

# Transaction costs, institutional rigidities and the size of the clean development mechanism

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## Abstract

Transaction costs and institutional rigidities will reduce the attractiveness of the Kyoto Protocol flexibility mechanisms compared to domestic greenhouse gas abatement options. The clean development mechanism (CDM) in particular is likely to entail considerable costs of baseline development, project registration, verification and certification. The activities implemented jointly pilot phase and the prototype carbon fund programme give indications about these costs. There is evidence that projects with high implementation costs have high transaction costs as well. Moreover, CDM projects have to be approved by host country institutions, and so far only a small share of host countries has been able to set up these institutions. Several of the larger host countries intend to only approve projects if the market price is above a certain threshold. Some governments will also levy fees to finance costs of approval bodies. We assess these issues using a quantitative model of the Kyoto Protocol permit market. We conclude that while changes in demand from Annex B countries remain the crucial factor, the size of the CDM will depend to a significant degree on transaction costs and institutional barriers in host countries.

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## 1. Introduction

The Kyoto Protocol allows industrialised countries and countries in transition (Annex B countries) to generate greenhouse gas emission credits through investment in emission reduction projects in countries without emission targets. This instrument is called the “clean development mechanism” (CDM), and the emission credits are called “certified emission reductions” (CERs). Theoretically the CDM will lead to an equalisation of marginal abatement costs throughout the world. A number of modelling exercises have calculated a global market price assuming friction-free trading of emission credits (Weyant, 1999; Springer, 2003).

However, it is becoming increasingly clear that there will be substantial transaction costs and other institutional barriers that could considerably reduce the size and change the distribution of the CDM. So far, they

have been addressed only in a few models, usually by shifting marginal abatement costs curves vertically (e.g. Böhringer and Löschel, 2002, p. 152ff). We investigate the emerging evidence on CDM transaction costs, incorporate the findings in a simple model of the global market for greenhouse gas permits, and analyse a range of scenarios.

## 2. CDM transaction costs and institutional barriers

For most Annex B countries the emission targets under the Kyoto Protocol are below their business-as-usual emissions path. They thus have a net demand for emission reduction permits. Only some Annex B countries are expected to have a net supply of permits, mainly due to the availability of excess permits (“hot air”) as economic recession has led to a reduction in greenhouse gas emissions, and from joint implementation (JI) projects. The remaining source of permit supply in the international market is the CDM.

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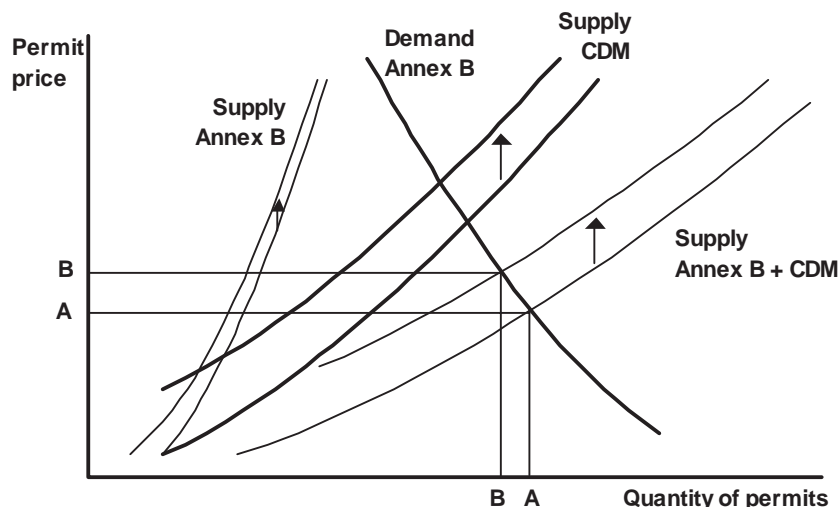


Fig. 1. How transaction costs influence the use of the Kyoto Mechanisms.

The supply curve for CERs from CDM will start at zero if additionality tests exclude projects with negative costs (as in Fig. 1); otherwise it will have a negative cost segment. The summation of the CDM and Annex B supply curves leads to the world supply curve, and the demand curve derives from emission reduction requirements in net permit buying countries and their cost schedules of domestic abatement.

Transaction costs shift the supply curves upward and lead to a reduction of quantities traded and a rise in the equilibrium price. In Fig. 1, point A represent the market equilibrium without transaction costs, and B with transaction costs.<sup>1</sup> The lower trading volume indicates that countries will abate more domestically compared to a situation without transaction costs.

A critical question is whether transaction costs will remain constant over the whole range of abatement or whether they change. Here it is useful to look at the different categories of transaction costs, which we define in Table 1.

Heller (1999) rightly argues that transaction costs strongly depend on the institutional framework. The situation may differ considerably between host countries and this influences the negotiation of all mechanisms, as well as the approval costs of the project-based CDM and JI. Transaction costs will be higher in countries with an inefficient regulatory framework and lead to a competitive disadvantage vis-à-vis other countries.

An elaborate project cycle may increase up-front transaction costs but reduce them ex-post. Rules that enhance transparency will be crucial to reduce search

costs even if they entail ex-ante costs. Funds such as the prototype carbon fund (PCF) can reduce transaction costs by developing generic procedures such as standardised contracts. They can also specialise in specific project types.

