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by

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Abstract

Joint Implementation (JI) under the Framework Convention of Climate Change means that countries could partly offset their national abatement commitments by investing in CO_2 abatement projects abroad. JI is introduced as a mechanism for achieving a certain global abatement target less costly by separating the commitments from the implementation of measures. This paper studies the design of a JI contract when the investor has incomplete information about the foreign firm which carries out the JI project (the host). Asymmetric information leads to a decrease in the potential cost-savings from JI. Furthermore, private information held by the potential host firm could give the firm a significant positive utility of participating in JI projects. The possibility of being a host for a JI project in the future can prevent potential host firms from investing in profitable abatement projects today. The paper analyzes the impact on emissions of CO_2 of strategic behavior among potential hosts for JI projects.

1. Introduction

The United Nations Framework Convention on Climate Change (FCCC) states that developed country Parties may implement policies and measures jointly with other Parties in contributing to the achievement of the objection of the Convention. The concept of Joint Implementation (JI) is, however, not yet precisely defined by the FCCC.

JI is one way of reducing the global cost of achieving a cut in global emissions of greenhouse gases (GHGs) through international cooperation. The idea of JI is to reduce the total cost of a given reduction in the emissions of GHGs by separating the *commitment* of each country Party from the *implementation* of measures. Countries that have committed themselves to reduce their emissions of GHGs could meet their obligations by investing in abatement projects in other countries, in agreement with the other country Parties. This will reduce the *total* cost of meeting the commitments of the investing countries if their cost of abatement is higher than the abatement costs in the host countries.

Research has shown that the cost of achieving a given global abatement target could be reduced significantly if countries coordinate their abatement policies. For example, Barrett (1992), using engineering data on costs, estimates the cost of implementing the European Union's stabilization target for CO_2 emissions to be 50 times less expensive with cost-effective abatement, compared to a requirement that each member state stabilizes its own emissions. Burniaux et al. (1992) consider a stabilization scenario in which the OECD countries stabilize their emissions by 2010 at 80 per cent of their 1990 levels and the non-OECD countries stabilize their emissions at a level that is 50 per cent higher than their 1990 levels. They find that the global abatement cost of this stabilization scenario could be cut in half by cost-effective abatement. When comparing the two studies Barrett (1993a) points out that Burniaux et al. (1992) assume that cost-effective abatement is carried out between countries within regions. The European Community countries are treated as a group which implements abatement within the Community in a cost-effective manner, whereas Barrett (1992) treats the European Community as separate countries. Hence, if the marginal abatement cost varies significantly between countries within regions, the study carried out by

Burniaux et al. will under-estimate the potential cost savings from Joint Implementation.

Another advantage of Joint Implementation is that it could reduce the "emissions leakage" in situations involving unilateral abatement initiatives. Unilateral emissions reduction, e.g., through taxes on carbon-based fuels, could induce a significant increase in emissions in other countries. Pezzey (1992) demonstrates that this effect might be quite strong. The reason for emissions leakages is that the unilateral action will tend to lower the prices on carbon-intensive fuels and improve the competitiveness in other regions where energy is not taxed. The initial unilateral abatement can thus partly be offset by increased emissions due to higher production of carbon-based goods in other countries. Joint Implementation could reduce the leakage because it will reduce the cost of the climate policies and therefore the competitive disadvantage.

Because Joint Implementation reduces the cost of meeting national commitments and makes the unilateral abatement target more effective at reducing global emissions, countries might revise their targets upwards. Hence JI could have real environmental benefits. Barrett (1993b) discusses the impact of abatement costs on the choice of unilateral emissions targets when countries act strategically. He concludes that lower cost of achieving global abatement give parties to the FCCC an incentive to undertake more abatement unilaterally, than they otherwise would.

The motivation for the investing countries to participate in Joint Implementation is to receive credits for their abatement projects abroad. The emissions reduction following from a JI project will therefore represent a value for the country if it offsets some of the more costly domestic emissions reductions. A precondition for a JI-regime is firstly that some countries have made binding commitments, and secondly, that there is a system for crediting the investing countries for the abatement obtained from the JI projects.

So far the FCCC does not include any binding commitments for emissions reduction. A discussion of a possible future JI-regime must thus be based on some assumptions on the design of such a regime.

There are different options for designing a JI-regime. (See e.g., Torvanger *et.al.* (1994) and Mintzer (1994) for analyses of possible arrangements to institutionalize JI). The simplest form is a bilateral agreement between two parties. A more ambitious option is a "clearing house" for JI projects (see Hanisch (1991)). Countries can present relevant abatement projects to the clearing house, which registers the projects and offers an assemblage of projects to investors, which in turn for the investment receive abatement credits. This paper will, however, focus on bilateral agreements. We relate the analysis to the micro level, where an investor firm in one country negotiates a contract with a host firm in another country.

It is useful to distinguish between a JI project between two firms in countries that have both made binding commitments regarding their emissions, and between a firm in a country which has made binding commitments and firm in a country without. The main criticism of JI refers to the problem of estimating the actual net abatement of the latter type of projects. Estimating net abatement requires an estimate of an unobservable baseline for the emissions in the absence of the JI project. Furthermore, the impact on emissions of the realization of a JI project could be difficult to observe. Even in the case where the firmwide emissions *ex post* is manageable to estimate the nationwide effects may fall significantly short of the firmwide effects. The project may have a significant impact on fossil fuel use in other activities through market interactions. These problems are *inter alia* discussed in Bohm (1994). It is thus in general a difficult and costly task to estimate baseline scenarios for the host countries and to estimate the actual abatement effects of a JI project. The starting point of this paper is, however, perfect information *ex post* on the baseline in the absence of any JI projects and actual abatement of the project. The problems discussed in this paper is how informational constraints affect the cost-savings of JI and the distribution of welfare between hosts and investors, and how strategic behavior among the potential hosts could lead to a decline in abatement.

If the investor had complete knowledge about the abatement achieved and the investment costs of different JI options, the project with the lowest cost per unit abatement would have been carried out first. However, due to incomplete information about the different JI projects, the investor is not able to tell the final impact on abatement of the different JI options in advance.

