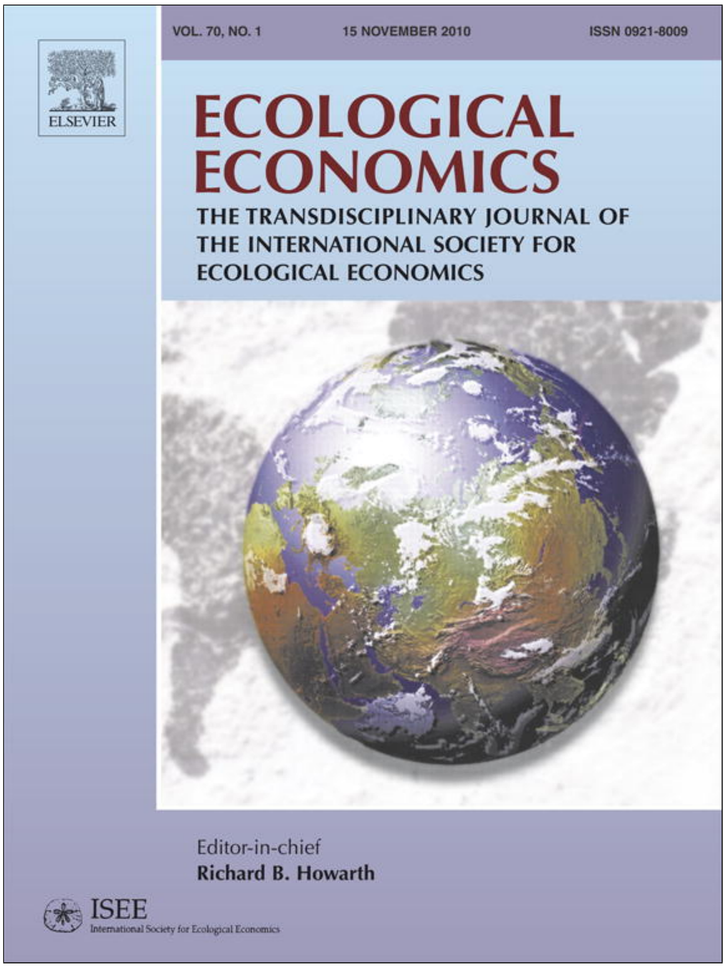
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Analysis

The impact of discounting emission credits on the competitiveness of different CDM host countries

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ABSTRACT

Discounting the value of emission credits has been proposed as a possible approach for addressing some of the shortcomings of the Clean Development Mechanism (CDM). It could be used to compensate for non-additional CDM projects; to increase the incentive for advanced developing countries to move from the CDM to own mitigation commitments; and to improve the competitiveness of less developed countries as hosts for CDM projects. We assess the impact of discounting on the distribution of CDM projects in host countries, with a special focus on Least Developed Countries (LDCs). CDM-specific abatement cost curves are built for 4 regions: China, India, other advanced Asian countries and LDCs. Abatement costs are estimated using the information provided in the project documentation of 108 projects from 17 subtypes in 16 host countries. Abatement potentials are derived from the current CDM pipeline for each region. For LDCs, we additionally include an optimistic potential estimation by adding to the current pipeline the potential found by a World Bank study for LDCs in Sub-Saharan Africa. We then assess the effect of two emission credit discounting schemes on these abatement cost curves. Credit discounting is differentiated by host countries, based on an index composed of per capita GDP and per capita emissions. In the first scheme, it only affects the most advanced CDM host countries; in the second one it also affects China. We find that discounting has an impact on the competitiveness of individual CDM host countries in the carbon market, as it affects their abatement cost curves. It could become an instrument for incentivising advanced developing countries to leave the CDM and engage in other farther-reaching climate-related commitments, as a result of the resulting emission credit cost increases. However, even with discounting, LDCs remain unimportant in terms of abatement potential if the financial, technical and institutional barriers to CDM development in these countries are not overcome.

1. Introduction

Through the Clean Development Mechanism (CDM), greenhouse gas emission reductions from projects in developing countries can be acquired by industrialised countries to comply with their Kyoto Protocol emission reduction targets. By the end of 2008 (UNEP Risoe Centre, 2009), the CDM has mobilised almost 4500 projects, out of which 1300 have been formally registered with the CDM Executive Board and are thus accredited for generating emission credits[1]. Each tonne of CO_2-equivalent emission reductions achieved by the CDM generates one emission credit, which is then used by industrialised countries (or companies in them) to offset their own emissions. Thus, each tonne reduced by a CDM project allows increasing emissions in industrialised countries by one tonne. Theoretically, this is no problem as long as the reduction from the CDM project is real and as long as incentives for introduction of emission reduction policies in developing countries are not distorted. About 2.7 billion emission credits are expected to be generated in total by CDM projects by 2012.

The key criterion for ensuring that emission reductions from CDM projects are real is “additionality”. Additionality means that a CDM project has to be outside the “business-as-usual” development scenario for its region or country. This is, there are financial, economic, technical or other barriers for its implementation, which only the CDM incentive manages to overcome. This is a necessary condition for CDM projects to really contribute to reducing global GHG emissions: if a CDM project is not additional, using its emission credits to offset emissions in industrialised countries will lead to an actual increase in emissions. There is substantial criticism that a significant amount of CDM projects does not have a very credible additionality argumentation (see e.g. Castro and Michaelowa, 2008; Michaelowa and Purohit, 2007; Schneider, 2007).

The CDM was designed with the idea of an instrument to introduce developing countries to climate policy in a voluntary manner, without affecting their development objectives. It was conceived as a

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[1] Throughout this paper, the term “emission credits” is used to refer to the CDM's Certified Emission Reductions (CERs).

