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Technology transfers in the Clean Development Mechanism: an incentives issue

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ABSTRACT. The Clean Development Mechanism (CDM) offers abatement cost savings under the Kyoto Protocol by allowing credits for emission reductions obtained in signatory developing countries. The paper argues that technology transfers can improve incentives for cost-effective emission reductions under bilateral CDM contracts when there is asymmetric information between the investor and the host party.

JEL classification: Q20; D82

Key words: Global climate change; Asymmetric information; The Clean Development Mechanism; Optimal incentives: Technology transfers

1. Introduction

The Kyoto Protocol, signed in December 1997, specifies binding emission reduction targets for anthropogenic greenhouse gas emissions for countries listed in its Annex B. The Protocol includes three flexible mechanisms (UNFCCC, 1998); emissions trading (article 17), Joint Implementation, JI (article 6), and, the Clean Development Mechanism, CDM (article 12). Whereas emissions trading and JI apply to signatories listed in Annex I[1] of the United Nations Framework Convention on Climate Change (UNFCCC), the CDM was developed as a means of involving developing countries in global climate change mitigation policies. Specific conditions were imposed on the CDM to increase its acceptability. First, it should

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[1] Annex I of the UNFCCC includes mainly the OECD countries, except recent entrants Mexico, South Korea, plus Russia and the Central European countries. Annex B of the Kyoto Protocol comprises almost identically the countries in Annex I of the UNFCCC but for Turkey and Belarus.

contribute to sustainable development in the host country of the investment. Second, emission reductions should be additional to what would have occurred in the absence of the project activity.

In contrast to the emission reduction units from JI, which are granted only in the commitment period 2008–2012, the recent Marrakech Accords of November 2001 allow for a prompt start of the CDM by crediting already implemented CDM projects from 1 January 2000. Although some precursors to projects exist (Dixon, 1999), the CDM properly defined has been delayed in its implementation, mainly because of political difficulties surrounding the ratification of the Kyoto Protocol. Even if an early ratification of the Kyoto Protocol were obtained, some specific problems obstruct the implementation of the CDM.[2] The main problems are shared also by the other project-based mechanism, JI: the baseline emission scenario is not observable *ex ante* and it is difficult to verify the emission reduction obtained by the project.[3] Because of the difficulties to observe the actual emission reductions, both the investing party and the host party have incentives to overstate the emission reductions created by the project: the host party in order to obtain a higher transfer payment, and the investing party in order to maximize the credits earned towards its emission reduction commitment under the Kyoto Protocol. Incomplete information limits the efficiency gains from JI (Hagem, 1996), and Wirl, Huber, and Walker (1998) and Janssen (1999) propose some mechanisms and institutions to provide correct incentives for JI projects when there is asymmetric information between the investing party and the host party. Yet, contracts under the CDM are concluded with somewhat different purposes and conditions. First, the host party does not have a binding emissions target, so there are incentives for global emissions leakage. Second, the commercial potential of a CDM project could outweigh the value of its emission reduction credits. It must be remembered that the goal of the CDM is not only to obtain cost-effective emission reductions but also to contribute to sustainable development in the host country. As long as the CDM is regarded simply as an extension of JI, its role in involving Non-Annex I countries in climate change policy will be difficult, since developing countries will fail to see the interest in the mechanism from their viewpoint (Goldemberg, 1998). This paper explicitly incorporates the specific characteristics of the CDM. In this context, I will show that technology transfers are not only a matter of equity, but can help to solve some of the incentive problems of implementing the CDM when there is incomplete information. The uncertainty around emission reductions from land-use change and forestry activities is particularly great, and difficulties of monitoring and enforcement have reduced the credibility of the CDM among environmental groups. Designing self-enforcing contracts is thus important if the CDM is to be used to its full potential.

The analysis also contributes to solutions of another potential problem of the CDM: 'cream-skimming'. According to this argument, developing

[2] Comprehensive expositions are contained in Goldemberg (1998), Barrett (1998), and Grubb (1999).

[3] The baseline problem is not treated here, and it may be less of a problem in JI at the macro level, since each party has a national baseline (the Kyoto quota). At a project level the problem persists for both mechanisms.

countries that host CDM projects are likely to lose out since the cheap abatement options will be exploited by Annex I countries. If, at a later time, the host countries will be subject to a binding emission reduction target, only more expensive options of abatement remain. Rose, Bulte, and Folmer (1999) recently formalized the argument. They showed that under certain assumptions on technological change, the stock of abatement possibilities in the host country indeed could decrease due to the flexibility mechanism. The authors conclude that one policy priority is to design transfer payments to compensate for this effect. Such payments are part of the contracts I analyse here. I will show how a combination of transfer payments and technology transfers can contribute to solving the incentive problem between the investor and the host party when there is private information.