Some of the relevant information about the impact on the abatement or the cost of an investment may be private information held by the host. The host may have more accurate information about its ability to utilize new technology. The host may thus have more information than the investor about the impact on the production function of an investment. Furthermore, the abatement achieved by an investment could also be dependent on the actions taken by the host during the project period. For instance, actions to maintain the machinery and training of employees to operate new machinery could have a significant impact on the abatement achieved by the investment. These actions could, however, be difficult for the investor to observe. The investor could therefore face two types of asymmetric information: The host has private information about the impact on the production function of the JI investment, and private information about its own actions during the project period. The two types of asymmetric information are in the literature usually referred to as adverse selection and moral hazard.

Private information held by the host has an impact on the design of JI contracts. The investor has two objectives for a JI contract that will be in conflict under asymmetric information. The investor wants the host to take the correct actions during the project period. Furthermore, the investor seeks to minimize the cost of the project and hence keep the financial transfer to the host at the minimum level necessary to persuade the host to accept the contract. In the next section the design of a JI contract under asymmetric information is analyzed in a model with two types of host firms and one option for investment. The model is based on Laffont and Tirole (1993).

The third section analyzes the design of a JI contract in the case of so called no-regrets investment projects. No-regrets projects can be undertaken at negative costs, meaning they are profitable even if global climate benefits are not included in the calculations. (Confer Selrod and Torvanger (1994) for a further discussion of no-regrets options). Since the use of energy is costly for the firm, investments in energy-efficient technologies could be profitable for the potential host firm. These investment projects should not be accepted as JI projects, since the projects should be undertaken anyway. Furthermore, no-regrets projects should decrease the baseline emissions scenario relative to the observed emissions *ex ante* of the implementation of a JI project. If an investment in new technology that reduces the emissions is profitable for the firm, the level of emissions following from the new technology should form the baseline.

A main characteristic of the design of JI contracts under asymmetric information is that private information held by the firms may be beneficial for the firms if they are chosen to be a host for a JI project. The potential host firms may act strategically to take advantage of their private information. One type of strategic behavior is to abstain from investing in less polluting technology to avoid revealing their private information. Strategic behavior of the potential host firms may therefore have an adverse effect on emissions. The impact on emissions of strategic behavior is studied in a two-period model in section 4. Section 5 presents a numerical illustration of the model. Concluding remarks are given in the last section.

2. The model

The type of JI project analyzed is a bilateral agreement between an investor in one country and a host firm in another country. It is assumed that the investor's country has a binding quantitative target for emissions. The government in the investor's country has imposed a carbon tax to meet the target. The users of carbon-based fuels are exempted from tax on the amount of carbon abated abroad through JI projects. The benefit for the investor per unit carbon dioxide (CO_2) abated is therefore equal to the national carbon tax. The JI project is an investment in a new energy-efficient technology. Consider an investor that wishes to enter into a JI contract with a firm in another country. The investor observes the use of energy and hence emissions from the firm, but has incomplete information about the impact on the production function of the JI investment. The use of energy *ex post* is function of an energy efficiency parameter, β, and the firm's different actions, from now on referred to by the generic term *effort*. The effort put into the project will reduce the use of energy, but is not possible for the investor to monitor the effort. We restrict the analysis to the situation where there are only two possible outcomes for the efficiency parameter *ex post*. The efficiency parameter can take one of the two values $\{b_1,b_2\}$, where $b_1 < b_2$. If the efficiency parameter is b_1, the firm is henceforth referred to as an efficient firm, while it is referred to as an inefficient firm if the efficiency parameter is b_2. Before the investment takes place the firm has private information about its *ex post* efficiency parameter. It is, however, assumed that the value of the two different efficiency parameters is common knowledge, but the investor is incapable of identifying which b to attach to the firm *ex ante*. We assume that it is worth realizing the JI project even with an inefficient firm. The amount of the commodity produced by the host firm is a fixed quantity normalized to 1.

The JI contract and the JI project have to be accepted by an international control commission in order to be accepted as a way to fulfill the national target. The commission awards abatement credits to the investor's country. It is in the interest of the commission to ensure that abatement credits awarded are equal to the actual abatement achieved by the project. The investor is only exempted for taxes on abatement accepted by the control commission. In this section it is assumed that there is only one investment option. In the next section we study a situation with two investment alternatives.

Notation

i	- 1,2 is referring to the type of agent
β_i	- Efficiency parameter. $\beta_1 < \beta_2$
v	- Pr [$\beta = \beta_1$]. Probability of choosing an efficient firm. $v \in (0,1)$
E	- Energy measured in CO_2-units
E^0	- The observed use of energy by the host firm *ex ante*
γ	- The energy efficiency parameter *ex ante*
J	- The price of the JI investment
p	- Price per unit E
t	- National tax per unit CO_2
e	- Effort
$w(e)$	- The host firm's disutility of effort
C	- Observable monetary cost of introducing new technology in the production
F	- Monetary transfer *in addition* to the reimbursement of the observable cost C
Π	- Investor's profit
U	- Host firm's utility

The production function *ex ante* and *ex post* of the JI investment are given by

$$\textit{Ex ante}: \quad E^0 = \gamma \tag{1}$$

$$\textit{Ex post}: \quad E = \beta - e \tag{2}$$

The investor commits itself to reimburse the firm's observable cost of the JI project. The monetary cost of carrying out the JI project is

$$C(\beta, e) = J - p(E^0 - (\beta - e)) \tag{3}$$

where $C'_e(\beta,e) < 0$. The firm's effort decreases the monetary cost of the project, but represents a disutility to the firm. The firm's utility of participating in the JI project is

$$U = F - w(e) \qquad \textbf{(4)}$$

Where F is the monetary transfer in addition to the reimbursement of the monetary cost, and w(e) is the disutility of effort. $w'(e) > 0$, $w''(e) > 0$.

Note from (2) that

$$e = \beta - E \qquad \textbf{(5)}$$

Substituting this expression in (4) gives

$$U = F - w(\beta - E) \qquad \textbf{(6)}$$

If the firm is willing to accept the contract, the utility obtained from participating in the project should be at least equal to the utility achieved by not participating. The profit received by producing with the old technology, and hence the utility, is normalized to zero. The individual rationality constraint (IR) amounts to

$$U = F - w(\beta - E) \geq 0 \qquad \textbf{(7)}$$

The investor's profit of the project is the value of the emissions reduction minus the cost of carrying out the project, (C), and the financial transfer to the firm (F). The value of the emissions reduction per unit of CO_2 is equal to the national carbon tax. It follows from (2), (3) and (6) that the investor's profit function can be written

$$\Pi(E,U) = -J + (p+t)(E^0 - E) - w(\text{b} - E) - U \quad \textbf{(8)}$$

Complete information

To discuss the impact of asymmetric information it is useful to first study the characteristics of the JI contract under complete information about the efficiency parameter (β). The investor specifies the energy use required, *E*, and the financial transfer, *F*, in the JI contract offered to the host. If the investor could observe the efficiency parameter when the host firm is chosen the investor would specify the level of energy use required that would maximize (8) subject to (7).