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transitional step before these countries also commit to own emission reduction targets. However, a shortcoming of the CDM is that the financial subsidy generated by the sale of emission credits may turn into a disincentive for advanced developing countries to take up emissions reduction commitments. Further, the CDM project portfolio is very unevenly distributed across potential host countries. China, India and Brazil account for over 71% of all projects and 76% of expected emission credits. Least Developed Countries (LDCs) host just 41 CDM projects in the pipeline (0.9%), out of which only 10 projects are registered. Sub-Saharan Africa (SSA) hosts 66 projects, but South Africa accounts for 41% of these (UNEP Risoe Centre, 2009). The Marrakech Accords that specify the detailed rules of the mechanisms under the Kyoto Protocol emphasise the importance of an equitable geographical distribution of CDM projects across countries and regions (UNFCCC, 2001); several studies have discussed the impact of this distribution on equity, efficiency and environmental considerations (Cosbey et al., 2005; Keller, 2008). Mitigation potential, institutional CDM capacity and general investment climate have been used as predictors of attractiveness of CDM host countries for CDM projects (Jung, 2005). Further, familiarity between investing country and host country, operationalised as past bilateral trade, past bilateral aid and colonial relationship, was found by Dolšak and Bowerman Crandall (2007) to be an even more important factor explaining CDM location decisions. More recently, Keller (2008) finds that population size is the most important variable influencing the location of CDM projects across host countries, which gives a different perspective to the discussion on the "unfairness" of CDM project distribution. When excluding the four largest host countries from the sample, he also finds that abatement potential, institutional framework and CDM capacities all have some explanatory power among countries of similar size.

While economic efficiency considerations dictate that the emission reductions should first take place wherever they are cheaper, equity concerns suggest that the CDM incentive should be more proactively directed towards less developed countries. These concerns are politically founded on the second goal of the CDM, which is to contribute to sustainable development in its host countries. Further, more autonomous climate mitigation action by advanced developing countries (beyond just offsetting) is needed to achieve the long-term environmental goals of the climate convention, which would mean that a system for gradually phasing out the CDM in these countries is needed (Cosbey et al., 2005; Schneider, 2008).

Discounting the value of emission credits according to host countries has been proposed as a possible approach for addressing these shortcomings of the CDM. As we will elaborate further below, discounting could be used to compensate for fictitious reductions from non-additional CDM projects; it could be designed to increase the incentive for advanced developing countries to move from the CDM to own mitigation commitments; and it could also be applied to improve the competitiveness of less developed countries as hosts for CDM projects.

This paper thus seeks to assess the impact that a new policy, discounting of emission credits, could have on the geographical distribution of the CDM, with a special focus on Least Developed Countries and Sub-Saharan Africa. Section 2 briefly summarises the existing research on discounting emission credits and its possible impacts on carbon markets. In Section 3 we discuss the relationship between discounting of emission credits and host country competitiveness in the CDM. In Section 4 we provide estimates for emission credit costs and potentials for different project types in Africa and other CDM host regions, based on previous studies and our own empirical research on the current CDM project portfolio. Section 5 analyses the impact of two emission credit discounting schemes on the competitive position of these CDM host regions by looking at the remaining CDM potential in these country groups. Section 6 discusses the results and draws the conclusions from this study.

2. Discounting emission credits

Discounting CDM emission reductions means that not all reductions generated by a project enter the carbon market, so that part of the effort is not used to offset emissions elsewhere, but provides real global GHG emission reductions (Schneider, 2008).

Why is such a discounting policy desirable, if the CDM is intended to make emission reductions cheaper? Discounting was first proposed by Greenpeace (2000) as a measure to safeguard the environmental integrity and the additionality of the CDM. This was a response to the widespread critique that it is very difficult to prove that a project proposed as CDM is not a business-as-usual situation and is thus leading to "real" emission reductions. Using discounting to safeguard additionality is however a complex task, as it would imply knowing the share of non-additional credits being issued despite all quality checks, and modifying the discount factor over time to reflect possible changes in this share. This would deter investors and, more importantly, penalise both non-additional and truly additional projects. For a numerical example of how additionality-based discounting could work, see Michaelowa (2008).

The early discussion on discounting also suggested that it could be used to compensate for the uncertainty related to establishing baselines, to provide an incentive for greater domestic action in countries with reduction targets, and to penalise negative social and environmental effects of CDM projects (Jackson and Begg, 1999). Ten years later, the discussion still focuses on using discounting for improving the CDM's environmental integrity, while influencing other shortcomings of the mechanism as well. Environmental Defense (2007), for example, proposed to differentiate discount rates across countries in order to "discourage further use of the CDM by large emitting developing countries and to direct the mechanism towards poorer developing countries" (ibid, p. 2). This is in line with the political objective, enshrined in the Kyoto Protocol itself, that the CDM should assist developing countries in achieving sustainable development, and that it should do it in an equitable manner (UNFCCC, 2001). It is also in line with the now recognised fact that the current system of emission reduction targets for industrialised countries and the CDM for developing countries is not enough for ensuring a long-term stabilisation of the climate system (Gupta et al., 2007). More climate mitigation action by developing countries, especially the large and advanced ones, is needed.

Chung (2007) proposed discounting as contribution of developing countries to global emission reductions without having to resort to country-specific commitments. This idea could be developed into a system where discounting provides an incentive for advanced developing countries to take up emissions reduction commitments. Discounting would build such an incentive, as taking up a commitment means that reductions achieved through domestic reduction projects count 100%, whereas under the discounting scheme, they would be valued less. The incentive would increase if the discount factor was progressively linked to the level of development of the host country (Michaelowa, 2008). Discounting by countries could also be used to promote CDM project development in African and Least Developed Countries by applying lower or no discount rates (or even granting more credits than reductions actually achieved) for projects in these countries (Schneider, 2008).

Discounting could also be varied according to project types, as suggested by Chung (2007) and elaborated by Schneider (2008). Thus, projects with beneficial characteristics could be favoured over less desired ones by assigning them a lower discount rate, no discount rate or even a multiplier above 1. For example, projects with large sustainable development benefits or using innovative technologies could be favoured, while projects with very large windfall profits or questionable additionality could be burdened. Despite these promising features, agreeing upon such a set of different discount rates could become very challenging at the UN level. Sustainable development priorities are defined differently by each country and their valuation is still very subjective and complex. The level of innovativeness of a technology is subjective to contextual factors, e.g. to the host country. Additionality depends not only on project type, but also on country-specific factors. This complexity would make it difficult even for technical experts to set appropriate discounting factors. Therefore we do not assess this type of discounting.