### 3. Empirical evidence for CDM transaction costs<sup>2</sup>

There is not much experience with project-based environmental policy mechanisms. Harrison and Schatzki (2000) have looked at transaction costs of different US environment policy mechanisms. For the project-based mechanisms “Offsets” and “Netting” they were 10–15,000€ per transaction.<sup>3</sup> The UNFCCC launched a pilot phase of activities implemented jointly (AIJ) in 1995—prior to the proposed implementation of the Kyoto Protocol—in order to learn more about the possible operation of projects under international flexibility mechanisms. So far, 152 projects have been reported, of which approximately 70 quantify transaction costs. However, the definitions used vary considerably, so that these numbers have to be used with caution and we thus do not list them here. The Swedish AIJ programme in the Baltic states is the only AIJ programme with a consistent reporting of transaction costs in four categories (technical assistance, follow-up, reporting and administration) over time. It includes 51 projects that have been strongly standardised. The Swedish data can be analysed concerning:

- Impacts of project categories. One would expect that transaction costs of renewable energy projects are

<sup>1</sup> In our example, transaction costs are applied to the supply curve. If transaction costs have to be borne by the demand side, the demand curve is shifted to the left, which also leads to an increased permit price. Furthermore, at this stage for simplicity reasons we assume constant marginal transaction costs. This assumption will be compared to empirical data and relaxed accordingly below.

<sup>2</sup> See Michaelowa et al. (2003) for a comprehensive review of transaction costs of the Kyoto Protocol flexibility mechanisms.

<sup>3</sup> We use € throughout the paper assuming a 1:1 exchange rate with US\$.

Table 1  
Definition of transaction cost components

Transaction cost components	Costs incurred by investors and hosts as they seek out partners for mutually advantageous projects	Relation to project size	Estimates of transaction costs (€ 1000s unless otherwise stated)
Search costs		Fixed	15
Negotiation costs	Includes those costs incurred in the preparation of the project design document that also documents assignment and scheduling of benefits over the project time period. It also includes public consultation with key stakeholders	Degressive	25–400
Project documentation costs	Development of a baseline and monitoring plan	Fixed	35
Approval costs	Costs of authorisation from host country	Proportional	40 <sup>a</sup>
Validation costs	Review and revision of project design document by operational entity	Fixed	15–30
Registration costs	Registration by CDM Executive Board	Slightly degressive	10
Monitoring costs	Costs to collect data	Fixed	10
Verification costs	Cost to hire an operational entity and to report to the CDM Executive Board	Degressive	8 per turn
Certification costs	Issuance of CERs by UNFCCC Executive Board	Degressive	n.a.
Enforcement costs	Includes costs of administrative and legal measures incurred in the event of departure from the agreed transaction	Proportional	n.a.
Transfer costs	Brokerage costs	Proportional	1%
Registry costs	Costs to hold an account in national registry	Proportional	0.03%
<i>Minimum fixed cost</i>			150

Sources: Cost estimates from the case studies below and SGS (2002); the registry cost is derived from costs of share deposits at online brokerages.

<sup>a</sup>There is no experience with this category yet.

lower than those of energy efficiency projects due to the more situation-specific need of planning and the higher number of participants in the latter case.

- Impacts of start date within the same project categories. Learning effects should reduce transaction costs of projects that started later.
- Economies of scale within the same project categories.
- Host country specifics within the same project categories.

However, one should be cautious about applying these cost estimates to full-scale CDM and JI projects as in the Swedish programme no costs for external validation and certification accrued.

Concerning project categories,<sup>4</sup> we find an average technical assistance and administration cost of 20.5% of total project cost for energy efficiency projects, while it is only 14.4% for renewable energy projects. Concerning the start dates of the projects, there is a declining tendency of transaction costs over time, as expected (see Table 2).

If however we look at the size of projects, we see that the apparent difference is just due to the greater average size of the renewable energy projects. Economies of scale

<sup>4</sup>The mixed projects are excluded in these calculations as well as projects with no entry in one of the two cost categories “technical assistance” and “administration”.

Table 2  
Swedish AIJ projects: transaction costs as a share of total costs, by start year

Start year	Transaction costs as percentage of total costs (number of projects in brackets)	
	Energy efficiency projects	Renewable energy projects
1993	—	18.3% (3)
1994	16.8% (1)	12.9% (4)
1995	28.8% (3)	14.7% (6)
1996	20.1% (6)	14.3% (9)
1997	20.0% (9)	12.3% (1)
1998	12.7% (3)	14.0% (2)
Average	20.5% (20)	14.4% (25)

Note: Transaction costs include only technical assistance and administration.

Source: UNFCCC (2002).

are very important and the differences between project types of the same size are negligible (Table 3).

The PCF, operated by the World Bank, provides funding to host partners who wish to develop CDM and JI projects. Some estimates of the transaction costs of these projects have been made and these are presented in Tables 4 and 5. Data have been supplied by staff at the PCF and are not published as yet. Table 4 presents the ranges, together with a “typical” or average, for the

Table 3  
Swedish AIJ projects: transaction costs per abatement unit, by project size

Size (t CO <sub>2</sub> /yr)	Transaction costs in €/t CO <sub>2</sub> <sup>a</sup> (number of projects in brackets)		
	Energy efficiency (number of projects)	Renewable energy (number of projects)	Mixed (number of projects)
> 10,000	—	1.3–1.8 (5)	1.4 (1)
5000–10,000	—	1.7–3.1 (8)	—
2500–5000	2.7 (1)	2.7–5.6 (5)	4.6 (1)
1000–2500	3.0–9.7 (6)	5.1–11.1 (8)	11.7 (1)
500–1000	17.8–40.4 (3)	—	16.2 (1)
100–500	29.1–61.2 (9)	—	—
< 100	80.8–123.9 (2)	—	—

Source: UNFCCC (2002).