Since the main theoretical approach of the paper is based on transfer payments and contract theory, a brief justification for applying the method in this context is necessary. Transfer payments have sometimes been criticized, and alternative methods such as linking the environmental negotiation with a secondary negotiation have been suggested (Folmer, van Mouche, and Ragland, 1993; Carraro and Siniscalco, 1997; Botteon and Carraro, 1998). However, linking the CDM with other negotiations, such as trade cooperation or official development assistance, would seem politically unacceptable, since one of the main demands of the G77 was that the CDM be additional to official development assistance. The main criticism levied against transfers, namely that a victims pay principle may result is not the case here, where it is the industrialized country that provides a transfer to the developing country. Indeed, the use of issue linkage has been shown to be useful for avoiding free-riding in a multiple party international agreement, whereas here the CDM contract is signed between one investor and one host party, and there is an international enforcement body: the executive board of the CDM. Even though enforcement of the CDM may be weak, the cost of certification of emission reductions and the control by the executive board may incur lower overall costs than the costs arising from issue linkage.[4]

The CDM can be conceived in several different manners: a multilateral fund similar to the Prototype Carbon fund established by the World Bank, or a unilateral initiative by a non-Annex I country. In addition, it is clear that the CDM probably will include the participation of many non-profit organizations and government agencies, as was the case in the pilot phase of Activities Implemented Jointly. The model used here cannot possibly reflect this complex reality, but it is aimed at analysing the particular incentive problems in a bilateral CDM with one investor and one host country negotiating an emission reduction project.

1.1. Relation to previous analyses of incentives in the Clean Development Mechanism

The approach taken in this paper of modelling the investor as the principal is related to some previous research results. Wirl, Huber, and Walker

[4] Endogenizing the costs of different enforcement regime for the CDM would indeed be a fruitful topic for future research.

(1998) propose that the objective of a regulator maximizing global welfare can be delegated to the investing (industrial) country by allowing the industrial country to deduct emission reductions obtained abroad from an exogenously specified emission reduction baseline (Proposition 2, in Wirl, Huber, and Walker, 1998).

The novelty of this article is to explicitly account for technology transfers and to show their role in creating counterbalancing incentives to any incentives for cheating on emission reductions. There is no explicit incorporation of technology transfers in the Kyoto Protocol. Indeed, Grubb (1999) argues that the Protocol treats technology transfers as a separate topic, despite its importance being realized by most parties. Here, we will show that technology transfers are not only a matter of equity, but that such transfers can help to contain incentives for misrepresentation of actual emission reduction costs and hence emission reductions obtained under the CDM. The use of financial transfers as side payments to induce participation in international agreements has a long history, and a precedent for environmental agreements is the Montreal Protocol on Substances that Deplete the Ozone Layer. Here, the transfers are not simply financial, but represent real technology transfers. It is the transfer of the property right to the emission reduction capacity that creates counterbalancing incentive for the agent, as will be shown below.

The issue of technology transfers in the implementation of the flexible mechanisms of the Kyoto Protocol was previously raised by Yang (1999), who analyses the impact of transfers from the North to the South in a regional dynamic general equilibrium model (a modified RICE model) with greenhouse gas accumulation as a global externality. The financial transfers of that model can be interpreted as real technology transfers and motivated by differences in abatement costs of a global externality across countries. Some of the policy relevant results from the analysis are that transfers do not have a strong impact on domestic abatement rates; that transfers are not large as a proportion of domestic GDP (below 0.5 per cent); and that transfers can increase the welfare both of the North and the South (Yang, 1999). Yang's analysis brings empirical evidence in support of technology transfers. In what follows, I will use a theoretical model by Lewis and Sappington (1989a, 1989b) to argue for the positive incentive effects of technology transfers, when monitoring problems complicate emission reduction projects.

The structure of the paper is as follows. Section 2 presents a model of contracting under the CDM when there is asymmetric information between the investor and the host party related to a technical abatement efficiency parameter. A simplified version of this model yields the standard inefficiency result of contracts under asymmetric information. The aim of the article is to show how this inefficiency may be mitigated in the CDM. First, there is the possibility that the project may have a commercial potential (section 3.1). Depending on the correlation between the efficiency parameter of the agent and the commercial revenues from the project, incentives for truthful emission reductions may be strengthened. A second possibility (section 3.2) that can mitigate the efficiency loss from asymmetric information originates from the fact that host countries, at present, do not have emission reduction constraints. Future emission constraints would impose different costs on each country, and, thus, the reservation utility of each host party would be type dependent. Depending on the correlation between abatement efficiency and reservation utility, type-dependent utility may mitigate the efficiency loss from asymmetric information. In section 4, I go on to argue that countervailing incentives can be created following Lewis and Sappington (1989a, b) by taking seriously the constraint that the CDM should contribute to sustainable development. This objective would be promoted by technology transfers, which furthermore would mitigate incentives to overstate costs if the correlation between abatement efficiency and the technological capacity that is transferred is negative. Section 5 draws out the resulting policy implications and concludes.

2. The model

The investing party is treated as the principal, with the objective of obtaining emission reductions through the CDM to be able to comply with its emission reduction objective under the Kyoto Protocol.[5] For this purpose the principal chooses to invest in a CDM project for a quantity of emission reductions denoted E.[6] The investor's utility from the emission reduction obtained abroad is denoted $V(E)$ and assumed to be an increasing and concave function in E.[7] CDM projects can take place in a variety of sectors. Examples of CDM projects from the energy sector include supply- and demand-side energy efficiency projects, coal–gas conversion of conventional electricity plants or conversion to biomass, and investment in other renewable energy sources, such as solar energy.

Potential host parties for the emission reduction investment differ in type by a parameter β, which is distributed on an interval $[\underline{\beta},\bar{\beta}]$. The demanded emission reduction abroad is a function of the parameter β of the host party, $E(\beta)$. A high value of β implies a high marginal cost of

[5] The investing party could be a national government or a private sector entity. In the latter case, it is assumed that some national policy is in place that gives incentives to private parties to implement emission reductions.