There are basically two approaches for implementing a discounting policy in the CDM. Supply-side discounting implies that only a certain fraction of the verified emission reductions leads to issuance of emission credits. This type of discounting would require an agreement at the UN level, but would have the advantage of being applicable to the whole carbon market. Demand-side discounting means that a percentage of the issued credits is retired from the market by the buyers, sending it for example to a cancellation account. Demand-side discounting allows for different credit buyers to set different discount rates, which would complicate the linking of different emission trading schemes and could distort emission credit prices (Schneider, 2008). While demand-side discounting makes little sense from a pure economic point of view, as demanding countries are expected to aim at getting as many credits as possible for the lowest price possible, political and environmental reasons are influencing these decisions. For example, the American Clean Energy and Security Act passed in the House of Representatives in June 2009 includes a discounting provision for international offsets (which would include CDM credits): from 2018 on, one international offset will be equivalent to 0.8 emission allowances in the US market (Pew Center, 2009). The reasons for such a demand-driven discounting scheme are, on the one hand, improving the environmental integrity of the scheme, and on the other, promoting domestic green jobs by favouring domestic reductions (or domestic offsets) over international ones. As the American market is expected to become the largest carbon market in the world, carbon credit sellers will not be able to escape such a unilateral discounting provision.

We use Environmental Defense's and Chung's suggestions that discounting could be used to improve the geographical distribution of CDM projects as a starting point, and elaborate on Michaelowa's proposal for a differentiation between host countries. We try to answer the question whether such a discounting scheme with differentiation between host countries could really have an impact on host country competitiveness in the CDM market, with focus on Least Developed Countries.

3. Discounting emission credits and host country competitiveness

Discounting emission credits will have an impact on the value and the amount of emission reductions from different CDM host countries. The higher the discount rate, the less credits are issued or traded for the project, and thus the higher the abatement cost. At the same time, the higher the discount rate, the less emissions reductions are credited, so the more the mitigation potential is penalised. Increased costs and reduced potentials are likely to lower the competitiveness of the CDM host countries affected by discounting.

The competitiveness or attractiveness of individual CDM host countries depends on several general and CDM-specific factors. Following Ellis and Kamel (2007), Michaelowa (2003) and Silayan (2005), important general considerations are:

- An enabling business environment: stable and transparent general institutional framework, stable and predictable investment laws.
- The existence of relevant financial incentives, such as tax reductions for renewable energies, import tariff reductions for CDM technology, etc.
- Reduced ownership restrictions for foreigners.
- Undistorted energy pricing policies.
- Local technical capacity and awareness of the CDM as a project financing option.
- Availability of underlying project finance, especially through local financial capacity.
- Availability of large and cheap CDM project options, whose value can offset the transaction costs of the CDM pipeline; this is coupled to the country's emissions mitigation potential.
- Other country or project-related risks that render the performance of the project uncertain.
- Existence of historical business or aid relationship with emissions credit buyer (Dolšak and Bowerman Crandall, 2007).

CDM-specific criteria are:

- Existence of CDM-related institutions: Kyoto Protocol ratification and establishment of an operational national CDM approval authority.
- Clear, capable and effective CDM policy framework: clear rules for national approval, timely and simple procedures, low national transaction costs, experience and continuity of national approval staff.
- Existence of CDM promotion offices.
- CDM awareness in government, industry, consultants and financial intermediaries.
- Existence of baseline data for project design.
- Existence of applicable CDM methodologies for the desired project type.
- Constraints on eligibility of specific project types — for example by the EU ETS or other major credit buyers.
- Capacity of auditing companies (validators or “designated operational entities”) in the relevant region.
- Temporary credits for certain project types, which have lower value in the market.

Discounting will clearly have no effect on the host country's business environment, on the institutional framework or on technological and methodological capacity. Some other measures have been undertaken in several countries to overcome at least the institutional barriers: the Nairobi Framework is an initiative launched during the climate negotiations in Nairobi in December 2006, aimed at enhancing the geographic distribution of CDM projects mainly through capacity building. It has contributed to improve some of the CDM-specific criteria, by establishing CDM authorities and approval rules, as well as creating awareness in the public and private sectors and initiating project portfolios in many countries. However, it was unable to integrate the financial actors. Further, capacity building has not addressed more technical needs, such as generating data for baselines or designing methodologies for project types that are more likely in less developed countries (Okubo and Michaelowa, 2010).

Discounting could contribute to further improve project-specific and cost-related factors by shifting the financial incentives of the CDM towards more backward countries, and could thus contribute to fostering CDM development in, for example, Sub-Saharan Africa or the Least Developed Countries.

However, more structural factors, such as political and economic stability, mitigation potential, technical capacity, and infrastructure are more difficult to change in the short term.

As discounting will not have an impact on the institutional criteria but rather on the value of emission reductions from different countries, we will focus our subsequent analysis on the host country potential for specific abatement technologies, and their abatement cost.

4. Estimating emission credit costs and CDM potentials

Right now, some individual CDM host countries or regions have sufficiently large CDM project portfolios to be able to empirically

Table 1
Project sample.

Project subtype	Sample size	Project financial discount rate (s) (%)	Median project lifetime (years)	Min and max lifetime (years)	Host countries
Biogas power	7	7, 8, 10, 15, 16	10	7, 21	China, South Africa, Guatemala, Honduras, India
Biogas flaring	4	10	8.5	7, 10	Brazil, Armenia
Biomass energy	8	7, 8, 10, 15	20	10, 25	South Africa, Kenya, China
Cement blending (*)	2	–	25	25	India, Indonesia
Coal mine methane	5	8, 11.8, 13.5	15	7, 20	China
Energy efficiency own generation	8	8.5, 10, 12, 13, 15	19	10, 20	China
Fugitive gases	4	10, 15, 20	15	10, 21	Qatar, India, Indonesia, Nigeria
Hydro existing dam	6	4, 8, 12, 14, 15	25	21, 40	China, Brazil, South Korea, Peru
Hydro new dam	6	8, 10, 12	26	20, 50	China
Hydro run of river	5	8, 10	27	20, 30	China
Landfill gas composting	7	8, 8.5, 10, 12, 15	10	7, 30	China, Bangladesh, Indonesia, Malaysia
Landfill gas flaring	4	8, 10, 13.75	10	7, 15	China, South Africa, Indonesia, Malaysia
Landfill gas power	9	8, 8.5, 10, 12	15	10, 21	Bangladesh, China
N_2O (adipic)	4	0–15	26	21, 30	China, Brazil, South Korea
N_2O (nitric)	10	0–15	21	7, 30	Brazil, South Africa, Colombia, China
New efficient gas power plant	6	8	20	20, 21	China
Wind	13	8	21	20, 25	China

estimate the cost of emission credits for specific project types, and possibly, regions. In addition, assessments of GHG mitigation potentials in different regions, including Africa, are available from the literature (e.g. Bakker et al., 2007; de Gouvello et al., 2008; Vattenfall, 2007; Wetzelaer et al., 2007).