The solutions to the maximizing problem under complete information are given by (9) i) and ii) if the firm is efficient and by (9) iii) and iv) if the firm is inefficient.

$$\begin{aligned} &i)\ \ w'(e_1) = (p+t) \\ &ii)\ \ U_1 = 0 \\ &iii)\ \ w'(e_2) = (p+t) \\ &iv)\ \ U_2 = 0 \end{aligned} \quad \textbf{(9)}$$

where $e_i = \beta_i - E_i$ $\quad i = 1,2$

Let $e_1 = e_2 = e^*$ be the solution to (9) i) and iii).

To implement the optimal solution (9) the investor specifies a transfer-energy pair dependent on the type of firm. Let the transfer-energy pair $\{E_1^*(\beta_1,e^*), F_1^*\}$ characterize the JI contract offered to an efficient firm and the transfer-energy pair $\{E_2^*(\beta_2,e^*), F_2^*\}$ characterize the JI contract offered to an inefficient firm. Due to the specification of the production function, the contract designed for the two types differ only on the specification of the level of energy use required. The contract offered to an efficient firm specifies a lower energy level than the contract offered to an inefficient firm. The contracts ensure that the firm exerts the first-best effort level, which in the model is equal for both types of firms. The first-best level of effort, e*, ensures that the marginal disutility of effort for the host firm is equal to the marginal benefit of effort for the investor. The financial transfer specified in the two different contracts is identical. Since financial transfers are costly for the investor, the firm is left with no rent, that is, $U = 0$. The financial transfer exactly covers the firm's disutility of the effort exerted: $F_1^* = F_2^* = w(e^*)$.

The use of energy is observed by the control commission at the end of the production period. The control commission awards the investor's country abatement credits, (*AC*), equal to the actual abatement achieved by the project.

$$AC_i = E^0 - E_i^* \qquad \textbf{(10)}$$

Asymmetric information

If the type of firm is unknown to the investor, it is optimal for the investor to offer the host firm a two-contract menu, one designed for the efficient firm, $\{E_1,F_1\}$, and one designed for the inefficient firm, $\{E_2,F_2\}$. In order to ensure that the firm chooses the contract designed for it, the utility of that contract must exceed or be equal to the utility of taking the contract designed for the other type. The incentive compatibility constraint (IC) makes certain that the contract designed for the type is the one preferred by the type.

The incentive compatibility constraints for the inefficient firm and efficient firm are given by, respectively

$$IC_1: \quad U_1 = F_1 - w(\mathrm{b}_1 - E_1) \geq F_2 - w(\mathrm{b}_1 - E_2)) \qquad \textbf{(11)}$$

$$IC_2: \quad U_2 = F_2 - w(\mathrm{b}_2 - E_2) \geq F_1 - w(\mathrm{b}_2 - E_1)) \qquad \textbf{(12)}$$

Rewriting IC_1;

$$U_1 \geq U_2 + Q(e_2)$$

$$where \qquad \textbf{(13)}$$

$$Q(e_2) \equiv w(e_2) - w(e_2 - (b_2 - b_1))$$

and

$$e_2 = b_2 - E_2 \qquad \textbf{(14)}$$

$Q(e_2)$ expresses the difference in the disutility between an efficient and an inefficient firm achieving a certain level of energy use *ex post* of the JI investment. Since w"(*e*) > 0 and $b_1 < b_2$, $Q(e_2)$ is higher the lower the level of energy use, that is, the higher the effort level required from the inefficient firm:

$$Q'_{e_2}(e_2) = w'(e_2) - w'(e_2 - (b_2 - b_1)) > 0 \qquad \textbf{(15)}$$

The individual rationality constraints (IR) for each type amount to

$$IR_1: \quad U_1 = F_1 - w(\beta_1 - E_1) \geq 0 \tag{16}$$

$$IR_2: \quad U_2 = F_2 - w(\beta_2 - E_2) \geq 0 \tag{17}$$

It follows from the fact that w(e) is increasing in e, that IR_1 is satisfied if IC_1 and IR_2 are satisfied. Hence we can ignore IR_1 in the optimization problem.

The investor's optimal two-contract menu is found by

$$\begin{aligned} \max E\,[\Pi(E_1, E_2, U_1, U_2)] &= v[-J + (p+t)(E^0 - E_1) - w(\beta_1 - E_1) - U_1] \\ &+ (1-v)[-J + (p+t)(E^0 - E_2) - w(\beta_2 - E_2) - U_2] \end{aligned} \tag{18}$$

subject to (12) and (17).

Since the rents U_1, and U_2 are costly to the investor, (12) and (17) are binding at the optimum. (The IC for the inefficient firm, given by (11), is checked *ex post*.)

The optimal solution is characterized by

$$\begin{aligned} &i)\ w'(e_1) = p + t \\ &ii)\ w'(e_2) = p + t - \frac{v}{1-v} Q'(e_2) \\ &iii)\quad U_1 = Q(e_2) \\ &iv)\quad U_2 = 0 \end{aligned} \tag{19}$$

It follows from (9) and (19) that $e_1 = e_1^*$ and $e_2 < e_2^*$. E_1 is hence equal to E_1^*, while E_2 is larger than E_2*.

This is the standard result for optimal regulation under asymmetric information derived in Laffont and Tirole (1993). Asymmetric information causes too low effort and no rent for the inefficient firm and a positive "informational" rent ($Q(e_2)$) and optimal effort for the efficient firm. The ability for the efficient firm to mimic the inefficient firm forces the investor to give the efficient firm a positive rent. When the type of firm is unknown to the investor, the efficient firm can always mimic the inefficient firm and choose the contract designed for the latter. Note from (5) that $e = E$-b. From the fact that $b_1 < b_2$, an efficient firm exerts less effort than an inefficient firm to use the same amount of energy. Choosing the contract designed for the inefficient firm therefore leaves the efficient firm with a positive rent, since F_2 has to satisfy (17). The investor therefore has to give the efficient firm a positive rent larger than the rent it can receive by mimicking the inefficient firm, to make it beneficial for the firm to choose the contract designed for it. The rent decreases when the inefficient firm's effort is lowered. The higher effort level requested from the inefficient firm, the higher rent must be given to the efficient firm. The investor could design a two-contract menu that induced both types of firms to exert the first-best level of effort. However, that contract would result in a high rent for the efficient firm. To reduce the rent to the efficient firm the investor lowers the effort level requested from the inefficient firm.