[6] It is thus implicitly assumed that the marginal cost of emission reductions in potential CDM host countries is lower than the principal's domestic marginal abatement cost. The assumption is contested; for example, based on a panel data econometric approach, Karp and Liu (2001) find that only 19 of the 37 developing countries in their sample have costs below the OECD equilibrium carbon price. Transaction costs could also swamp any cost differential that exists. However, on the basis of the models in the Energy Modeling Forum, there seems to be consensus on cost savings from emissions exchange between industrialized and developing countries. The studies reviewed in the IPCC Third Assessment Report (IPCC, 2001) indicate national marginal abatement costs of up to US1990$ 600/tC with no trade, the range US$ 20–150/tC with Annex I trading, and the range US$ 15–86/tC with global trading under scenarios with no transaction costs.

[7] The concavity of the function expressing the valuation of the emission reduction holds for a country investor that values emission reductions according to a damage function from global climate change.

emission reductions: if $\beta_1 > \beta_2$, then $C(E(\beta_1), \beta_1) > C(E(\beta_2), \beta_2)$. In this manner, $\underline{\beta}$ represents the most efficient agent, and $\bar{\beta}$ the least efficient agent. Furthermore, I simplify the model by assuming constant unit costs of emission reductions, *c*:[8]

$$C(E(\beta),\beta) = \beta c E(\beta) \tag{1}$$

In return for the emission reductions the investor makes a transfer payment $T(\beta)$ to the host party.

The motivation for a CDM project in the energy sector is not only the investment in carbon abatement. The value of any certified emission reductions gained under the CDM comes in addition to revenues from sales of energy and entails a stream of future commercial revenues, denoted $\pi(\beta)$.[9] One example in the electricity sector includes rural electrification projects, where the private investors expect a flow of revenues in future years due to the project. Most investors look for opportunities to gain access to a market, or increase their trade, and the addition of the value of the certified emission reductions can be a factor to turn a project using a carbon-emitting technology into one using a more climate-friendly technology. JI projects can also bring commercial revenues,[10] but especially for the CDM it is crucial not to omit this feature in an analysis of agents' incentives, since the host country itself can propose projects for the CDM with the objective of attracting foreign investment for development. The main factor motivating an investor in the CDM is the expected implementation of climate policy instruments in their home country. However, the AIJ pilot phase showed that part of the non-policy motivations for investors derived from a desire to improve market access in some countries, and anticipations of future revenue streams from expanding commerce, in addition to public relation gains (Dixon, 1999). Different assumptions on the relationship between the efficiency parameter and the commercial revenue will be investigated in the analysis. The part of the commercial revenue accorded to the host party is denoted $\alpha \in [0,1]$, with $(1-\alpha)$ accruing to the investing party. The host party's objective is to maximize the income from the emission reduction project, net of costs

$$U(\beta) = \alpha\pi(\beta) + T(\beta) - \beta c E(\beta) \tag{2}$$

Imperfect information on behalf of the investor creates a possibility for the host party to exaggerate its emission reduction costs in order to receive a larger compensatory transfer. I make the standard assumption that the principal (here, the investor) does not know individual values of β, but only its overall density function, $f(\beta)$, and distribution function $F(\beta)$ on the interval $[\underline{\beta},\bar{\beta}]$.

8 The assumption simplifies derivations – the results follow through generally as long as costs are convex in β.

9 The notation is used to define the expected net present value of future revenues.

10 Although the primary interest in JI as manifested in the pilot phase of Activities Implemented Jointly lay in reducing the cost of emission reductions, secondary interests were expressed in promoting climate change technologies and market opportunities (Dixon, 1999; Lile, Powell, and Toman, 1998).

Based on the revelation principle, the problem is written in the form of a mechanism under which the host party receives compensation according to the announcement of its efficiency parameter, $\hat{\beta}$. Assuming that there are no other externalities involved in the transfer of emission reduction credits, the objective of the investor is

$$\underset{T(\beta),E(\beta)}{Max} \int_{\underline{\beta}}^{\bar{\beta}} [V(E(\beta)) + (1-\alpha)\,\pi(\beta) - T(\beta)]f(\beta)d\beta \tag{3a}$$

$$\text{s.t.} \quad \alpha\pi(\beta) + T(\beta) - \beta c E(\beta) \geq 0 \tag{3b}$$

$$\alpha\pi(\beta) + T(\beta) - \beta c E(\beta) \geq \alpha\pi(\beta) + T(\hat{\beta}) - \beta c E(\hat{\beta}) \quad \forall\beta,\forall\hat{\beta} \tag{3c}$$

Note that it is assumed that the commercial rent is related to the true value of β. The constraints are standard. Equation (3b) embodies the individual rationality constraint, which imposes the condition that the net profits of the host party have to exceed the alternative opportunities representing its reservation utility, here assumed identical and equal to zero. The incentive compatibility constraint in (3c) ensures that the host party will reveal actual costs of emission reductions truthfully, so that the announcement $\hat{\beta}$ equals actual costs β.