<sup>a</sup>Throughout, we use tonnes of carbon dioxide (t CO<sub>2</sub>) as our unit of emissions.

Table 4  
CDM projects under the PCF: pre-implementation transaction cost components and ranges

	(€1000s per project)		
	Typical cost	Low cost	High cost
Negotiation	250	125	366
Approval	40	35	207
Development of baseline and of monitoring and verification protocol	35	30	40
Validation	30	30	35
Sub-total	355	220	648
10% contingency	36	22	65
Total pre-implementation transaction costs	391	242	713

Source: PCF (2002).

transaction costs associated with the pre-implementation phase of the project cycle for the PCF projects.

Certification costs are mainly fixed as reported by certifiers.<sup>5</sup> SGS (2002) clearly states that verification and certification costs are relatively independent of project size; they quote an estimate of 17,000€ for the first verification and 8500€ for each additional round. This is supported by KPMG (2002) who stress that “whereas there will be some correlation between the cost of validation and verification and the size of the project the relationship will not be linear”. DNV (2002) stresses that the credibility of certifiers would be jeopardised if their fee is proportional to the quantity of emissions reductions verified.

For the four PCF projects for which there are complete data, there is a close, though not perfect, correlation between size of project and transaction cost per tonne of CO<sub>2</sub> reduced (Table 5). Due to the large

size of the projects, transaction costs per tonne are much lower than in the Swedish AIJ cases.

PricewaterhouseCoopers (2000) estimated transaction costs for five generic project types: a combined cycle gas turbine (CCGT) plant or retrofit CCGT project, each with 0.4 million CERs per year; a wind project with 32,000 CERs; and two photovoltaic projects with 1 MW (370 CERs) and 100 kW (37 CERs) capacity. Their estimates for transaction costs were 0.1 €/t for the large project, 0.9 €/t for the wind project, 75 €/t for the large and 750 €/t for the small PV project. EcoSecurities (2000) looked at a 150 MW gas plant with 0.35 million CERs/year; and a 2 MW biomass plant generating 35,000 t CERs/year. Total transaction costs for the large project reach 0.3–0.7 €/t, for the small project 0.4–1.1 €/t. The relatively high costs for the large project are due to the assumption that certification and enforcement costs are proportional to the amount of CERs generated.

The costs of the operation of the CDM Executive Board (EB) are to be borne by project proponents in form of a fee. This fee is above 0.1 €/t CO<sub>2</sub>, if a project has an annual reduction of less than 2000 CERs assuming a 21-yr lifetime. For large projects, the fee quickly becomes negligible.

Empirical evidence thus suggests that economies of scale are the most important determinant for the share of transaction costs in total costs, because fixed costs form a significant part of transaction costs. Table 6 gives an indication of the relation between project size and transaction costs. It is mainly based on the PwC study, the PCF and the Swedish experiences. However, other data fit more or less well in this picture, and were used to determine the upper and lower bounds of the five categories. But it should be stressed that this is only a rough picture and further research is necessary in order to come up with better data.

The smaller categories are dominated by project types that typically have relatively high marginal abatement costs; there is thus a compounding of high abatement and transaction cost for the smallest project categories.

<sup>5</sup>SGS, KPMG, DNV, PricewaterhouseCoopers, EcoSecurities and others are private companies engaged in validating, monitoring and certifying greenhouse gas abatement projects.

Table 5  
CDM projects under the prototype carbon fund (PCF): transaction costs by country groups

Country/ world region	Sector	Transaction costs							
		t CO <sub>2</sub> reduction	Project lifetime	Pre-implementation	Implementation Year 1	Implementation Year 2	Certification <sup>a</sup>	Total project transaction costs	Transaction costs per t CO <sub>2</sub>
Mexico	Agriculture	2508	8	482	161	321	51	1788	0.71
North Africa	Electricity	5830	20	397	277	120	102	3056	0.52
South America	Electricity	5867	20	176	88	n/a	102	1703	0.29
South America	Agriculture	11,266	21	220	110	n/a	102	2192	0.19

Source: PCF (2002), personal communication.

<sup>a</sup>SGS figures, biannually.

This suggests that projects below some threshold may not be viable.

This size threshold is reconfirmed by statements made by two institutions active in the field of GHG reduction projects. The PCF considers any project with a volume below 3 million t CO<sub>2</sub> of cumulative greenhouse gas benefits unattractive due to transaction costs. That would be a threshold of about 50,000 t CO<sub>2</sub>/yr for a 20-yr project. According to Shell (2001), transaction costs should not be more than 25% of proceeds from permit sales in order to make a project viable. Given current market prices, this would give a cost threshold of about 1 €/t CO<sub>2</sub>.

Many project types currently discussed under the CDM with substantial development benefits would then not be viable. These projects often already have relatively high marginal abatement costs and thus would be less attractive than large ones.