On the basis of these empirical abatement costs and potentials for specific regions, we can estimate how different discounting schemes could affect those regions' competitiveness in the emission credit market, if we assume that abatement costs and potentials are the main criteria for locating CDM projects (i.e., if we disregard the institutional and legal dimensions described in Section 3).

4.1. Emission credit costs

General CDM project information is available from a public database, the CDM pipeline, which is maintained and updated monthly by UNEP Risoe Centre (UNEP Risoe Centre, 2009). More specific information for each project is also publicly available in the project documentation that can be downloaded from the CDM website of the UN[2]. For some projects, this documentation contains financial information, which we use for estimating emission abatement costs for the different CDM project technologies.

Project financial information can be provided in the documentation as Internal Rate of Return (IRR), as Net Present Value (NPV), as full cash flows or not at all. We define a project's abatement costs as the net present value of the project costs (investment and operation) minus its revenues (e.g. income from electricity sales), all divided by the amount of GHG emission reductions it expects to achieve (which is indicated by the amount of emission credits the project expects to generate over its lifetime, also time-discounted).

Overall abatement costs provide a measure of the profitability and attractiveness of the project — if the costs are negative, the project is profitable even without the CDM profit; if they are low enough, they can be compensated through the sale of credits; and if they are too high, the project is not profitable even with emission credit sales. However, not only this overall profitability is relevant for the decision to undertake a project, but also the upfront costs, since they need to be covered by financial resources that are frequently scarce, risky and difficult to access in developing countries. Therefore, in this paper we also analyse project investment costs per credit.

We have done abatement and investment cost estimations for a sample of CDM projects in 16 host countries. The first intention was to evaluate project costs in Sub-Saharan Africa (SSA) and Least Developed Countries (LDC). However, as of end of 2008 there are only 26 registered projects in these countries, few of which contain sufficient financial information. China was thus first included in this assessment due to its large project portfolio, which makes it easy to compare similar projects and their abatement costs and thus find possible outliers; its tendency to use the "investment analysis" for additionality demonstration rather than the "barrier analysis", which rarely provides sufficient financial information[3]; the large diversity of project types and sizes being implemented there; and its still relatively low rural development level, which in some provinces is similar to the situation in LDCs. Finally, projects from other countries were included in the sample for project subtypes that were not sufficiently represented yet. The sample consists thus of 108 projects from 17 project subtypes in 16 countries, as can be seen in Table 1.

4.1.1. Full abatement costs

Two important factors in the abatement cost calculations of a project – also shown in Table 1 – are its expected lifetime and the financial discount rate used for obtaining its present value. Cost calculations in CDM projects have the tendency to consider a lifetime equal to its crediting period[4], even if the project will have a longer life. As most CDM projects choose a 3×7-year crediting period, the lifetime considered in the calculations tends to be 20 or 21 years. Some projects even consider just 7 years, especially those where the only income stream is the emission credit revenue. Some others – especially hydro projects – acknowledge a longer operational lifetime, but consider the CDM revenue only during the crediting period. We do not homogenise project lifetimes, but take the lifetime that most likely informed the investment decision by the project proponent: the CDM crediting period, in the case of projects with only income from emission credits, or the whole operational lifetime, in the case of projects with other revenue streams.

Project financial discount rates and financial benchmarks are also chosen by the project proponent, but need to be justified. Financial

[2] Each project has a standardised "Project Design Document" (PDD), which is used throughout the approval process and is publicly available for analysis.

[3] The demonstration of additionality is a crucial step for CDM project approval. It is usually performed by applying a standardised tool, whose central pieces are either a "barrier analysis" or an "investment analysis". The first one is intended to describe the barriers of technological, financial or other nature that would prevent the implementation of the project in the absence of the CDM, while the latter should show that the financials of the project (e.g. internal rate or return or net present value) are not attractive without the CDM. It is up to the project developer to choose which one of these analyses he wishes to apply.

[4] The crediting period is the period of time during which a CDM project is entitled to receive emission credits. Project developers can choose between a fixed 10-year crediting period or a 7-year crediting period that can be renewed up to two times (thus totalling 21 years).

Table 2
Host countries and financial discount rates.

Host country	Number of projects in sample[a]	Range of financial discount rates used in project documents	Standardised financial discount rate for abatement cost calculations	Source
Armenia	1	10%	10%	Project documents
Bangladesh	2	12%	12%	Project documents
Brazil	7	0–25%	10%	Project documents
China	68	7–13.5%	8%	Project documents
Colombia	1	Not available	10%	By default 10%
Guatemala	1	7%	8%	Project documents
Honduras	2	Not available	10%	By default 10%
India[a]	4	14.72–16%	15%	Project documents
Indonesia	4	10–18%	10%	By default 10%
Kenya	1	15%	15%	Project documents
Malaysia	5	8–10%	10%	Project documents
Nigeria	1	20%	15%	Adjusted to 15% for comparability
Peru	2	12–14%	12%	Project documents
Qatar	1	10%	10%	Project documents
South Africa	4	10–13.75%	10%	Project documents
South Korea	4	0–15%	8%	Project documents

[a] The project sample has been constructed to be balanced by project types and not necessarily by host countries. For example, there are very few projects from LDCs with reliable financial information. Similarly, Indian projects have a tendency to exclude the investment analysis from their project documentation, and in those projects with investment analysis, the variance of the resulting costs is very high and thus we preferred to leave these data out of the sample.

discount rates appear to be relatively constant within countries and sectors, at least within the energy sector in China, where most projects use a factor of 8%, and smaller or riskier ones apply 10 or 12%. Still, there is significant variation in the financial discount rates chosen for projects in the energy efficiency category, for example, maybe due to the high variety of industries implementing these efficiency measures (cement, chemicals, iron and steel, coke ovens, etc). In order to have comparable information and to avoid the possible effect of financial discount rates being manipulated by project developers to obtain more convincing financial figures[5], we homogenise the financial discount rates in each host country. The choice of financial discount rate is guided by the rates proposed by most CDM projects in the respective country. In countries where the project documentation does not supply this information, a default 10% has been taken. See Table 2 for an overview of host countries, financial discount rates used in them, and standardised financial discount rates.

To obtain the abatement cost per tonne of CO_2eq emissions reduced, we take in the denominator the amount of emission credits the project expects to generate over its lifetime (thus, over 10 or over 21 years, depending on the choice of crediting period by the project developer), discounted with the same financial discount rate as the one used for the costs. In this way we obtain constant emission credit costs[6].