Before analysing the optimal CDM contract, note that when the commercial rent is zero the problem reduces to a standard model of JI contracts under asymmetric information with a consequent efficiency loss. A long line of principal-agent literature has shown the inefficiency of contracts under incomplete information.[11] Since the result is well known, I only present the main implications here and leave the detailed proof to an Appendix:

Proposition 1

When there is asymmetric information between a host country and an investor that considers the transfer of a payment in return for implementation of a costly emissions reduction, host party utility will be decreasing in the efficiency parameter ($U'(\beta) = -cE(\beta) < 0$). *The contracted level of emissions reduction for the most efficient agent* ($\beta = \underline{\beta}$) *will not be distorted, but sub-optimal levels of emission reductions will be contracted with all other agents***.**

Proof In Appendix.

Because of asymmetric information, host parties to emission reduction projects would have incentives to maximize the income earned from the project by exaggerating abatement costs in order to get higher financial compensation. The contracted levels of emission reduction levels are therefore distorted from first best to make contracts incentive-compatible (as in the models of JI by Hagem, 1996 and by Wirl, Huber, and Walker, 1998). The principal basically reduces payment of costly information rents by reducing the emission reduction that is demanded by agents stating high cost realizations. In the next section, I will show how special features of the CDM may mitigate this distortion.

[11] See chapter 7 in Fudenberg and Tirole (1991) or Salanié (1997) for textbook expositions.

3. Countervailing incentives as an intrinsic feature of CDM contracts

3.1. The impact of the commercial rent of the project

The possibility of there being commercial revenue linked to the emission reduction project modifies the standard conclusion on the efficiency losses from asymmetric information under JI/CDM. This section derives the solution to the problem stated in equations (3), following Lewis and Sappington's (1989a) analysis of countervailing incentives.

Necessary and sufficient conditions for an agent to truthfully reveal β are now[12]

$$U'(\beta) = \alpha\pi'(\beta) - cE(\beta) \qquad \forall\beta \tag{4a}$$

$$E'(\beta) \leq 0 \tag{4b}$$

Condition (4b) is a normal monotonicity constraint implying that the lower the abatement cost, the larger the emission reduction that will be demanded. Unlike the standard case defined in Proposition 1, equation (4a) indicates that agent utility may increase or decrease with β, depending on the relation between the efficiency parameter and the commercial revenue from the project. Whenever $\pi'(\beta) \leq 0$, utility decreases monotonically with β, yielding the standard result in proposition 1. However, if $\pi'(\beta) > 0$, countervailing incentives will exist. The likelihood of this will be discussed later, but for now, consider the following possibility.

Parties with a high β have less efficient equipment for emission reductions. However, an argument on the basis of declining marginal productivity of investment would be that the gain from investing in such a country to update its energy-using equipment is higher than in a country that already has efficient equipment. While acknowledging that the relationship between the commercial rent and the efficiency parameter is an empirical matter, we will start by exploring the possible consequences of countervailing incentives, following Lewis and Sappington (1989a).[13] The calculations are simplified by the assumption that commercial revenue is proportional to the agent's efficiency parameter: βπ. The utility of a truth-telling agent then varies according to $U'(\beta) = \alpha\pi - cE(\beta)$. Since the demanded emissions reduction will be smaller the less efficient the agent is, $E'(\beta) \leq 0$, the emission reduction effect is likely to outweigh the impact of commercial revenue for low levels of β. For high levels of β, the demanded emission reduction is small and utility is likely to be increasing in β. The solution will therefore differ according to the region of β:[14]

$$\begin{array}{lr} \beta \in [\underline{\beta}, \beta_1] & \alpha\pi - cE(\beta) < 0 \\ \beta \in [\beta_1, \beta_2] & \text{when } \alpha\pi - cE(\beta) = 0 \\ \beta \in [\beta_2, \bar{\beta}] & \alpha\pi - cE(\beta) > 0 \end{array} \tag{5}$$

[12] See for example Guesnerie and Laffont (1994).

[13] At the end of the section, I will discuss different interpretations of the relationship between the commercial revenue from the project and the efficiency parameter.

[14] It is assumed that $cE(\bar{\beta}) < \alpha\pi < cE(\underline{\beta})$. The utility is invariant with β in an interval $[\beta_1, \beta_2]$, since απ does not vary with β.

The utility of an agent can accordingly be defined as follows

$$U = \begin{cases} \int_{\beta}^{\beta_1} [cE - \alpha\pi] d\beta & \beta \in [\underline{\beta},\beta_1] \\ 0 \qquad \text{for} & \beta \in [\beta_1,\beta_2] \\ \int_{\beta_2}^{\beta} [\alpha\pi - cE] d\beta & \beta \in [\beta_2,\bar{\beta}] \end{cases} \tag{6}$$

Since $U(\beta) = \alpha\beta\pi + T(\beta) - \beta cE(\beta)$, solving the transfer T gives

$$T(\beta) = \begin{cases} \int_{\beta}^{\beta_1} [cE - \alpha\pi] d\beta + \beta[cE - \alpha\pi] & \beta \in [\underline{\beta},\beta_1] \\ \beta[cE - \alpha\pi] \qquad \text{for} & \beta \in [\beta_1,\beta_2] \\ \int_{\beta_2}^{\beta} [\alpha\pi - cE] d\beta + \beta[cE - \alpha\pi] & \beta \in [\beta_2,\bar{\beta}] \end{cases} \tag{7}$$

The total surplus from the CDM project can be defined as W

$$W = V + \beta[\pi - cE] \tag{8}$$

The first part is the investor's valuation of the emission reduction. The second part represents the commercial revenue from the project and the third part its total cost.