The probability distribution plays a crucial role in the determination of the optimal contract. We will in the following assume that $w'''(e) \geq 0$, which implies that $Q''(e_2) \geq 0$. $Q''(e_2) \geq 0$ is a sufficient condition to ensure that the effort level, e_2, which solves equation (19) ii), is lower the higher value of v. Furthermore, let $U_1^*(v)$ denote the (reduced-form) rent left to the efficient firm when the probability of the efficient firm is v. Since $U_1^*(v) = Q(e_2(v))$ and $Q'(e_2) > 0$, $U_1^*(v)$ is decreasing in v. This lead to the following conclusion, as is pointed out in Laffont and Tirole (1993), chapter 1:

- The most efficient agent enjoys a higher rent when the investor's probability of the efficient type is lower.

- The effort of the least efficient firm is lower when the investor's probability of the efficient type is higher.

Let the expected profit under complete information and under asymmetric information be denoted EP^{CI} and EP^{AI} respectively. The investor's expected loss in profit due to asymmetric information, denoted $EL(\cdot)$, is

$$EL(\bullet) = E\,\Pi^{CI} - E\,\Pi^{AI} = v\,Q(e_2) + (1-v)\,[(p+t)(e_2^{*} - e_2) - (w(e_2^{*}) - w(e_2))] \qquad \textbf{(20)}$$

where e_2* is the first best effort level and e_2 is the effort level requested from the inefficient firm under asymmetric information, given by (19).

The first term on the right-hand side expresses the expected transfer of income from the investor to the host firm and the second term expresses the cost of the expected efficiency loss due to a non-optimal effort level.

The expected loss in profit, $EL(\cdot)$, is concave in v. $EL(\cdot)$ reaches its maximum for v equal to $\underline{n}$, where $\underline{n}$ is characterized by; $Q(e_2(\underline{n})) = (p+t)(e_2{*}-e_2(\underline{n}))-(w(e_2{*})-w(e_2(\underline{n})))$.

3. Model with two investment alternatives.

In the above section it was assumed that there was only one investment alternative, and it was not profitable for any of the two types of firms to invest in the new technology. The baseline CO_2 emissions from the firm were thus the observed emissions before the investment took place.

In this section we study the effect on JI contracts of an investment alternative that is profitable for the firm under normal market conditions, a so-called no-regrets project. No-regrets projects will decrease the baseline emissions scenario relative to the observed emissions *ex ante* of an investment. If it is profitable for the firm to invest in new technology that reduces its emissions, the level of emissions following from the new technology should form the baseline. The benefit for the firm of an energy efficient investment is the reduction in energy expenditure.

Consider a situation where there are two investment alternatives. One is identical to the investment project described in the previous section, from now on called the JI project. The other investment alternative is less costly but implies a smaller increase in energy efficiency. However, it is profitable for one or both of the firm types. The project is henceforth called the K project.

The use of energy if the firm invests in the K project is given by

$$E^K = \mathrm{ab} - e \qquad \textbf{(21)}$$

where α is an efficiency parameter for the no-regrets project. $\alpha > 1$, which implies that the no-regrets project, K, is a less energy efficient investment than the JI project ($\alpha\beta > \beta$). α is assumed to be common knowledge.

The utility for the potential host firm of investing in K is given by the cost reduction caused by the investment less the disutility of effort and the cost of investment, J^K.

$$U^K = p(E^0 - (\alpha\beta - e)) - J^K - w(e) \tag{22}$$

Maximizing (22) with respect to e gives the optimal effort level characterized by

$$w'(e) = p \tag{23}$$

The emissions and utility levels if the K project is carried out optimally are given by (24) i) and ii) if the firm is efficient, and by (24) iii) and iv) if the firm is inefficient.

$$\begin{aligned}
&i)\quad E_1^K = \alpha\beta_1 - e^K \\
&ii)\; U_1^K = p(E^0 - E_1^K) - J^K - w(e^K) \\
&iii)\; E_2^K = \alpha\beta_2 - e^K \\
&iv)\; U_2^K = p(E^0 - E_2^K) - J^K - w(e^K)
\end{aligned} \tag{24}$$

where e^K is the solution to (23).

K is a no-regrets investment project for firm i if U_i^K given by (24) is positive. If K is a no-regrets project the utility achieved by the investment will be the firm's reservation utility for the JI project offered by the investor. Since $\beta_1 < \beta_2$ it can be seen from (24) that the reservation utility for the efficient firm is higher than for the inefficient firm. If K is not profitable, the investment will not be carried out by the firm. The reservation utility is then equal to the utility achieved by producing with the old technology, which is normalized to zero. Let U^R_i denote the reservation utility of type i. The reservation utilities for the two types are

$$U_i^R = U_i^K \quad if\ U_i^K > 0$$

$$U_i^R = 0 \quad if\ U_i^K \leq 0 \qquad i = 1,2 \tag{25}$$

The individual rationality constraints for the efficient firm (IR_1) and the inefficient firm (IR_2) are, respectively

$$IR_1: \quad U_1^{JI} \geq U_1^R \tag{26}$$

and

$$IR_2: \quad U_2^{JI} \geq U_2^R \tag{27}$$

where U_i^{JI} is the utility achieved by carrying out the JI project described in section 2.
In this situation the usual assumption in the literature of equal reservation utility for the two types of firms is no longer satisfied.

The incentive compatibility constraints for the inefficient firm and efficient firm are, respectively

$$IC_1: \quad U_1^{JI} \geq U_2^{JI} + Q(\beta_2 - E_2) \tag{28}$$

$$IC_2: \quad U_2^{JI} \geq U_1^{JI} - Q(\beta_2 - E_1) \tag{29}$$

Where $$Q(\beta_2 - E_i) \equiv w(\beta_2 - E_i) - w(\beta_2 - E_i - (\beta_2 - \beta_1)) \quad i = 1,2 \tag{30}$$

Recall that the investor is only credited abatement in excess of no-regrets abatement and that β_1, β_2 and α are common knowledge, and hence also known by the control commission. The JI contract and the JI project have to be accepted by the control commission. It is in the interest of the control commission to only credit the investor's country for actual abatement, which is abatement in excess of no-regrets abatement. The control commission will hence only accept two-contract menus where it can learn the efficiency parameter β of the firm by observing the contract selected. By learning the efficiency parameter, the control commission will know the amount of no-regrets abatement it should subtract from the observed abatement. This rules out the possibility that the investor could design a two-contract menu where the IC_1, given by (28), was not satisfied to hide the fact that the host could be an efficient type, and hence achieve more abatement credits than actual abatement.