CDM transaction costs have not been included in the estimations. Even though transaction costs represent a significant sum, especially for small-scale projects, we have opted for simplifying the calculations in this assessment.

Another important consideration in the abatement cost calculations is the treatment of the baseline costs. The baseline is generally conceived as the situation without project. This situation without project may imply a different investment or the continuation of the current situation without a new investment. Many energy-related CDM projects argue that their baseline is the status quo, the continuation of the present situation without investment. In some cases, this implies expenses, such as buying energy from the grid or buying coal. In these cases, avoiding or reducing these expenses is considered as a revenue for the project and is included in the abatement cost calculations. But in some other cases, the baseline situation does not imply costs for the project owner, and thus is not included in the calculations. In very few cases, the baseline represents a new investment, e.g. in a new fossil fuel-based power plant. Avoiding this investment is again considered as a saving achieved by the project.

Figs. 1 and 2 show box plots of the estimated abatement costs of the projects in the sample, both with the original financial discount rates and with the financial discount rates standardised by us, respectively.

In these results, it is clear that even within project subtypes there is still a high variability in cost estimations, and that thus these estimations need to be taken with care. However, even with this high variability, our results reproduce very closely the range and ranking of costs reported in other abatement cost studies (US EPA, 2006; Vattenfall, 2007; Wetzelaer et al., 2007): methane and industrial gas

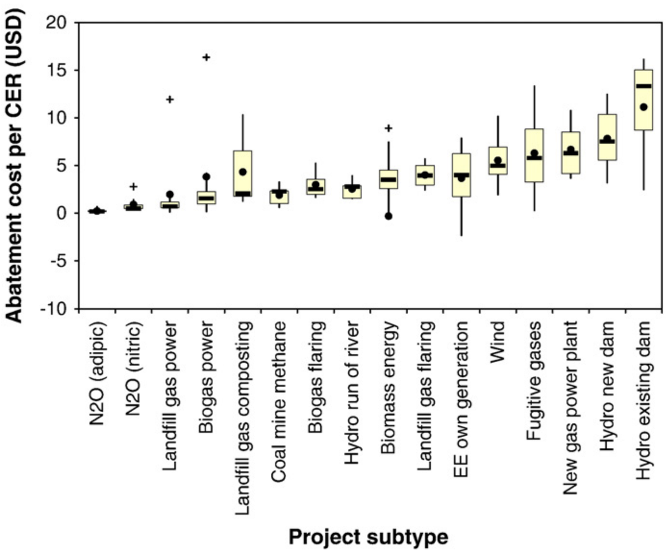

Fig. 1. Abatement cost per emissions credit by project subtypes with original financial discount rates (US$) based on projects' net present value and discounted amount of emission credits over its lifetime.

[5] Project developers have an incentive to manipulate their figures and try to show low revenues, so that the project appears financially unattractive, which is a requisite for being considered additional.

[6] In a previous version of this paper, we made the cost estimations on the basis of the full (non-discounted) amount of emission credits, but just from the first crediting period (this is, over 10 or over 7 years). This approach was chosen due to the uncertainty involved in crediting period renewal, and the resulting high likelihood that project developers calculated their profitability on the basis of the emission credits from just the first crediting period. However, time-discounting also controls for this uncertainty and leads to a clearer interpretation of the cost estimates. The results from both cost estimation approaches do not differ substantially.

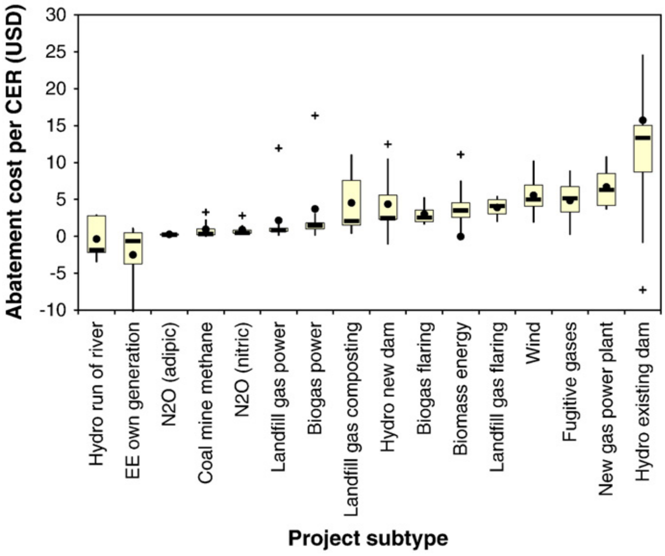

Fig. 2. Abatement cost by project subtypes with standardised financial discount rates (US$) based on projects' net present value and discounted amount of emission credits over its lifetime.

reduction projects are cheaper than CO_2-reduction projects, basically due to the higher global warming potential of these other gases; renewable energy projects, specifically wind and hydro projects including the construction of dams and also natural gas power plants are among the costlier ones. All this is consistent with other abatement cost curves and supports our results. The abatement costs of most of these CDM projects are below 20 US$, which is an indication that the emission credit income could make them attractive.

The variability of costs within project subtypes stems from various factors. Above we have already discussed the impact of project lifetimes and financial discount rates on the cost estimations, and these figures can be manipulated easily to make projects appear non-attractive. However, there are also large differences in the technologies used within project subtypes. For example, biogas power projects can consist of a sophisticated bioreactor, or just of a plastic membrane covering the already existing anaerobic lagoons, which allows to capture the methane. Further, biodigesters can be imported or can be manufactured domestically, which will also have an impact on costs. Biomass projects include energy generation from rice husks, bagasse, palm oil residues, forest residues, and a variety of other agricultural or industrial by-products. Energy efficiency projects take place in cement, steel, chemical, petrochemical and other industries and can encompass different efficiency measures. Hydroelectric projects have very different sizes, and smaller ones (among those including a dam) typically imply higher abatement costs. Finally, different countries can have different cost structures, with differing energy prices, taxes or financial incentives for specific technologies that may have an impact on overall abatement costs. Ideally, we should have a different project sample for each host country and estimate country-specific CDM abatement costs, however, due to time constraints and to the fact that most countries still have too few registered CDM projects, this has not been possible.