Substituting for $T(\beta)$ in the original problem defined in equation (3a), using derivation by parts and the definition of W, the welfare maximization problem can be rewritten as

$$\begin{aligned} \underset{E(\beta)}{Max} \int_{\underline{\beta}}^{\beta_1} \left\{ W - \frac{F(\beta)}{f(\beta)} [cE - \alpha\pi] \right\} f(\beta) d\beta + \int_{\beta_1}^{\beta_2} W f(\beta) d\beta \\ + \int_{\beta_2}^{\bar{\beta}} \left\{ W - \frac{(1 - F(\beta))}{f(\beta)} [\alpha\pi - cE] \right\} f(\beta) d\beta \end{aligned} \tag{9}$$

Assuming that the conditions for an interior solution hold, the first-order conditions of the optimization problem are

$$V'(E(\beta)) - c\left(\beta + \frac{F(\beta)}{f(\beta)}\right) = 0 \qquad \forall\, \beta \in [\underline{\beta},\beta_1] \tag{10a}$$

$$V'(E(\beta)) - c\left(\beta - \frac{(1 - F(\beta))}{f(\beta)}\right) = 0 \qquad \forall\, \beta \in [\beta_2,\bar{\beta}] \tag{10b}$$

Unlike the standard result of proposition 1, there is now no distortion in the emission reduction demanded either by the most efficient agent or by the least efficient agent. However, the distortion in the emission reductions demanded for units with $\beta \in [\underline{\beta},\beta_1]$ involves a sub-optimal level of emission reductions, whereas units with $\beta \in [\beta_2,\bar{\beta}]$ will ask for too large a reduction compared to that which is socially optimal. In the interval of low efficiency, the effect of the commercial revenue is not strong enough to outweigh the incentives for exaggerating costs, so the principal would contract lower levels of emission reductions than that which would be optimal in order to reduce the information rents paid to those agents. At the higher end of the efficiency scale, the presence of countervailing incentives causes the principal to ask for larger emission reductions than would be optimal, since the incentives from the commercial revenue outweigh the incentives for cost exaggeration. The principal therefore would like to induce the agent not to understate the efficiency parameter, and so will offer higher emission reduction levels in order to induce truthful revelation. In the mid interval, where the countervailing incentives exactly balance each other, agents are pooled at the same emission reduction level and receive no rents (see Lewis and Sappington, 1989a, for formal proofs). The presence of countervailing incentives thus limits the information rents that the regulator normally has to pay when there is asymmetric information. The results of this section can be summarized in the following proposition:

Proposition 2
When the implementation of the CDM project involves commercial revenue shared between the host party and the investor, the efficiency of the CDM depends on the relation between the commercial revenue and the efficiency parameter. If profits are invariant to or decrease with the efficiency parameter, the standard inefficiency result under asymmetric information prevails. However, if $\pi'(\beta) > 0$, *countervailing incentives can occur and the investor can then partially limit the information rents transferred to the host party.*

Proposition 2 was illustrated above with a derivation based on the simplifying assumption that the commercial rent is linear in the efficiency parameter. Maggi and Rodriguez-Clare (1995) show how the effect of countervailing incentives depends on whether the agent's net utility is quasi-concave or quasi-convex in the private parameter. Here, I have chosen the simplest manner to introduce the possibility that countervailing incentives may exist due to the commercial revenue linked to CDM projects. As stated in proposition 2, the information rents gained by agents and the distortion of the emission reduction will depend on the sign of $\pi'(\beta)$. Earlier, a simple hypothesis was formulated implying that $\pi'(\beta) > 0$. However, the relation is a matter of empirical verification and of the type of greenhouse gas, and the opposite relation could apply. For example, since there is a close link between energy use and carbon dioxide emissions, projects with a large potential for energy savings through efficiency investments normally yield large carbon dioxide emission reductions. The older the current energy equipment is, the larger are the potential savings. This would imply that countries with old infrastructure also have low variable costs of carbon dioxide emission reduction, and if the commercial potential from such projects also increase the older the current equipment is,[15] then $\pi'(\beta) < 0$.

[15] Standard assumptions on decreasing marginal productivity imply a larger profit potential from energy investments in countries with low levels of energy infrastructure.

3.2. The impact of an anticipated future emission constraint

A second important feature of the CDM to bring into the analysis relates to the fact that the host country currently does not face an emission reduction target. It may however anticipate such a constraint in the future (see Rose, Bulte, and Folmer, 1999). Each country's reservation utility will then depend upon its belief in the severity of this future constraint and its anticipation of the international carbon value. Intuitively, the higher a country's current marginal abatement cost the more reluctant it will be to allow other countries to 'mine' its abatement opportunities, because it will have a high expected marginal user cost of exploiting those abatement opportunities today rather than at the time when it has commited to an emission reduction of its own. This translates into an assumption that the reservation utility of each country can be written as $\bar{u}(\beta)$, with $\bar{u}'(\beta) > 0$.