### 3.1. Transaction costs of emissions trading

Brockmann et al. (1999, p. 90) quote transaction costs of SO<sub>2</sub> trading in the US of 1% of the project volume. In the beginning, they were about 5% (Klaassen and Nentjes, 1997) but when an active spot market with several specialised brokers developed, they quickly came down. Kerr and Maré (1997) found broadly defined transaction costs of about 10% in the case of the US lead phasedown programme, the first large scale emissions trading programme, albeit with a relatively small number of participants. Brokerage fees in the grey market for greenhouse gas emission rights are currently not transparent, but thought to be around 5–7%. A lower boundary for transaction costs in a highly liquid market of a well-defined financial commodity may be 0.2%—these are the rates quoted by direct brokerage firms in securities and bonds (see e.g. Comdirect-Bank, www.comdirect.de). Using a price of 4 €/t CO<sub>2</sub>, the transaction cost would thus start at 0.2 €/t and finally settle at around 1 cent.

### 3.2. Overall transaction costs

The overall effect of transaction costs on trading activity is shown in Fig. 2. Trading among Annex B countries consists of JI and international emissions trading (IET). IET will quite likely have the lowest transaction costs, which are more or less proportional to the quantity of emissions reduced, resulting in constant marginal transaction costs.<sup>6</sup>

Therefore, the CDM supply has to bear higher transaction costs and is much more affected by increasing marginal transaction costs—as one moves into project categories with higher implementation

<sup>6</sup>The amount of emissions reduced serves as a proxy for the trading volume.

Table 6  
Project size, types and indicative transaction costs

Size	Type	Reduction (t CO <sub>2</sub> /yr)	€/t CO <sub>2</sub>
Very large <sup>a</sup>	Large hydro, gas power plants, large combined heat-power (CHP) plants, <i>geothermal</i> , landfill/pipeline methane capture, cement plant efficiency, large-scale afforestation	> 200,000	0.1
Large	Wind power, <i>solar thermal</i> , energy efficiency in large industry	20,000–200,000	0.3–1
Small	Boiler conversion, demand side management, small hydro	2000–20,000	10
Mini	<i>Energy efficiency in housing and small and medium enterprises, mini hydro</i>	200–2000	100
Micro	<i>Photovoltaic</i>	<200	1000

*Italics:* Project types that typically have relatively high marginal abatement costs.

<sup>a</sup>There are no experiences with this project category yet.

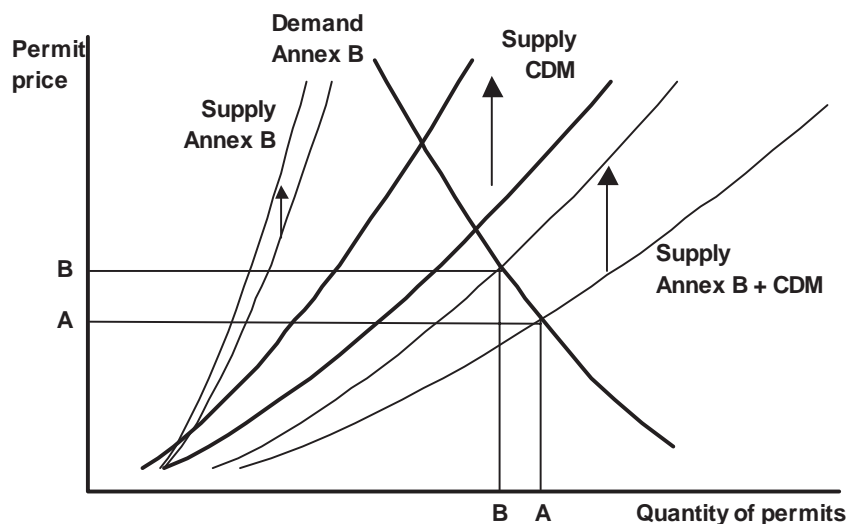


Fig. 2. Effect of increasing marginal transaction costs on the permit market.

costs, transaction costs increase as well.<sup>7</sup> In other words, project options higher up the marginal cost curve also carry higher transaction costs. Based on the empirical data described above, transaction costs tilt the CDM supply curve upward, rather than just shifting it, as commonly assumed and illustrated in Fig. 1. All in all, the share of the CDM in the carbon market will be less than in a world without transaction costs.

### 3.3. Institutional rigidities in host countries

Countries can host CDM projects only if they have set up a “Designated National Authority” (DNA) that formally approves project proposals. Moreover, they must have ratified the Kyoto Protocol. By July 2003, only 16 developing countries had notified their DNA to the UNFCCC Secretariat. In many countries, the decision on the DNA has been stalled due to inter-ministerial conflict for several years. It is likely that projects in those countries will suffer serious delay.

<sup>7</sup>We assume increasing marginal transaction costs since we assume that small scale projects tend also to have larger marginal abatement costs (see Table 6).

Thailand has stipulated that every CDM proposal has to be approved by cabinet; one can imagine the transaction costs caused by that rule.

If a country has managed to set up its DNA, it has to decide about the fees charged to project proponents. Sri Lanka plans to levy 1% of estimated CERs. Moreover, countries could contemplate levying a tax on CERs akin to royalties for natural resource exploitation. Many countries, among them China and India, are unhappy with the current low market price and have discussed setting a minimum price before approving CER sales.

## 4. Modelling the impact of transaction cost and institutional rigidities on the CDM market

### 4.1. Required emissions reductions

The emission reductions required of Annex B countries under the Kyoto Protocol are defined as the difference between business-as-usual emissions and the maximum emission levels specified in the Protocol.

Implementing the Kyoto Protocol without the United States and Australia means the demand in the global

carbon market will be greatly reduced. Under projections by the US Department of Energy (EIA, 2002) used for the modelling here, emission reduction requirements of OECD Annex B countries except the United States and Australia amount to 1.3 Gt CO<sub>2</sub>/yr in the energy sector. This figure does not take into account non-carbon dioxide emissions and crediting for sequestration. In the United States by comparison, the projected overhang of emissions over the Kyoto target level amounts to over 2 Gt CO<sub>2</sub>/yr by 2010.