Another important point to discuss in these results is the existence of CDM projects with net negative abatement costs. If we consider the financial discount rates used by the project proponents in the project documentation, these negative-cost projects are only two, just one biomass energy and one energy efficiency project. The biomass project substantiates its additionality through a barrier analysis, but includes an annex showing the cash flow of the project with a positive Net Present Value. The energy efficiency project substantiates additionality through the comparison with an alternative project: even if the CDM project activity has a positive NPV, the alternative has an even better one, so that it would be the preferred course of action.

If we take country-standardised financial discount rates, also some other projects have negative costs, and surprisingly, run-of-river hydroelectric projects and own-generation energy efficiency projects even have a mean negative cost. Our whole sample in these project categories is from China, where most projects originally used 8% as financial discount rate, while some hydro projects used 10% and energy efficiency ones even higher rates. We standardised all Chinese financial discount rates to 8%, on the grounds that most energy-related projects in this country use this figure. But then, half of the energy efficiency projects and all hydro projects that originally took 10% financial discount rate become financially attractive.

4.1.2. Up-front investment costs

One of the main barriers for investing in infrastructure in Least Developed Countries and Sub-Saharan Africa is the availability of up-front financing. The main costs of renewable energy projects are investment costs, as they do not bear annual fuel costs. Whether CDM revenues can cover a substantial amount of the up-front investment costs could constitute an important factor in the decision to undertake a project or not[7]. For these reasons, we have repeated our empirical estimation using total investment costs per emission credit. The results are shown on Fig. 3.

Here again, we observe a high variance in the investment costs of the different project subtypes. As in the case of the full abatement costs, this reflects the variability in technologies used, their origin, and the project sizes. On the other hand, the sequence of project types according to investment costs is again consistent with the previous assessments: projects involving new infrastructure, such as large renewable energy projects or gas power plants have larger investment costs. Projects involving a relatively small change in a process, such as N_2O reduction, landfill or biogas projects have smaller costs.

4.2. CDM emission abatement potentials

There are few comprehensive studies on the emissions abatement potential in developing countries. Notable are the studies by Wetzelaer et al. (2007), Bakker et al. (2007) and, more recently, De Gouvello et al. (2008).

Based on data from climate mitigation studies in 30 countries, Wetzelaer et al. (2007) developed an abatement cost curve for the non-Annex I region in the year 2010, focusing mainly on CO_2 and to a lesser extent on CH_4 emission reductions.

The study concluded that the total abatement potential for the whole non-Annex I region in the year 2010 amounts to about 2 Gt CO_2eq/yr at a price of US$ 50/tCO_2eq or less. About one third of this potential is expected to be achievable at negative or zero incremental costs. Approximately 1.7 Gt CO_2eq/yr appear feasible at costs of up to US$ 4/tCO_2eq, including transaction costs. 66% of the total abatement potential was found in China (37%), India (23%), Brazil (4%) and South Africa (2%) (Wetzelaer et al., 2007).

Building on the above-mentioned study, Bakker et al. (2007) tried to find the market potential of abatement options in non-Annex I countries by 2020. Their study differentiates between technical abatement potential (reductions that can be realised based on technical and physical parameters), economic potential (reductions that can be realised below a certain cost level) and market potential (reductions that can be realised considering other barriers).

[7] In this context, again the consideration of which credits are considered in the cost calculations (just pre-2012 credits, those expected from the first crediting period, or those from all crediting periods) is critical for investment decisions. For similar reasons as above, we consider again that all credits projected for the first crediting period are used in these calculations.

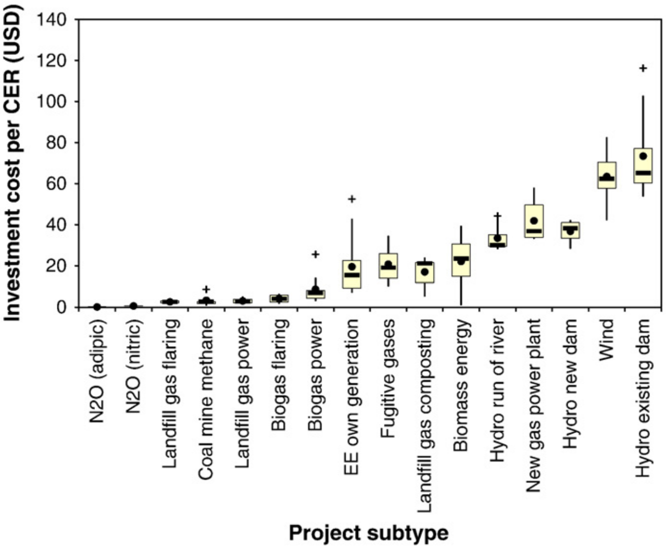

Fig. 3. Investment cost per emissions credit by project subtypes (US$) based on projects' total investment costs and discounted amount of emission credits over its lifetime.

Bakker et al. (2007) updated and completed the abatement cost curves, by including information from new country studies, extrapolating them from 2010 to 2020, and adding new technology options (carbon capture and storage, and forestry) and non-CO_2 GHGs. In order to find out the market emissions reduction potential, they included a scenario-based analysis of the impacts of different CDM-related factors on the abatement potential: the eligibility of technologies under the CDM, the future application of the additionality criterion, the success of programmatic CDM, the investment climate and institutional environment in the host countries, and the existence of non-financial barriers related to the uptake of technology. In the scenarios, only the abatement potential of the options was varied, not the cost. Accounting for the uncertainties related to eligibility decisions, additionality criteria, programmatic CDM and technology adoption, the market potential for CDM projects was estimated at 1.6–3.2 $GtCO_2eq$/yr at costs up to 20 €/tCO_2eq in 2020.

In these and other GHG abatement cost studies, the estimated potential of GHG reduction options with net negative costs is significant. Such "no-regret" reduction options seem to conflict with rational behaviour. The reasons for their existence mentioned in the literature include market imperfections leading to lack of knowledge about the reduction options, misaligned incentives of companies and consumers, social preferences, lack of priority, lack of investments due to limited financial markets and the definition of cost (social versus financial cost). The least-cost abatement measures – especially demand-side energy efficiency measures – imply mobilising billions of diffuse emission sources across many sectors and regions, and thus achieving them may be politically challenging. It is often suggested that in order to remove these market barriers, further costs are incurred that should be added to the technology costs. These costs are not normally included in abatement cost studies (Bakker et al., 2007; Enkvist et al., 2007; Wetzelaer et al., 2007).