The impact of type-dependent utility is similar to the countervailing incentives created by any commercial revenue from the project. It amounts to a reformulation of the problem stated in equations (3) with the reservation utility equal to $\bar{u}(\beta)$, instead of 0 in equation (3b). Type-dependent utility may occur for several reasons, but a direct link to the features of the CDM would be the anticipation of future emission constraints. Maggi and Rodriguez-Clare (1995) show how the assumption on type-dependent utility will affect the solution to the problem. The necessary conditions for an incentive-compatible scheme (4a) and (4b) now change into:

$$U'(\beta) = \alpha\pi'(\beta) - cE(\beta) - \bar{u}'(\beta) \tag{11a}$$

$$E'(\beta) \leq 0 \tag{11b}$$

Condition (11b) is identical to (4b). Equation (11a) now indicates that even when $\pi'(\beta) \leq 0$, agent utility may decrease or increase with β depending on the relation between the efficiency parameter and reservation utility, $\bar{u}'(\beta)$. If the reservation utility were linear in β, the results would be qualitatively similar to the standard model, with utility unambiguously decreasing in β. The plausible assumption of a reservation utility that increases with the marginal abatement cost will similarly result in utility monotonically decreasing in β. However, it is possible that if reservation utility decreases with efficiency at an increasing rate, ($\bar{u}'(\beta) < 0$ and $\bar{u}''(\beta) \leq 0$), countervailing incentives exist which may mitigate the information rent due to private information. The main objective here was to illustrate that there can exist different possibilities under which countervailing incentives may occur as intrinsic features of CDM contracts and mitigate the inefficiencies normally resulting from asymmetric information. On the basis of the above discussion it does not seem likely, though, that the reservation utility would be lower the more efficient the country is in emission reduction ($\bar{u}'(\beta) < 0$) and that countervailing incentives can arise for this reason. In the next section, it will therefore be shown how countervailing incentives can be created for contracts under the CDM even if not intrinsically present.

4. Technology transfers as a means of creating countervailing incentives

The previous section applied the theory of countervailing incentives (Lewis and Sappington, 1989a) to the design of emission reduction contracts under the CDM. As shown in Lewis and Sappington (1989a, 1989b) and in Maggi and Rodriguez-Clare (1995), countervailing incentives can result as an intrinsic feature of production or utility functions. However, the principal can also create countervailing incentives. In this section, I will follow Lewis and Sappington (1989a, 1989b) to show how the inclusion of technology transfers in the CDM can create incentives that will mitigate efficiency losses from incomplete information.

Introduce the possibility for the investing party to transfer productive capital to the host party, to be used for emission reductions. In the context of the CDM, the capital thus represents emissions abatement technology. It is denoted K and has an *ex ante* unit cost of $(\beta_e c)$ for the investing party. For simplicity, I follow the assumption made in Lewis and Sappington (1989a) of a fixed proportion production function, such that each unit of K enables the agent to produce one unit of emission reduction. The value of the transferred capital to the agent varies inversely with the efficiency parameter. An agent with high efficiency in emission reduction (low β) has modern equipment with a higher fixed cost of capital than an agent with high marginal abatement costs but older equipment with a low fixed capital cost. Alternatively, agents with low abatement cost (low β) are more efficient because they have higher fixed capital costs in investment in know-how, than have less efficient agents (high β) with high variable costs.

The host party can use this technology as it wishes, in particular to produce further emission reductions that it may resell on an international emission credit market. The host party objective is now[16]

$$U(\beta) = T(\beta) - \beta c E(\beta) + \beta c K \qquad (12)$$

Whereas the earlier analysis assumed there was some positive expected flow of net benefits from the emission reduction project that was shared between parties, the analysis now focuses on an outright transfer of productive capacity. This is directly in line with the negotiations about technology transfer for global climate change policy, whose focus is on the transfer of capital equipment (or know-how) to the developing countries.

The modified objective of the investor is

$$\underset{T(\cdot),E(\cdot),K}{Max} \int_{\underline{\beta}}^{\beta} [V(E(\beta)) - T(\beta)] f(\beta) d\beta - \beta_e c K \qquad (13a)$$

$$\text{s.t.} \quad T(\beta) - \beta c E(\beta) + \beta c K \geq 0 \qquad (13b)$$

$$T(\beta) - \beta c E(\beta) + \beta c K \geq T(\hat{\beta}) - \beta c E(\hat{\beta}) + \beta c K \qquad \forall \beta, \hat{\beta} \qquad (13c)$$

The investing party's objective function now includes its expected cost of the technology. The reformulated problem is similar to the basic problem

[16] In comparison with the basic model, any commercial rent is omitted for simplicity.

stated in equations (3) and its solution is therefore omitted here (see Lewis and Sappington, 1989a). The effect of including technology transfers is summarized in proposition 3:

Proposition 3
The optimal CDM contract involves the transfer of abatement technology for agents with $\beta \in [\beta_1, \beta_2]$ *to an amount* $K = E^* (\beta_k)$ *where* $\beta_k \in [\beta_1, \beta_2]$. *There will be no rents for such agents, although rents are positive for agents with* $\beta \in [\underline{\beta}, \beta_1]$ *and* $\beta \in [\beta_2, \bar{\beta}]$. *Like before, demanded emission reductions are distorted downward in the low cost region and upward in the high cost region. At the extreme points, there will be efficient levels of emission reductions.*

Proof The proof follows Lewis and Sappington (1989a) and is therefore omitted here.

