions are capped at 66 per cent of their BaU emissions**

| | | Developing countries | Developed countries | World |
|---|---|---|---|---|
| National emissions quota | % of BaU | 66 | -63 | 33 |
| | $GtCO_2$ | 30.4 | -10 | 20.3 |
| Simulated emissions | $GtCO_2$ | 15.2 | 5.2 | 20.3 |
| Export of emissions units | $GtCO_2$ | 15.2 | -15.2 | 0 |
| Emissions reduction | $GtCO_2$ | 30.8 | 10.6 | 41.4 |
| Cost of emissions reduction | USD billion | 1 772 | 608 | 2 380 |
| Net cost of purchasing emission units | USD billion | -1 744 | 1 744 | 0 |
| Net cost | USD billion | 28 | 2 352 | 2 380 |
| | % of GDP | 0 | 2.6 | 1.1 |

For the developed countries, a global cap and trade system is preferable to the CDM because the transaction costs are much lower and it includes all cost-effective measures to reduce emissions in developing (and developed) countries. However, the developing countries have not been willing to take on binding emission commitments. Many of them are, not surprisingly, sceptical to the idea of quantitative emission caps since their future economic development, and thus their "need" to generate emissions, is uncertain.[18] An agreement that includes corrections over time to allow for unforeseen changes, for example in the population growth rate, could help to reduce the level of uncertainty. Another possibility is a stepwise approach to full participation in a cap and trade regime, initially including only a limited number of sectors. However, this may entail large-scale carbon leakage if, for example, only parts of energy use are included in the cap and trade system.

The most serious obstacle to the inclusion of developing countries in a global cap and trade regime in the future may however be the CDM itself. As long as the mechanism exists, the developing countries can carry out emission-reduction projects and sell CERs without taking on any of the risks associated with binding emission commitments. Thus, the existence of the CDM increases the benefits to developing countries of not taking on such commitments. If the CDM is phased out, this will strengthen the incentive for developing countries to take part in a cap and trade regime, since the benefits of not joining the regime will be reduced.

To gain support for an ambitious climate agreement, it will be necessary to phase out the CDM and establish a climate regime in which the price of emissions is the same in developed countries and

[18] See Kallbekken and Westskog (2005) for a numerical analysis comparing the costs of a binding agreement and the CDM.

developing countries (or at least the largest emitters). According to our calculations, if developing country emissions are capped at the BaU level, we estimate that the costs incurred by developed countries will correspond to 4.4 per cent of their GDP. The costs will be considerably higher if the only mechanism for restricting developing country emissions is the CDM, which is not cost effective. The likelihood of developed countries being willing to adopt an ambitious climate agreement will also be considerably reduced if the CDM is not replaced by a cap and trade regime.

# 5. Conclusions

The title of this paper asks whether the CDM has a viable future. If global emissions are to be stabilised at a level that prevents substantial global warming (550 ppm), our answer is that it clearly has not. An ambitious climate agreement with this target will require substantial cuts in emissions in developing as well as developed countries. The CDM is not an efficient tool for achieving deep cuts in emissions, because transaction costs are high, it is not cost effective, and there is a high risk that emissions reductions will be overestimated. The CDM is in fact an obstacle to the development of a cost-effective global cap and trade regime, because it increases the benefits to developing countries of not taking on binding emission commitments. The CDM should be phased out so that developing countries have a stronger incentive to take part in a cap and trade regime.

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## Appendix

In this paper, we have used a simple calibrated model that divides the world into eight regions/countries: Africa, China, India, other developing countries in Asia, Latin America, the US and Canada, Europe, OECD-Asia, and Norway. However, here we only report aggregate results for developed and developing countries.

The model includes linear cost curves for each country or region, all starting from the origin. They are calibrated on the assumption that the marginal cost of reducing emissions to 66 per cent of the BaU level is USD 115 per ton $CO_2$ for all countries. In other words, the model does not take into account the fact that there may be a greater potential for low-cost emissions reductions in developing than in developed countries. Furthermore, it is assumed that there is perfect competition in the emissions trading market, so that the marginal cost in all countries is the same as the carbon price, and that all countries meet their commitments.

It is very uncertain how high the price of carbon must be to reduce global emissions to 20.5 $GtCO_2$ in 2050. IPCC (2007b) gives some idea of the level of uncertainty. For a scenario where the target is a greenhouse gas concentration of 550 ppm $CO_2e$, the IPCC suggests that the price in 2050 will be in the range USD 30–155 per ton $CO_2$. We have assumed that the price will be USD 115 per ton $CO_2$, which is within the upper half of the price interval estimated by the IPCC.

In the model, emissions in country i, $E_i$, are found using the following equation:

$$E_i = E_{0i} - b_i p$$

where $E_{0i}$ is the volume of BaU emissions in country $i$, $p$ is the carbon price and $b_i$ is a country-specific parameter. This is calibrated on the assumption that reducing emissions to 67 per cent of the BaU level in 2050 will require a carbon price of USD 115 per ton $CO_2$.

Given the linear structure of the model, the carbon price is determined by the following equation:

$$p = \frac{\sum_i E_{0i} - \sum_i Q_i}{\sum_i b_i}$$

where $Q_i$ is the total emission quota for country $i$.