Crediting of carbon sequestration through forest management under Article 3.4 of the Kyoto Protocol amounts to 115 Mt CO<sub>2</sub>/yr for the “net buyers” of emission credits. In addition, Article 3.4 provides for unlimited crediting of increases in carbon storage in agricultural soils. Assuming that additional storage amounts to 10% of the central estimate for soil carbon storage, this would amount to 56 Mt CO<sub>2</sub>/yr, but could easily be higher (see Jotzo and Michaelowa, 2002).

#### 4.2. Supply of excess permits from economies in transition

According to recent estimates the total amount of surplus Assigned Amount Units (AAUs) or “hot air” in economies in transition (EITs) such as Russia and the Ukraine may well be above 1 Gt CO<sub>2</sub>/yr over the first commitment period—a similar magnitude as the projected excess in emissions over targets under business-as-usual in OECD Annex B countries excluding the United States and Australia. Consequently, supply of hot air is a pivotal factor in the carbon market.

The Marrakech Accords place no restriction on the sale of surplus AAUs. However, it is highly unlikely that all available surplus AAUs will be sold in the first commitment period, or that most of Annex B demand will be met using these surplus permits. Reasons for supply restraint include that some permits will be banked for use in future commitment periods, or retained in order to avoid crowding out of JI projects; while many permit buyers may not be willing to rely on buying “hot air” permits, even if this were the cheapest option of fulfilling the letter of their commitment, for political reasons.

At this stage it is not possible to judge the amount of hot air that will actually enter the market. In this analysis, it is assumed that the amount will be 400 Mt CO<sub>2</sub>/yr over the first commitment period, or around one-third of the projected total available.

#### 4.3. Market modelling using marginal abatement cost curves

Our model of the global carbon market is based on marginal abatement cost curves (MACCs), which trace the incremental cost of reducing emissions in different

countries and sectors. This partial equilibrium modelling approach has become increasingly popular over recent years, and a number of authors have used models based on MACCs to evaluate scenarios for international climate policy (for example den Elzen and de Moor, 2002; Löschel and Zhang, 2002; Blanchard et al., 2002; Grütter et al., 2002, among others).

It should be noted that this approach is different from using a general equilibrium model, in that feedback effects between greenhouse gas abatement activities and other parts of the economy are not captured. In the partial equilibrium approach, MACCs typically are derived from general equilibrium model results, and assumed to be independent of any particular outcome in the permit market. The assumption that MACCs are robust is supported by Ellerman and Decaux (1998) who found that with MIT’s EPPA general equilibrium model, “whatever the trading scheme, whatever the extent of the market, the marginal abatement curves are almost identical”. Klepper and Peterson (2003) by contrast point out that MACCs generated with a general equilibrium model can shift in different scenarios because of linkages through world energy prices. Comparing modelling results using MACCs derived from a scenario where the United States participate in the Kyoto Protocol to results using MACCs adjusted for the US withdrawal, they find a difference of 11% in the estimated permit price for the same scenario. This shift is not negligible, but it is small compared to the primary effects on the permit market of such a drastic change in the scenario. Furthermore, equilibrium quantities of abatement and permit trade remain practically unchanged because all MACCs shift by approximately the same amount.

Therefore the second-order effects that models based on exogenous MACCs miss out on are likely to be small in comparison to the primary parameters that shape the permit market. The purpose of policy oriented models such as ours is to compare scenarios and illustrate the effect of changes in market parameters. MACC-based models are well suited for this purpose, bearing in mind that the results from simulation models—be they partial or general equilibrium—should not be interpreted as forecasts.

#### 4.4. Our model

The focus in our model is on the CDM.<sup>8</sup> The model allows for comparative analysis of the impacts of different market scenarios and implementation rules on the CDM. It is a supply/demand model for a single

<sup>8</sup>The model in this paper is an extended and recalibrated version of the *Pelangi’s Emissions Trading* (PET) model, which was originally built for the World Bank’s *National Strategy Study* on CDM in Indonesia (Indonesia, GTZ and World Bank, 2001).

commodity, carbon emission credits, in the first commitment period (2008–2012) of the Kyoto Protocol. We assume that these credits will be traded in a perfect international market, so that there is a single global price for emission credits, including for those from CDM projects. Marginal abatement costs in equilibrium however differ between the flexibility mechanisms, because transaction costs and taxes drive wedges between the price and the net marginal implementation cost. The model provides a “snapshot” representation of the global carbon market in the year 2010 as an approximation of averages over the first commitment period. CER accumulation in the years before 2008 is included.

A detailed description of the model structure and calibration of key parameters can be found in Jotzo and Michaelowa (2002). For this paper, we have extended the model with increasing marginal transaction costs and additional CDM taxes, in line with the empirical findings above. We have also recalibrated the data to account for the Australian government’s decision not to ratify the Kyoto Protocol, and to allow for CDM projects for the capture of methane from landfills.

#### 4.5. Calibration and assumptions in the standard scenario

Supply and demand curves are derived from marginal abatement cost curves for carbon dioxide in the energy sector. The curves for the general energy sector are calibrated with reference to results from the MIT EPPA model. They differ between countries, depending on the magnitude of emissions and the availability and cost of options to reduce them. For the CDM and JI, the EPPA abatement estimates were scaled back to reflect the fact that only a limited subset of the economy wide abatement options are eligible and feasible under project-based mechanisms. In addition, we explicitly model the use of flared gas in oil and gas extraction as well as the capture of methane from landfills for CDM projects.