The investor's optimal JI contract offered to the firm is found by maximizing

$$E[\Pi(E_1^{JI}, E_2^{JI}, U_1, U_2)] = v[-J + (p+t)(E^0 - E_1^{JI}) - t(E^0 - E_1^K) - w(\beta_1 - E_1^{JI}) - U_1] \\ + (1-v)[-J + (p+t)(E^0 - E_2^{JI}) - t(E^0 - E_2^K) - w(\beta_2 - E_2^{JI}) - U_2] \quad \textbf{(31)}$$

subject to the binding constraints in (26) to (29).

The binding constraints in (26) through (29) are determined by the difference in reservation utilities for the two types of firms. In the previous section, the two types had identical reservation utilities. This implied that IR_1, given by (16), was satisfied if IC_1 and IR_2, given by (17) and (12), were satisfied. We could, hence, ignore the individual rationality constraint for the efficient firm in the investor's optimization problem. This is, however, not the case, when the two types of firms have different reservation utilities. If the difference in reservation utilities is large, the IR_1 given by (26) may become binding. This means that the efficient firm will achieve a utility level (U_1^{JI}) equal to its reservation utility U_1^R. Furthermore, the effort required by the inefficient firm will show less deviation from the first-best level than in the contract designed in the case of identical reservation utilities. If the difference in the reservation utilities is sufficiently large the binding constraints are IR_1 and IC_2. In that case the inefficient firm will get a positive informational rent and carries out the project with a first best effort level, while the efficient firm gets no rent and carries out the project with an effort level above the first best. (See Laffont and Tirole (1993), chapter 6, for an analysis of optimal contracts with a type-dependent reservation utility. They define possible regimes characterized by the binding constraints in (26) through (29)). We will, however, in the following assume that IC_1 and IR_2 given by (27) and (29) are the binding constraints. The optimal two-contract menu is then identical to the two-contract menu presented in the previous section characterized by (19), except that the utility of the two types has increased by U_2^R. The optimal two-contract menu is thus characterized by

$$i)\quad w'(\beta_1 - E_1^{JI}) = p + t$$

$$ii)\quad w'(\beta_2 - E_2^{JI}) = p + t - \frac{v}{1-v} \bullet Q'(\beta_2 - E_2^{JI})$$

$$iii)\quad U_1^{JI} = Q(\beta_2 - E_2^{JI}) + U_2^R \qquad \textbf{(32)}$$

$$iv)\quad U_2^{JI} = U_2^R$$

The energy levels specified in the two-contract menu, E_1^{JI} and E_2^{JI}, are identical to the energy levels specified in the two-contract menu offered to the firm in the absence of a no-regrets alternative, given by (19).

The optimal contract will leave both type of firms with a positive rent. The inefficient firm gets a rent equal to its reservation utility. Since we have assumed that IR_1 is not binding, the rent left to the efficient firm is at least as large as its reservation utility (U_1^R). That is, the difference in reservation utilities (U_1^R - U_2^R) does not exceed $Q(\beta_2\text{-}E_2^{JI})$, where E_2^{JI} is given by (32 ii). Hence, the extra rent the investor gives to the efficient firm in order to prevent it from taking the contract designed for the inefficient firm is large enough to make the efficient firm better (or equally well) off by accepting the JI contract than implementing the no-regrets project.

The no-regrets alternative causes a decline in the investor's profit for two reasons. First, the investor receives less abatement credits. The control commission credits the investors for abatement in excess of no-regrets abatement. The abatement credits amount to

$$AC_i = (E^0 - E_i^{JI}) - (E^0 - E_i^K) = E_i^K - E_i^{JI} \qquad \textbf{(33)}$$

where E_i^K is the energy level following from the no-regrets project if it is carried out optimally and E_i^{JI} is the energy level specified in the optimal two-contract menu characterized by (32). Second, the investor has to increase the financial transfer given to the firms by U_2^R, compared to a situation without the no-regrets alternative. The loss in the investor's profit due to the no-regrets alternative is larger if the chosen host is an efficient firm than if it is an inefficient firm. The reason for this is that the increase in financial transfer is identical for both type of firms, but the decline in the abatement credits, due to the no-regrets project, is larger for an efficient firm than for an inefficient firm since $E_1^K < E_2^K$.

4. Impact on CO_2 emissions of a future JI-regime.

A main result from asymmetric information is that the firm that carries out the JI project may get a positive rent. This section discusses the possible adverse effect on CO_2 emissions of leaving a positive rent to the firm. The possibility of being chosen as a host for a JI project, and thus receiving a positive rent in the future, may reduce the incentive to invest in less polluting technology today. Strategic behavior of the potential host firm may therefore have an adverse effect on CO_2 emissions. We will analyze the impact of strategic behavior on emissions in a two-period model. In this section we will assume that there are several investors and potential hosts. Each investor carries out one JI project.

Consider a situation where a country, henceforth called the investing country, commits itself to reach a target for emissions at some time in the future (T). In order to achieve the target, carbon taxes will be imposed on carbon-based fuel use at time T. Users of carbon-based fuels are exempted from the tax on the amount of CO_2 units they abate through JI projects accepted by a control commission. There is a certain number of large users of carbon-based fuels which will invest in JI-projects abroad. The government sets the tax rate so that the emission target is achieved, given the anticipated amount of abatement achieved by JI projects abroad. Another country without a target for its emissions, henceforth called the host country, has accepted to be a host country for JI projects. We assume that there are several potential host firms in the host country. At the time of the investing country's announcement of its future emissions target, there exists an investment option that is profitable (a no-regrets option) for some of the firms in the host country. This investment option will lead to a reduction in the use of energy. If a firm implements the no-regrets investment, it will increase its utility. However, it may reveal its private information on the efficiency parameter to the potential investors through the investment. Hence, by implementing the no-regrets project, the firm may lose the future opportunity to obtain a positive rent due to asymmetric information. The firm faces a trade-off between increased utility, due to the no-regrets investment, and the expected positive rent if it abstains from the no-regrets project.