The important result is that the use of technology transfers reproduces the effect of intrinsic countervailing incentives. In the intermediate region, $\beta \in [\beta_1, \beta_2]$, the principal should transfer technology and demand a fixed emission reduction. For this mid interval of agents, the two countervailing incentives then offset each other and so agents receive zero rent from the project. In the low-cost region, the incentives to overstate variable costs are larger than the incentives to understate the value of the fixed capital, so the principal will contract sub-optimal emission reduction levels for these agents. In the high-cost region, the incentives for overstating variable costs are outweighed by the incentives to understate the value of the transferred capital, so the principal will adjust contracted emission reduction levels upwards. Emission reductions are efficient at the extreme points of the efficiency scale. Compared to the basic model result in proposition 1, the information rent gained by agents due to their private information is thus reduced.

The source of the countervailing incentives are the technology transfers in the form of productive capacity *K*. Without the technology transfer, the agent would have incentives to exaggerate the emission reduction cost parameter β to receive a higher compensatory transfer payment. With the technology transfer included, overstating β means exaggerating the value of the technology to the agent, a value which the agent rather would like to understate, and so, the agent's original incentives not to reveal costs truthfully are partially counterbalanced. In comparison with financial transfers, it is essential that there is a real transfer of productive capital. This is seen in equations (13a)–(13c), which show that if the unit cost of the capacity were not different between the principal and the agent, the transfers would amount to standard financial transfers.

The model represented the host party as an agent and the investor as the principal. The analysis holds for two private sector parties or for the case when the two actors represent national governments, and the terms host party and host country were used interchangeably. However, a more detailed analysis of the CDM would comprise at least four parties: the investing party, the government of the country of the investing party, the investment partner in the host country, and the host government (regulator in charge of overseeing the implementation of the CDM), in addition to the true principal: the Conference of the Parties to the UNFCCC. Janssen (1999) showed that credible enforcement on behalf of the host government on any cheating host party could guarantee implementation of a CDM contract yielding real emission reductions. The possibility of either relying upon the enforcement power of the host country national environmental agency or the delegation of the contract obligations to a credible non-interested third party are means of circumventing the inherent incentive problems of the CDM when there are monitoring difficulties of actual emission reductions and costs. When such possibilities are not available, this paper has shown an alternative means of improving the incentives to produce real emission reductions. It should be noted, though, that the analysis abstracted from the potentially important problem that the principal could collude with the host country in order to delude the Executive Board of the CDM. An alternative approach to the problem, which also is outside of the scope of this paper, would be to use a multilateral fund to pool CDM projects and thus avoid the exploitation of information asymmetries in a bilateral contract.

There exist practical difficulties of actually implementing technology transfers, however. First, the relevant technology may not be in the hands of the investor. The model presented here includes the principal's cost of the technology, which represents any licence fees that must be paid by the investor to transfer technology. The issue is further complicated, however, if the owner or patent holder of the technology has prohibited users to pass the technology on to certain countries. In addition, technology transfers are not limited to the narrow definition of hardware transfer. A successful transfer has to include training of local management and it is also dependent on a supporting infrastructure.[17] The definition of the IPCC Special Report (2000) indeed defines technology transfers as a 'broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to global climate change amongst different stakeholders ...'.

Given the difficulties of technology transfer, parties will have to find a trade-off between the gains from the incentives created by technology transfers, and the costs they imply. This paper has shown that in some cases technology transfers can help to mitigate incentive problems caused by private information on the costs of the project. Since the costs of the CDM include not easily verifiable transaction costs (which were very high in the pilot phase of AIJ), the concern for exaggerating overall costs is real. Any mechanism that can improve economic incentives to truthfully represent costs of emission reductions would be helpful. Whether the positive effect of technology transfers in this sense is enough to outweigh the difficulties cited above is not certain. In the long run, though, including technology transfers in JI or CDM contracts might alleviate the concern that the use of flexible mechanisms reduce incentives for host countries of JI projects to undertake investments increasing energy efficiency and thus reducing long-run emissions (Hagem, 1996). The dynamic effects of the policy proposed in this paper are thus important to investigate in future research.

[17] MacDonald (1992) elaborates on the conditions for successful technology transfers, illustrated with empirical case studies.

In the debate surrounding the implementation of the flexible mechanisms of the Kyoto Protocol, it has been suggested to bar some technologies completely from entering into the CDM. Proposals from the WWF, for example, include non-eligibility for non-renewable energy, and nuclear energy in particular, in the CDM. The aim of such a limitation on technology would be to further the objective of sustainable development, but its impact on the availability of technology transfers and incentives under the CDM needs to be explored further.

5. Conclusions

The paper presented an analysis of the incentive problems of implementing the CDM under asymmetric information between an investor and a host party, giving explicit attention to the role of technology transfers. It was argued that the inclusion of technology transfers is not only a matter of equity, but that such transfers in fact can contribute to incentive-compatible CDM contracts.

The investing party was modelled as the principal with the objective of implementing a certain emission reduction abroad. The host party objective is to maximize the transfer payment earned from the emission reduction project net of costs. The model also included any commercial revenue linked to the project. First, I showed that the basic model leads to a well-known result from contract theory: asymmetric information between the principal and the agent (host party) on a parameter representing the agent's abatement efficiency limits the efficiency gains from the emission reduction project. Then I investigated whether special features of the CDM could reduce such problems.