The main parameters used in the standard modelling scenario are as follows:

##### 4.5.1. Emissions trading

- All Annex B countries except the United States and Australia comply with their Kyoto commitments and engage in international emissions trading.
- Countries with surplus AAUs, such as Russia and the Ukraine, sell a limited amount of their surplus AAUs and in addition host JI projects for emission reduction. Sales of surplus AAUs (hot air) are assumed to be limited to 400 Mt CO<sub>2</sub>/yr.

##### 4.5.2. CDM

- All developing countries participate in the CDM, albeit not immediately; differentiation in supply according to technical potential and costs.
- No no-regrets projects: All CDM projects have positive implementation costs.
- Sinks under the CDM: The quantity of sink CERs in the market is limited to 1% of assigned amounts of net permit buying countries, amounting to 62 Mt CO<sub>2</sub>/yr.<sup>9</sup> The cost of sink CERs is assumed lower than that of energy projects, reflecting the widely held view that forestry projects will be relatively cheap.

##### 4.5.3. Transaction costs and taxation

Transaction costs are differentiated between mechanisms to reflect differences in the costs for certification, reporting and verification requirements. Transaction costs for CDM and JI are modelled to rise with the permit price in the market. Transaction costs used in the standard scenario are:

- For Certified Emission Reduction Credits (CERs) from CDM projects: The minimum transaction cost is 0.25 €/t CO<sub>2</sub>, rising linearly with the permit price. At a permit price of 3.70 €/t CO<sub>2</sub>, the marginal transaction cost is 0.75 €/t. That is, transaction costs account for 20% of the permit price for the marginal (most expensive) projects in our standard scenario.
- For emission credits from JI projects: Minimum is 0.20 €/t CO<sub>2</sub>, rising to 0.75 €/t CO<sub>2</sub> at a permit price of 3.70 €/t CO<sub>2</sub>.
- A nominal amount of 0.10 €/t CO<sub>2</sub> for sales of permits under emissions trading.

Taxation of CERs is modelled as creating a wedge between the market price for permits and the amount per unit that the project implementers receive.

- CER taxation by host country (illustrative assumption): 10%.
- DNA fee (illustrative assumption): 1%.
- Adaptation fund levy (as per Marrakech Accords): 2%.

#### 4.6. Results in the standard scenario

Under standard assumptions described above, our modelling results are that one-third of effective emission reduction requirements would be met through CDM projects (Table 7). Domestic action in net buying countries—beyond accounting for sinks under Article 3.4—would fulfil around one quarter of aggregate

<sup>9</sup>EIT countries are eligible to invest in sink CDM projects, but as they are expected to be net sellers we assume that they do not make use of their allocation.

Table 7  
Share of mechanisms in meeting Annex B Kyoto Protocol commitments—standard modelling scenario

Mechanism	Mt CO <sub>2</sub> /yr	Share in market (%)
CDM	363	33
Domestic abatement in net buying countries (Annex B OECD countries except USA and Australia)	283	26
Joint implementation in EIT countries	59	5
Sales of AAUs by EIT countries (hot air)—modelling assumption	400	36
Total	1105	100

Table 8  
CDM volume, prices and revenue—standard modelling scenario

	Standard scenario
International permit price	3.66 € per t CO <sub>2</sub>
Price fetched by CDM projects after transaction costs and taxes (for implementation costs and net financial benefit to project implementers)	2.44 € per t CO <sub>2</sub>
Total CER sales	363 MT CO <sub>2</sub> /yr
Total CDM revenue over first commitment period of which:	6.6 billion €
Transaction costs	0.90 billion € (14%)
Taxes	0.93 billion € (14%)
For implementation costs and net financial benefit to project implementers	4.8 billion (72%)

reduction requirements, while emission credits from EIT countries would account for over 40% of the global carbon market—most from traded hot air, some from JI projects.

The results are sensitive to assumptions about how much hot air is traded, the potential for and cost of CDM projects as well as abatement in Annex B countries, and emissions growth in OECD Annex B countries. Sensitivity analysis on these supply and demand side factors is presented in Section 5.

The analysis here estimates the size of global CDM at 363 Mt CO<sub>2</sub>/yr. Energy sector projects account for 57% of total CERs generated in this calibration; the remainder comes from sinks, gas flaring and landfill gas projects. The international price, which is the same across the mechanisms due to fungibility between permits, is estimated at a little under 4 €/t CO<sub>2</sub>, under the assumptions outlined above. However, over a quarter of this would go toward transaction costs and taxes, leaving just around 2.50 €/t CO<sub>2</sub> for implementation of the project, and, in the case of low cost projects, as a profit for the project owners or operators (Table 8).

Total revenue from CDM projects would then be around 6.6 billion € over the first commitment period. Of this, around 14% would be spent on transaction

costs (less than the 20% for the marginal project because there are projects with lower transaction costs included as well), and a further 14% on taxes, under the assumptions in our standard scenario.

Experiences with projects in developing countries and the emerging forward market for emission offset credits show that emission offset projects in developing countries can be feasible at such relatively low prices. Market prices for CDM-type verified emission reductions created in 2000–2003 have ranged from 1.15 to 3.50 €/t CO<sub>2</sub> (Rosenzweig et al., 2002). The Dutch CERUPT programme bought 16.4 million CERs at an average price of 4.7 €/t CO<sub>2</sub> (SENER International, 2003), and the World Bank's PCF calculates with a central price of 3 €/t CO<sub>2</sub> (PCF, 2002).