The timing of the two-period model.

Period 1: From 0 to T.

The first period is the time between the investing country's announcement of the target for CO_2-emissions and the implementation of JI projects. At time 0 the investing country announces their target for emissions and the year (T) their commitments will be met. Each potential host firm in the host country chooses the investment strategy that maximizes its expected discounted utility over the two periods, contingent on the foreseen JI-contract offered for the second period, and the probability of being offered the contract.

Period 2: From T to infinity.

The second period is the lifetime of the JI project. At time T each investor in the investing country makes a bilateral agreement with one firm in the host country. The JI projects are assumed to last to infinity. The control commission observes the hosts' choice of contracts and awards the investors abatement credits.

The JI contract at time T.

We will assume that the potential host firms differ in the efficiency parameter *ex post* of an investment. We will, however, restrict the analysis to the situation where the efficiency parameter, β, takes one out of two values, as described in section 2. At the time of the announcement of the future emissions target there are n+m firms that are suitable as host for JI projects (n efficient firms and m inefficient firms). There exists an investment alternative that is a profitable investment for the efficient firm but unprofitable for the inefficient firms. The reservation utility for the inefficient firm is thus equal to zero. We will, henceforth, interpret the investment project K in the previous section as the annual outcome of the no-regrets project in the two-period model. Consequently it is assumed that the total investment cost of the project is paid by an equal amount (J^K) each year during the lifetime of the project. The no-regrets investment results in an annual energy use (E_1^K) equal to $\alpha\beta_1$-e^K, where e^K is the optimal annual effort level. The efficient firm's *annual* utility of the no-regrets project is thus given by

$$U_1^K = p \bullet (E^0 - (\alpha \bullet \beta_1 - e^K)) - J^K - w(e^K) \qquad \textbf{(34)}$$

where e^K is given by (21), i.e., $w'(e^K) = p$, where p is the price of energy (E).

At time T investors in the country with the binding emissions target seek hosts for JI projects. The investors receive abatement credits only for actual abatement, i.e., abatement in excess of no-regrets abatement. We will in the following assume that the abatement achieved by the no-regrets project, $(E^0\text{-}E_1^K)$, is so large that the investor receives more abatment credits if the project is carried out by an inefficient firm than by an efficient firm. Hence, $AC_1 < AC_2$. AC_1 is the difference between the energy use following from the no-regrets investment and the energy use required in the JI contract designed for the efficient firm, that is, $E_1^K - E_1^{JI}$. AC_2 is the difference between the observed use of energy *ex ante* of any investments and the energy use required in the JI contract designed for the inefficient firm, that is, $E^0 - E_2^{JI}$. The analysis is therefore restricted to the situation where each investors will choose a host firm among the firms that have not carried out the no-regrets project. However, it is throughout the analysis assumed that it is profitable for the investor to carry out the JI project with both types of firms.

As pointed out in section 3, the control commission would only accept JI contracts where the efficiency parameter of the host firm is revealed *ex post*. The investor has to either design a contract that is only accepted by the inefficient firm, or design a two-contract menu where the efficiency parameter of the host is learned by the host's choice of contract.

Since there are several potential host firms, the investor could design a contract that is only accepted by the inefficient firm. If the chosen host was efficient, it would turn the contract down and the investor could choose another firm and offer that firm the same contract. The contract would be accepted when the investor had found an inefficient firm. An efficient firm would therefore never carry out the project, and increased emissions due to the possibility of earning an informational rent in the future would never occur. A contract turned down by an efficient firm must specify a level of energy use that would leave an efficient firm with a rent less than its reservation utility if it took the contract. Hence, the efficient firm's individual rationality constraint (IR_1), given by (26), is not satisfied. The contract has to satisfy the following condition:

$$U_1^K > Q(\beta_2 - E_2) \qquad \textbf{(35)}$$

where $Q(\beta_2\text{-}E_2) \equiv w(e_2)\text{-}w(e_2\text{-}(\beta_2\text{-}\beta_1))$. $Q(\beta_2\text{-}E_2)$ is the informational rent achieved by an efficient firm if it accepts the contract.

We will in the following consider the situation where the value of E_2 that satisfies (35) is so large that the investor prefers to offer the host a two-contract menu. The two-contract menu offered to the potential hosts is characterized by (32). Each investor offers the contract to one of the potential hosts chosen at random. If the host is efficient it gets a positive informational rent and carries out the project with an optimal effort level. If the chosen firm is inefficient it exerts an effort level below the first-best and it receives no rent.

The potential host's optimal investment strategy at time 0.

Each potential host chooses the investment strategy that maximizes its expected utility over both periods at time 0. An inefficient firm will never carry out the alternative investment project K, since it is unprofitable ($U_2^K < 0$). Hence, we will only consider the investment decision for the efficient firms. It is assumed that the total number of potential host firms and the number of efficient firms at the time of the announcement of the emission target (at time 0) are known to all investors and potential hosts. Furthermore, the number of firms that implement the no-regrets investment in the first period is observed by all agents. This implies that the number of efficient firms at time T is common knowledge.

In order to examine the investment decision we will consider the decision of one arbitrary chosen efficient firm. The firm knows that if it invests in the first period it has revealed its efficiency parameter and will never be chosen as a host in the second period. If it abstains from investing in the first period there is a probability of being chosen as a host and receive the informational rent in the second period. If the firm is not chosen as a host at time T, the best it can do is to implement the no-regrets investment.

If the firm invests in the no-regrets project at time 0 the discounted utility of this investment, denoted I_1^K, over the two periods is given by

$$I_1^K = \int_0^{\infty} e^{-rt} \bullet U_1^K \, dt = \frac{1}{r} \bullet U_1^K \qquad \textbf{(36)}$$

where r is the discount rate and U_1^K is the annual utility of the no-regrets project given by (34).