The first possibility resides in the intrinsic features of the CDM. In particular, the cumulative abatement effect imposed on host countries anticipating a future emission reduction target would yield a type-dependent utility that, under certain conditions, partially could alleviate the incentive problems caused by asymmetric information about the efficiency parameter. Second, and maybe more likely, is that a positive correlation between the commercial revenues of the project and the agent's efficiency parameter could help to counterbalance any incentives to overstate costs. However, even in the absence of such intrinsic features due to the characteristics of the reservation utility or the correlation between the efficiency parameter and the commercial revenue of the project, the principal can design contracts to counterbalance the incentives to overstate costs. For an incentive-compatible contract, the principal should transfer abatement technology (capital) to the agent who should be free to exploit the capital for other revenue-producing options, including the generation of additional credits for sale on international emission markets. This is an application of the theory of countervailing incentives (Lewis and Sappington, 1989a, 1989b; Maggi and Rodriguez-Clare, 1995). By transferring control of a productive resource to the agent, countervailing incentives are created that contain the incentives for the agent to misrepresent private information.

Several practical problems may arise when actually trying to implement such technology transfers. First, the property right of the abatement technology may not be in the hands of the party investing in the CDM project. Patent problems might be negotiated, however. The model includes a variable representing the rental cost of the investing party to obtain the technology protected under a patent, so any licence fees should be counterbalanced by the gains to the investing party from the increased efficiency of the CDM project. In certain cases, outright export bans could of course obstruct the technology transfer. Second, in order for technology transfers to be successful, several conditions have to be fulfilled, in addition to the hardware transfer. Primary requirements include free information flow, the existence of a supporting infrastructure, and training of local management for long-term efficient operation. The role of technology transfers is thus complicated, but remains an issue where learning over time will facilitate the acquisition and use of the technology. This paper's modest contribution is to propose yet another reason for why it is urgent to start the process of technology transfer under the Clean Development Mechanism, in spite of and because of any information asymmetry between partners.

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Appendix

Proof of Proposition 1

With no commercial rent, the principal's problem reduces to

$$\underset{T(\beta),E(\beta)}{Max} \int_{\underline{\beta}}^{\bar{\beta}} [V(E(\beta)) - T(\beta)f(\beta)d\beta \tag{A1}$$

$$T(\beta) - \beta cE(\beta) \geq 0 \tag{A2}$$

$$T(\beta) - \beta cE(c) \geq T(\hat{\beta}) - \beta cE(\hat{\beta}) \qquad \forall\beta,\forall\hat{\beta} \tag{A3}$$

The problem is thus formalized according to the revelation principle as having the agent reveal a β, denoted $\hat{\beta}$, that is identical to its true β. The agent chooses to reveal a β according to the first- and second-order conditions for his optimisation problem, which is to maximize $T(\hat{\beta}) - \beta cE(\hat{\beta})$ with respect to $\hat{\beta}$:

$$T'(\hat{\beta}) - \beta cE'(\hat{\beta}) = 0 \tag{A4}$$

$$T''(\hat{\beta}) - \beta cE''(\hat{\beta}) \leq 0 \tag{A5}$$

Since (A4) has to hold as an identity, it can be differentiated

$$T''(\beta) - cE'(\beta) - \beta cE''(\beta) = 0 \tag{A6}$$

Taken together, (A5) and (A6) imply $E'(\beta) \leq 0$, and since an incentive-compatible mechanism has to entail truthful revelation of c, we also have that

$$U'(\beta) = -cE(\beta) < 0 \tag{A7}$$

Since information rents decrease in β, the (IR) constraint will bind only at $\beta = \bar{\beta}$. Using (A7), information rents can be written as $\int_{\beta}^{\bar{\beta}} - cE(z)dz$. Substituting for the transfer to the agent in the principal's objective function gives the modified problem

$$\underset{E(\beta)}{\text{Max}} \int_{\underline{\beta}}^{\bar{\beta}} \left[V(E(\beta)) - \beta c E(\beta) - \frac{F(\beta)}{f(\beta)} cE(\beta) \right] f(\beta) d\beta \tag{A8}$$

According to equation (A8), the transfer from the principal to the agent thus encompasses both the direct cost of emission reductions and the information rent for private information, represented by the third term. Since the more efficient agents easily can simulate being less efficient and needing larger compensation for costs, the information rents are weighted by the mass of efficient agents, $F(\beta)/f(\beta)$.

Emission reductions are given by the first-order condition

$$V'(E(\beta)) - c\left(\beta + \frac{F(\beta)}{f(\beta)}\right) = 0 \qquad \forall\beta \tag{A9}$$

Hence, the principal chooses a contract such that the marginal benefit from the emission reduction equals its marginal cost including information rents. The second-order condition for a maximum is satisfied since the function V is assumed concave in E.

It follows directly from (A9) that there is no distortion in the emission reductions demanded by an agent with $\beta = \underline{\beta}$. However, for all other agents, $F(\beta)/f(\beta)$ is positive, and given the concavity of V, emission reductions are distorted downwards.

In order to check the first-order approach taken here to solve the problem, differentiate (A9) to check whether the monotonicity constraint holds for $E(\beta)$:

$$E'(\beta) = \frac{c + \dfrac{d}{d\beta}\left(\dfrac{F(\beta)}{f(\beta)}\right)}{V''(E(\beta))} \tag{A10}$$

The monotonicity constraint, $E'(\beta) \leq 0$, is thus satisfied at the solution characterized by (A9) as long as $F(\beta)/f(\beta)$ is not decreasing in β. This corresponds to the condition of a monotone hazard rate in contract theory.