## 5. Sensitivity analysis on CDM supply

### 5.1. Changes in transaction costs

For sensitivity analysis on transaction cost assumptions, we vary developing countries' marginal abatement cost curves from the standard calibration by tilting the CDM supply curve. Changing these cost assumptions has significant effect on the modelling results (Table 9). In our "high" scenario, the transaction costs in the most expensive project amount to almost half of the permit price. As a consequence, the quantity of CERs sold is lower, with more abatement undertaken in net buying countries and through JI. A move up along the marginal cost curves in all countries results, and the price in the market increases. Lower CDM transaction costs have the opposite effect.

In terms of overall CDM revenue, the quantity and price effects largely cancel each other out. Under the parameters in this analysis CDM revenue would actually increase as a result of higher CDM transaction costs. This is because of the relatively inelastic demand for emission permits from Annex B countries, reflecting steeply increasing costs as more abatement is undertaken in industrialised countries. This result hinges on the assumption that supply of hot air remains unchanged.

However, higher transaction costs mean that there are fewer funds available for implementation and for net financial benefits to project implementers. This is shown in the simulation results, where the residual after tax and implementation costs drops from 4.8 billion to 3.1 billion € for the CDM as a whole, despite a small increase in overall CDM revenue.

### 5.2. Baseline and additionality rules

CDM project potential and costs are also affected by the type of baseline used. In the modelling context, more

Table 9  
Impact of higher and lower implementation and transaction costs for CDM projects

	Standard scenario	High CDM transaction costs <sup>a</sup>	Low CDM transaction costs <sup>b</sup>
International price (€/t CO <sub>2</sub> )	3.66	4.54	3.42
Marginal transaction costs (€/t CO <sub>2</sub> )	0.74	2.23	0.33
Share of CDM in global carbon market	33%	28%	34%
Total CER sales (MT CO <sub>2</sub> /yr)	363	310	378
Total CDM revenue over first commitment period (billion €)	6.6	7.0	6.5
CDM revenue for implementation and net financial benefit (billion €)	4.8	3.1	5.2

<sup>a</sup> Changes in parameters: CDM transaction costs starting from 1 /t CO<sub>2</sub>, and increasing at twice the rate.

<sup>b</sup> Changes in parameters: CDM transaction costs starting from 0.1 /t CO<sub>2</sub>, and increasing at half the rate.

Table 10  
“Generous” baselines and no-regrets projects

	Standard scenario	Generous baselines <sup>a</sup>	No-regrets potential <sup>b</sup>
International price (€/t CO <sub>2</sub> )	3.66	3.05	2.82
Share of CDM in global carbon market	33%	36%	38%
Total CER sales (MT CO <sub>2</sub> /yr)	363	402	418
Total CDM revenue over first commitment period (billion €)	6.6	6.1	5.9

<sup>a</sup> Changes in parameters: slopes of marginal abatement cost curves 50% flatter.

<sup>b</sup> Changes in parameters: additional supply of 100 Mt CO<sub>2</sub>/yr incurring only transaction costs and taxes, but no implementation costs.

“generous” baseline rules translate into flatter marginal abatement cost curves, as given projects would be credited with more CERs. Sensitivity analysis using curves that yield 30% more abatement at the same marginal cost shows that generous baseline rules would increase the total size of the CDM somewhat, while depressing prices (Table 10); again, assuming unchanged supply of excess permits from Annex B sellers.

A separate but related issue is additionality rules and the potential for “no-regrets” projects under the CDM. No-regrets denotes projects which reduce emissions and at the same time lead to financial savings. Such options can exist if there are barriers to investment, for example. Whether no-regrets projects will be eligible under the CDM depends on how strictly and comprehensively an additionality test will be applied (see Sugiyama and Michaelowa, 2001; Greiner and Michaelowa, 2003). Decisions by the CDM Executive Board to reject a number of baseline methodologies submitted by CDM project developers in June 2003 due to lack of additionality testing indicate that rules for additionality testing for CDM projects will be more stringent than expected. In addition, NGOs have identified additionality as a key criterion for CDM projects and have campaigned against non-additional CDM projects (Pearson and Loong, 2003). Even under “fast-tracking” of small CDM projects, as provided for under the Marrakech Accords, a test of barriers is included.

No-regrets projects are modelled by assuming additional supply of CERs that incur no implementation costs, thus shifting the aggregate CDM supply curve outward. Including 100 Mt CO<sub>2</sub>/yr of CER supply from

no-regrets projects is estimated to increase the total size of the CDM by only around 55 Mt CO<sub>2</sub>/yr, as these cheaper options reduce the price in the market and displace other, more expensive CDM project options.

### 5.3. Developing country participation and hot air supply

If prices for emission offset credits remain low, some countries may not be prepared to enter the CDM market in the first commitment period of the Kyoto Protocol—either for economic or political reasons. They would forego some investment inflows and miss out on some opportunities for accelerated modernisation of their production systems. Still, such a decision could be justified economically in terms of “not selling low-hanging fruit cheaply”: if there is an expectation that prices paid for offset credits in the future will greatly exceed those paid in the first commitment period, and if the mitigation options in question continue to exist in future, it may pay to wait.