If the firm chooses to abstain from the no-regrets investment, the firm has a possibility of being chosen as a host at time T and earn the positive informational rent each year in the second period. If the firm is not chosen as a host it will invest in the no-regrets project and achieve U_1^K each year. The probability of being chosen as a host will be dependent on the number of potential hosts and investors (JI-projects) at time T. The more efficient firms (n) that choose to invest in the first period the higher the probability of the firm being chosen as a host at time T. Let π be the probability of being chosen as a host at time T. π is given by

$$p = \frac{S}{n(1-q)+m} \qquad \textbf{(37)}$$

where q is the share of efficient firms which have invested in the first period and S is the number of JI-projects in the second period. The denominator is hence the number of potential hosts (efficient + inefficient) in the second period. π is increasing in the share of efficient firms which have implemented the no-regrets investment at time 0. Furthermore, as pointed out in first section, the informational rent left to an efficient firm when carrying out the JI project is dependent on the investor's probability of choosing an efficient firm. The informational rent is higher the lower the probability of choosing an efficient firm.

The probability of picking an efficient firm, v, is a decreasing function of q, given by

$$v(q) = \frac{n(1-q)}{n(1-q)+m} \qquad \textbf{(38)}$$

The expected utility of abstaining from implementing the no-regrets project for the firm, denoted EI_1^a, is given by

$$EI_1^a = \frac{1}{r} \bullet e^{-rT} \left[\pi(q) U_1^{JI*}(v(q)) + (1-\pi(q)) U_1^K \right] \qquad \textbf{(39)}$$

where $U_1^{JI}*(v(q))$ is the (reduced-form) rent left to the efficient firm in the optimal two-contract menu, given by (32), when the share of efficient firms that invest is q.

It is optimal for the firm to invest in the no-regrets project at time 0 if the utility of investing, I_1^K, exceeds or is equal to the expected utility of abstaining from the no-regrets investment, EI_1^a. The investment criterion is hence invest in the no-regrets project if and only if

$$I_1^K \geq EI_1^a \qquad \textbf{(40)}$$

Inserting from (36) and (39), the investment criterion (40) can be rewritten to

$$U_1^K \geq \frac{e^{-rT}\pi(q)}{(1 - e^{-rT} + e^{-rT}\pi(q))} \bullet U_1^{JI*}(v(q)) \qquad \textbf{(41)}$$

Since all efficient firms are identical, the investment criterion is identical for all efficient firms. It follows from (41) that the share of efficient firms that invest in the first period (q) is endogenous, determined by the investment criteria. U_1^K is a constant while the right hand side of (41) is increasing in q since $\pi'(q) > 0$, $v'(q) < 0$ and $U_1^{JI}*(v(q))$ is decreasing in v. Hence, the larger the share of firms that invest in the no-regrets project, the higher the expected utility of abstaining from the no-regrets investment.

The investment criterion leads to three different possible situations for the Nash equilibrium share of efficient firms that invest in the first period, denoted q*.

1) q* = 1. All efficient firms invest in the no-regrets project in the first period (at time 0). This is the Nash equilibrium if the utility of investing in the no-regrets project (U_1^K) is so large that (41) is satisfied for q = 1.

2) q* = 0. None of the efficient firms invest in the no-regrets project in the first period. This is the Nash equilibrium if U_1^K is so small that (41) is not satisfied for q = 0 .

3) 0 < q* < 1. Some of the efficient firms invest in the no-regrets investment in the first period and some abstain from the investment. The Nash equilibrium share of efficient firms which invest, is the value of q that makes the right hand side of (41) equal to U_1^K. The equilibrium share of efficient firms that invest is therefore larger the higher the value of U_1^K.

If 0 < q*< 1 there are several Nash equilibria, characterized by *which* of the efficient firms that invest in the no-regrets project. However, in all Nash equilibria, the *share* of efficient firms that invest equals q*.

To see why q* is a Nash equilibrium share, consider a situation where $q < q^*$, that is, the left hand side of (41) exceeds the right hand side. The efficient firms now get a higher utility by investing in the no-regrets project than by abstaining from the investment. If more firms invest, that is, q increases, the right hand side of (41) will increase. If a share of q* firms have invested, the expected utility of abstaining from investment equals the expected utility of implementing the no-regrets project. When q equals q* none of the efficient firms could increase their expected utility by reversing their investment decision. $q > q^*$ can not be an equilibrium, since this implies that the expected utility of abstaining from the no-regrets investment exceeds the utility of implementing the no-regrets investment (the right hand side of equation (41) exceeds the left hand side). The firms that have invested in the no-regrets project would thus increase their expected utility if they could reverse their investment decision.

The impact on CO_2 emissions of a JI-regime.

If the potential host firms act strategically, as in the model above, a JI-regime could cause an increase in CO_2-emissions from the host country *relative* to the situation without a JI-regime. In a situation without a JI-regime, the country with a binding emissions target would meet the target by domestic measures only. The potential host firms in the host country would thus lose the opportunity of earning an informational rent in the future. Hence, all the efficient firms would carry out the no-regrets project at time 0.

In a JI-regime the efficient firms in the host country may postpone the no-regrets investment until the time when the hosts of the JI-projects are chosen (T). If q* (the Nash equilibrium share of efficient firms that invest in the no-regrets project) is less than one, the JI-regime will cause higher emissions of CO_2 in the host country in the first period than in the absence of a JI-regime. The increase in CO_2 emissions in the host country due to a JI-regime, denoted dG, is given by

$$dG = T\, n(1 - q^*)(E^0 - E_1^K) \qquad \textbf{(42)}$$

dG is higher the smaller the share of efficient firm that carries out the no-regrets project in the first period. The time lag between the announcement of the emissions target and the implementation of the JI projects, (T), affects the CO_2 emissions in different directions. A lower T means that the investment is postponed for fewer years. This incurs, other things being equal, a lower emissions increase. However, a lower T, will reduce the incentive to implement the no-regrets investment. A lower T increases e^{-rT} and hence the expected discounted utility of abstaining from the no-regrets investment. A lower T will therefore cause an increase in the share of efficient firms which abstain from no-regrets investments. The impact on global emissions of the value of T and of the number of efficient and inefficient hosts at time 0, is further studied in a numerical illustration in the next section.

In the model presented above, a JI-regime will not cause any increase in emissions in the second period, since the control commission only awards credits for abatement in excess of no-regrets abatement. Furthermore, all efficient firms will implement the no-regrets projects in the second period if they are not chosen as host for a JI project.

5. Numerical illustration.

This section gives a numerical illustration of the model presented in the previous section. The numerical values of the parameters and exogenous variables of the model are given in table I.