A study commissioned by the World Bank (De Gouvello et al., 2008) has looked at the abatement potential in the energy sector in Sub-Saharan Africa, using the existing CDM methodologies to identify technologies that could promote GHG emission reductions and at the same time support energy development in the region. They have thus built a bottom-up inventory of clean energy projects applying 22 technologies in 44 countries in SSA, which includes over 3200 projects, among them 361 programmes of activities. These projects would amount to more than 170 GW of additional power-generation capacity, which is more than twice the region's current installed capacity, providing about four times the region's current modern-energy production. The resulting GHG emissions reduction potential would total about 740 million tCO_2 per year, and would be mainly related to the biomass sector.

This study also included estimated investment costs for many of the technologies found, but did not include a full economic analysis. Even investment data were unavailable for projects representing 36% of added power-generation capacity and 21% of emission reductions (De Gouvello et al., 2008).

4.3. Costs and potentials — abatement cost curves

Combining the information on standardised abatement costs for emission credit generation and CDM potential in different countries or regions, we obtain our basis for the comparison of CDM competitiveness: abatement cost curves.

Fig. 4 shows abatement cost curves for China, India, LDCs, and a group of selected high-income high-emissions Asian countries (Qatar, United Arab Emirates, Singapore, South Korea, Israel) without discounting the emission credits.

As abatement costs we use the median standardised abatement cost obtained for each project sub-type from our sample. HFC-23 reduction projects, very prominent in China and India, typically lack financial data in the project documentation, as their additionality (the main reason why financial information is disclosed) is guaranteed due to the fact that the only income stream for these projects is the sale of emission reduction credits. For this type of projects, abatement cost estimations from secondary sources (Harnisch and Hendricks, 2000; Jimenez, 2005; UNEP TEAP, 2002) have been used.

The abatement potential is estimated simply by summing up all emission reductions projected to be achieved by all projects in the CDM pipeline as of end of 2008 (UNEP Risoe Centre, 2009). This is a very approximate estimate. On the one hand, it does not include CDM projects not yet submitted for validation, so the potential may increase over the following years. On the other hand, it includes projects that may fail validation or registration, whose potential will thus not materialise. Finally, this estimation does not take into account the fact that credit issuance is for most project types actually less than the estimations provided in the project documentation. However, as these sources of bias are present in CDM projects over all host countries, we deemed these figures to be precise enough for our comparison.

For the group of Least Developed Countries, we include two estimations. The first one ("LDCs existing") is, as above, the sum of all emission reductions projected from the current CDM pipeline in this region. The second estimation ("LDCs potential") additionally includes the abatement potential estimated by De Gouvello et al. (2008) for the

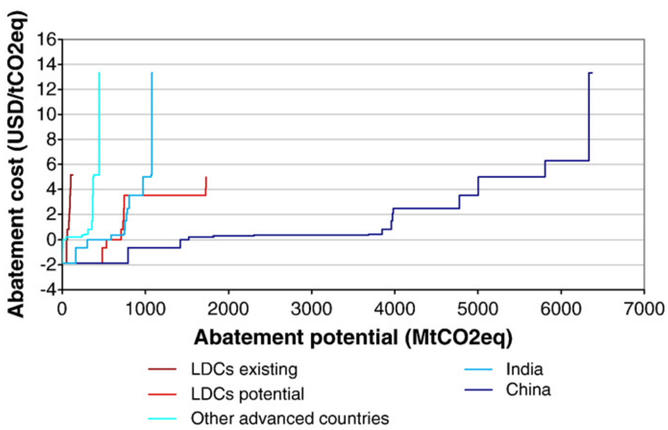

Fig. 4. Standardised abatement cost curves without emissions credit discounting. Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks, 2000; UNEP TEAP, 2002; Jimenez, 2005. Potentials from URC (2009) and De Gouvello et al. (2008). Own calculations.

LDCs in Sub-Saharan Africa, excluding the potential from biofuel projects, which so far do not have any approved methodologies. This provides an optimistic estimation of the abatement potential in these countries, which could be achieved if the technical, financial and institutional conditions are substantially improved.

It should be noted that these curves include project types without cost information. These appear at present at the left end of the curves, as having zero abatement costs. The projects without cost information represent 1.7% of the abatement potential in China, 8.6% in the advanced host countries, 7.3% in LDCs existing, 7.9% in LDCs potential and 26.5% in India. In the Indian case, about one third of this potential comes from supply-side energy efficiency projects, for which abatement costs should be similar that those in own generation energy efficiency projects, which have net negative costs when standardising the financial discount rates. Unfortunately, the financial information for supply-side energy efficiency is either non-existing or not very credible in the project documents analysed. While this inclusion might provide the wrong impression of a large quantity of low-cost (or zero-cost) project options, we opted for not omitting these data from the curves as they allow for a more realistic picture of the overall abatement potential.

5. Empirical assessment of the effect of discounting in selected countries

In this section we include the effect of two possible discounting schemes on the CDM abatement cost curves of the selected regions and countries.

5.1. Discounting scheme 1

We use per capita GDP and per capita emissions as the criteria for defining the discount factor for emission reductions, which captures the principles of capability to pay and responsibility towards climate change. Each country's GDP per capita and emissions per capita are compared to the average values for the whole world, using the data from IEA (2007). Both proportions are given the same weight, as both principles are equally important and are not directly correlated. Thus, the discount factors[8] are calculated as follows:

$$\textit{Discount factor} = 1 - \frac{2}{\frac{\textit{Country's emissions / cap}}{\textit{World average emissions / cap}} + \frac{\textit{Country's GDP / cap}}{\textit{World average GFP / cap}}}$$

Negative discount factors are not permitted, since this would imply issuing more than one emissions credit per tonne of emissions reduced. Table 3 shows the resulting discount factors for some countries included in this study. See Michaelowa (2008) for a more detailed description of this discounting scheme, including the calculations for other countries.

With this scheme, of our selected countries only those in the “Other Asia” group (Qatar, United Arab Emirates, Singapore, South Korea, Israel) are affected by the discounting. As can be seen when comparing Fig. 5 with Fig. 4, their abatement cost curve shifts to the left and upward as a result of the increase in costs per credit and the reduction in credit generation potential. Further, with this discounting scheme about 95% of the projects in the current CDM pipeline of these advanced countries would still be feasible with credit prices up to 20 US$ on average. Only a hydroelectric project in South Korea and a project for the reduction of fugitive natural gas emissions in Qatar would be lost. While projects in advanced countries become less competitive, current projects in LDCs are still non-significant at a

[8] In this paper, we understand discount factors as the percentage of emission reductions that is not credited. For example, a 30% discount factor would imply that only 70% of the measured emission reductions receive emission credits.