If some potential host countries opt out of the CDM, this will restrict supply of CERs and drive up the international price. As a result, more costly projects become viable in the remaining CDM host countries, but it also becomes significantly more attractive for Russia and the Ukraine to sell more “hot air”, and for net buyers to use these excess permits to fulfil their Kyoto obligations.

To illustrate this, we model the case where China, India, Indonesia and Brazil do not participate in the CDM; first, without change in trade of hot air, and second, with a 50% increase in excess permits traded, to

Table 11  
Non-participation of some non-Annex B countries and hot air trade

	Standard scenario	China, India, Indonesia and Brazil do not participate	
		Trade in hot air unchanged	Trade in hot air increased by 50%
International price (€/t CO <sub>2</sub> )	3.66	6.35	3.58
Share of CDM in global carbon market	33%	19%	15%
Total CER sales (MT CO <sub>2</sub> /yr)	363	212	168
Total CDM revenue over first commitment period (billion €)	6.6	6.1	3.0

Table 12  
Higher and lower Annex B emissions growth

	Standard scenario	High Annex B growth <sup>a</sup>	Low Annex B growth <sup>b</sup>
Emission reductions required in OECD Annex B countries, excl. USA and Australia (MT CO <sub>2</sub> /yr)	1105	1386	767
International price (€/t CO <sub>2</sub> )	3.66	6.41	1.18
Share of CDM in global carbon market	33%	35%	27%
Total CER sales (Mt CO <sub>2</sub> /yr)	363	489	207
Total CDM revenue over first commitment period (billion €)	6.6	15.6	1.2

<sup>a</sup>Change in parameters: high growth scenario from EIA (2002). Aggregate BAU emissions at 2010 in OECD Annex B countries excl. USA are 4.8% higher.

<sup>b</sup>Change in parameters: low growth scenario from EIA (2002). Emissions 5.8% lower.

600 Mt CO<sub>2</sub>/yr (Table 11). If hot air supply remains constant, the price for emission permits doubles as a result of the large potential CDM hosts not participating, while the overall volume of CDM drops, with a compensating increase in domestic abatement in net buying countries and under JI.

If however Russia and the Ukraine took advantage of the withdrawal of some developing countries from the CDM to expand their market share, the price in the market could be reduced again—in our scenario, back to its original level. In that case, the CDM would account for an even smaller share of total emission reductions under the Kyoto Protocol. Lower hot air sales would mean a boost for the CDM, higher volumes could considerably shrink it. In principle, sales of hot air could be expanded to the point where they account for the vast majority of permit sales at very low prices, largely crowding out the CDM—especially if second commitment period targets turn out not to be stringent, thus encouraging selling off surplus AAUs early. For hot air to dominate the market would however require that potential buyers would be content to fulfil their commitments to a large degree using surplus AAUs, which for many countries and corporations may not be the case.

#### 5.4. Sensitivity analysis of Annex B permit demand

Because the Kyoto commitments are framed as absolute targets, even relatively small changes in the

emissions growth path can have strong effects on the size of the emission reduction requirement, and therefore CER demand. In our example, we assume that emissions in the net buying countries are 5–6% higher/lower at 2010 than in the standard scenario, in line with EIA's (2002) alternative growth scenarios. This translates into changes in the required emission reductions of around 25–30%.

Assuming that supply of hot air remains unchanged, the effect on the CDM would be sizeable (Table 12). Under the high growth scenario, the CDM would play a much greater role; by contrast, if future Annex B emissions growth is low there may be very little effective demand for CDM projects. Permit prices are also estimated to vary significantly, compounding the effect on CDM revenue. With effective targets relatively close to business-as-usual, as is the case under the Marrakech Accords, relatively small changes in emissions could have major impacts on market prices and trading volumes.

## 6. Conclusions

The size of the CDM will depend, among other factors, on transaction costs. Evidence from AIJ and emerging CDM projects shows that transaction costs can account for a significant share of the total cost of CDM projects, especially in a market characterised by low permit prices. Transaction costs tend to increase as

one moves to project categories with higher implementation costs, and smaller projects will be at a disadvantage because fixed costs become a major factor.

Institutional rigidities and taxes on CDM projects levied by host countries are also likely to restrict CDM supply. Some developing countries may decide not to enter the CDM market if permit prices are low. This in turn would tend to benefit the remaining CDM suppliers and other sellers of emission permits.

Our modelling results show the importance of these supply side factors for the size of and revenue from the CDM.

Still, demand side factors have overwhelming importance for the CDM. The aggregate effective emission reduction commitment by those Annex B countries participating in the Kyoto Protocol is small, and the global carbon market in the first commitment period (2008–2012) will likely be characterised by low demand and low prices. Uncertainty remains about key market parameters such as effective emission reductions required in Annex B countries and permit supply from Russia and the Ukraine.

The prospect for large-scale emission reductions in developing countries through CDM projects appears slim in the medium term, but a sufficient number of CDM projects to gather experience and build institutions could still be achieved. The quality of domestic institutions, internal political stability, and efforts to market CDM projects to investors, will all be crucial for individual countries to secure their share in the emerging CDM market. Low permit prices create pressure to keep transaction costs low, for example by streamlining CDM related institutions and procedures. Experience from the AIJ pilot phase leads us to be sceptical about the potential for many developing countries to participate in a low-cost CDM; at the same time, the lowest cost reduction options are often not the most desirable projects from a host country's development viewpoint. Trade-offs between cost efficiency and development benefits will be a major challenge for CDM implementation.

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