Table I. Numerical values

parameter	Description	Values
β_1	Efficiency parameter (efficient firm)	150
β_2	Efficiency parameter (inefficient firm)	170
α	Efficiency parameter for the no-regrets project	1.25
J^{JI}	Investment cost for the JI-project	15000
J^K	Investment cost for the no-regrets project	2000
p	Price of energy per CO_2 -unit	150
t	CO_2 - tax in the investing country per unit of CO_2	300
w(e)	Disutility function	$2e^2$
E^0	Energy use ex post of investment (CO_2-units)	200
S	Number of investors/number of JI-projects	10
r	Discount rate	0.5

The full information solution to the problem, as described in (9), requires an effort level of 113 from both type of firms. The efficient firm uses 38 CO_2 units of energy and the inefficient firm uses 58 CO_2 units of energy *ex post* of the investment. Due to asymmetric information the investor reduces the effort level required from the inefficient firm and leave the efficient firm with a positive rent given by (19). The effort level requested from the inefficient firm, and hence the rent left to the efficient firm, is dependent on the investors' probability of choosing an efficient firm at time T. In this section we illustrate how the probability of choosing an efficient firm at time T will vary with T and the number of efficient (n) and inefficient (m) firms. These variables will affect the share of efficient firms that invest at time 0 and therefore the probability of choosing an efficient firm at time T. Furthermore T and m affect the increase in CO_2 emissions from the host country due to strategic behavior among the potential host firms.

We see from (42) that the increase in CO_2 emissions depends on the share of efficient firms that abstain from carrying out the no-regrets option and the number of years they postpone the investment (T). A higher T means that the expected utility of abstaining from the no-regrets project has decreased. Hence, the higher T, the fewer firms abstain from the investment, but those who abstain postpone the investment for more years. Table II shows how the increase in emissions of CO_2 from the host country, due to strategic behavior, varies with T. Table III shows how the number of efficient and inefficient firms affect the emissions increase.

Given the values from table I, the Nash equilibrium share of efficient firms that invest in the no-regrets project in the first period (q*) is equal to zero for $T \leq 4.3$. The maximum amount of emissions increase (dG) occurs for T equal to 4.3. If T is higher than 4.3, dG decreases in T. If T is larger than 10.4 all efficient firms invest in the no-regrets project in the first period and dG is hence equal to zero.

Table II. The impact on some of the endogenous variables of different values of T. (n=30 and m=30)

T	4	4.3	5	6	8	10.4
q*	0.0	0.0	0.17	0.39	0.72	1.0
v(q*)	0.5	0.5	0.45	0.38	0.22	0
e_2	93	93	96	100	107	113
dG	6000	6515	6210	5477	3332	0

Table III. The impact of differences in number of potential hosts (n+m) and the number of efficient potential hosts (n) at time 0. T = 6.

m n	25 25	35 25	25 35	35 35	45 35	55 35
q*	0.20	0.36	0.42	0.55	0.71	0.92
v(q*)	0.45	0.31	0.44	0.31	0.18	0.04
e_2	97	103	97	103	108	112
dG	6000	4766	6000	4766	2963	827

An increase in the number of efficient firms has no impact on the global emissions increase. The equilibrium number of efficient firms that abstain from investment, n(1-q*), is independent of n, that is, $\delta q^*/\delta n$ = 1-q*/n, where q* is the value of q that makes the right hand side of (41) equal to U_1^K. It thus follows from (42) that $\delta dG/\delta n$ is equal to zero.

An increase in the number of inefficient firms has two opposite effects on the increase in emissions (dG), where dG is given by (42). It can be seen from (38) that a larger number of inefficient firms will *cet. par.* decrease the investors' probability of picking an efficient firm (v). A lower v implies an increase in the informational rent $U^{JI}(e_2(v))$. It is thus more beneficial for the efficient firms to abstain from investing in the no-regrets project. On the other hand, a larger number of inefficient firms will cause a decline in the potential hosts' probability of being chosen as a host in the second period, given by equation (37). This will make it less beneficial to abstain from investing in the no-regrets project. The first effect causes *cet. par.* a smaller q* and thus a larger dG, while the latter effect causes *cet. par.* a larger q* and thus a smaller dG. The latter effect dominates the first effect in the calculations presented in table III.

6. Concluding remarks.

This paper has analyzed the impact of asymmetric information on the design of a JI contract, and how strategic behavior among potential hosts may lead to an increase in CO_2 emissions. The starting point of the analysis is that a country has a binding target for its emissions that could be partly offset by abatement abroad. We have analyzed JI contracts between one investor and one host firm. The efficiency parameter *ex post* of an investment was private knowledge to the firm *ex ante* of the investment, and the effort exerted during the project period was unobservable for the investor. We restricted the analysis to a situation where the efficiency parameter *ex post* could only take two different values. In the first section we analyzed the impact on the JI contract of asymmetric information when there was only one investment option. The general result from the theory was derived: asymmetric information causes to low effort and no rent for the inefficient firm, and first best effort level and a positive rent to the efficient firm. Asymmetric information hence reduces the cost-savings potential of JI. However, a JI option could significantly reduce the cost of achieving a target compared to domestic measures. Furthermore, the possibility of earning a positive rent due to asymmetric information is beneficial for the hosts.

In section 3 we analyzed the impact on JI contracts in the case of a no-regrets investment alternative. A no-regrets investment alternative may lead to different reservation utilities for the two types of firms. If the difference in reservation utilities is not too large, the effort levels specified in the optimal two-contract menu is unaffected by the no-regrets alternative. The investor's profit of carrying out the JI project will, however, decrease.

A possible adverse effect on CO_2 emissions of asymmetric information occurs for two reasons. First, a reduction in the cost saving potential gives the countries that have a binding emission target less incentive to set high targets for their abatement. Second, the positive rent left to the firms due to asymmetric information give the potential host firms incentive to abstain from implementing less polluting technology.

In the fourth section we examined the impact on CO_2 emissions due to strategic behavior among potential hosts. We assumed that there are several potential host firms and investors. Each investor offered a JI contract to one firm. An increase in global emissions occurs if some potential firms abstain from implementing a no-regrets project because of the possible informational rent they can earn if they are chosen to carry out a JI project in the future.

The increase in CO_2 emissions due to strategic behavior is *inter alia* dependent on the number of potential hosts relative to investors. More potential hosts reduce each firm's probability of being chosen as a host for a JI project in the future, and hence make it less profitable to abstain from investing in less polluting technology today. A JI-regime which involves a large number of host countries, and hence more potential host firms, would reduce the possible adverse effect on CO_2 emissions due to strategic behavior.

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