Table 3
Discount factors for the emission credits.

Host country	GDP/cap (PPP, 2000 US$)	Emissions/cap (t CO_2eq/year)	Discount factor under scheme 1	Discount factor under scheme 2
World	8492	4.22	–	–
Qatar	38,556	44.90	87%	93%
United Arab Emirates	22,715	24.37	76%	88%
Singapore	26,401	9.93	63%	82%
Israel	23,022	8.65	58%	79%
South Korea	19,837	9.30	56%	78%
China	6012	3.88	0%	39%
India	3072	1.05	0%	0%
Zimbabwe	1813	0.79	0%	0%
Cambodia	2503	0.27	0%	0%
Yemen	827	0.89	0%	0%
Mozambique	1105	0.08	0%	0%
Tanzania	662	0.11	0%	0%

Source: IEA, 2007. Own calculations.

global level, and future potential is still small compared to the Chinese pipeline. This shows that discounting cannot serve as a “magic bullet” that suddenly frees up a large CDM potential. Other barriers such as availability of domestic capital and skilled workers are so entrenched that the revenue from credit sales cannot remove them. CDM alone cannot overcome the legacy from decades of failed policies — even if getting some advantages compared to projects with a more development-oriented governance.

5.2. Discounting scheme 2

In this case, the discounting of emission credits is again based on an index composed of per capita GDP and per capita emissions, taking as basis the world average of both indicators. But discounting starts already when the country reaches half of the world's average emissions and GDP. This scheme is designed to include China among the countries affected by discounting. Overcrediting is again not possible. See Table 3 for the resulting discount factors and Michaelowa (2008) for a further description of this discounting scheme.

Under this scheme, both China and Other Asia are affected by discounting. Fig. 6 shows the result: while the potential in the Asian tigers is greatly reduced and the costs rise sharply, making a larger portion of its abatement potential uncompetitive (now also a couple of wind energy projects become infeasible, with costs slightly over 20 US$), still most of China's potential – albeit reduced and more expensive – remains competitive with credit prices below 20 US$. Under these conditions, all CDM projects in the current pipeline in

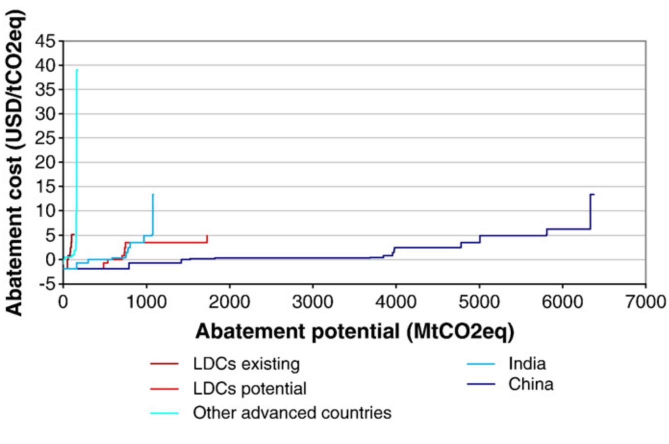

Fig. 5. Standardised abatement cost curves with discounting scheme 1.
Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks, 2000; UNEP TEAP, 2002; Jimenez, 2005. Potentials from URC (2009) and De Gouvello et al. (2008). Own calculations.

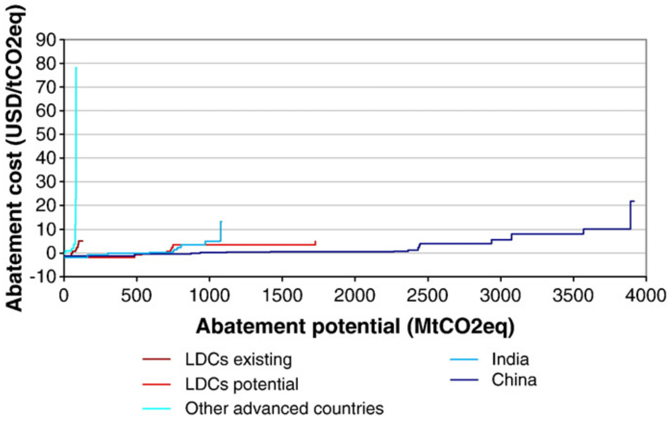

Fig. 6. Abatement cost curves with discounting scheme 2.
Sources: Cost data from Project Design Documents; for HFC-23 projects from Harnisch and Hendricks, 2000; UNEP TEAP, 2002; Jimenez, 2005. Potentials from URC (2009) and De Gouvello et al. (2008). Own calculations.

LDCs have smaller abatement costs than those in advanced countries. Their volume is however still unimportant. There is some hope if we look at the "LDCs potential" curve: assuming the barriers are overcome and these projects are implemented, their potential reaches half of the Chinese one, with costs below 5 US$/credit. This shows that once the purely technical potential becomes available due to the mobilisation of capital and removal of political barriers the higher credit revenue compared to other CDM host countries could make the difference. Countries that have reformed their policies and enabled the creation of domestic capital could use the CDM as lever to accelerate development.

6. Conclusions

Country-based discounting will of course have an impact on the competitiveness of individual CDM host countries in the carbon market, however, as shown above, this impact will depend on emissions abatement potentials and costs in the country.

Discounting could become an interesting instrument for incentivising advanced developing countries to leave the CDM and engage in other farther-reaching climate-related commitments, as a result of the steep credit cost increases that a discounting factor might generate.

However, this study shows that even under discounting schemes designed to include China, Least Developed Countries remain unimportant in terms of abatement potential from the CDM pipeline.

While there is a theoretically large abatement potential to be exploited in Africa, its materialisation requires overcoming financial, technical and institutional barriers. Given the large cheap potential in China and other countries, it is unlikely that discounting on its own will provide sufficient financial incentives to achieve this. But once countries start removing barriers, the CDM incentive could play a non-negligible role in development. Nevertheless, even under the optimistic scenario, where the financial, technical and institutional barriers in these countries are overcome and a larger potential becomes feasible, the larger abatement potential and the cheap abatement costs in China and other more attractive host countries will be harvested first.

Thus, discounting would only marginally contribute to enhance the competitiveness (in terms of abatement potential and costs) of LDCs within the CDM market.

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