WPS4131

Will Markets Direct Investments under the Kyoto Protocol?

Donald F. Larson and Gunnar Breustedt[1]

Abstract

Under the Kyoto Protocol, countries can meet treaty obligations by investing in projects that reduce or sequester greenhouse gases elsewhere. Prior to ratification, treaty participants agreed to launch country-based pilot projects, referred to collectively as Activities Implemented Jointly (AIJ), to test novel aspects of the project-related provisions. Relying on a ten-year history of projects, we investigate the determinants of AIJ investment. Our findings suggest that national political objectives and possibly deeper cultural ties influenced project selection. This characterization differs from the market-based assumptions that underlie well-known estimates of cost-savings related to the Protocol's flexibility mechanisms. We conclude that if approaches developed under the AIJ programs to approve projects are retained, benefits from Kyoto's flexibility provisions will be less than those widely anticipated.

Keywords: greenhouse gas; joint implementation; Kyoto Protocol, selection model.

JEL classifications: C34, D72, F35, F37, P16, Q58

World Bank Policy Research Working Paper 4131, February 2007

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the view of the World Bank, its Executive Directors, or the countries they represent. Policy Research Working Papers are available online at http://econ.worldbank.org.

[1] Donald F. Larson is with the Development Research Group at the World Bank. Gunnar Breustedt is with the Department of Agricultural Economics, University of Kiel.

1. Introduction

The strategy to limit greenhouse gas emissions laid out in the Kyoto Protocol relies on a set of novel market-based flexibility provisions intended to mobilize private foreign investment through market incentives. This is important since the scale of investment required to significantly reduce emissions precludes governments acting alone (Vrolijk, 2000). Further, the flexibility provisions are expected to greatly reduce treaty implementation costs by allowing countries to meet national treaty-bound emission limits by investing in projects in developing or transition economies that reduce global emissions at lower cost.[2] Global markets are envisioned, since the flexibility provisions permit trade in surplus allowances and credits generated through project investments.

In practice, the degree to which any particular investment activity generates credits toward treaty obligations depends on counter-factual baselines and other unprecedented features of the Protocol. Moreover, although the treaty provides guiding principals for implementation, the rules by which projects are initiated and performance is evaluated are left largely to treaty participants. Consequently, the decision to invest in Kyoto projects depends significantly on the heterogeneous institutions established in host and investor countries and on emerging conventions and standards among countries.

During debate on early drafts of the Protocol, treaty negotiators recognized that there was a limited understanding of how proposed investment provisions might work in practice. To gain experience, participants in the United Nations Framework Convention on Climate Change (UNFCCC) agreed to set up national pilot programs and agreed to report results from the pilots in a standard way. The national pilots, collectively referred to as Activities Implemented Jointly (AIJ), provide the most significant source of available experience on projects intended to offset greenhouse gas emissions.

In this paper, we make use of outcomes from the AIJ pilots to draw inferences about how project investments might be determined under the investment provisions of the ratified Kyoto Protocol. Of particular interest are the rules and procedures for reviewing, approving and monitoring projects that grew up under the national pilots. Descriptive studies discussed later in the paper suggest that these processes provided opportunities for additional, sometimes unrelated, national political objectives to influence project selection. This differs from the

[2] Jacoby, Prinn and Schmalensee (1998) and McKibbin and Wilcoxen (2002) provide general discussions of the economics of regulating greenhouse gases.

conceptual depiction of Kyoto-related institutions as impartial regulators of project quality and suggests that the institutional arrangements that gave rise to AIJ investments outcomes are not fully consistent with the competitive market outcomes that are anticipated from the flexibility provisions of the Kyoto agreement.

Specifically, we test whether project investments under the national AIJ programs were independent of the types of political considerations that motivate traditional models of development assistance. The distinction is important because, under the Kyoto Protocol, countries retain discretion in establishing domestic implementation rules. Moreover, because the national pilots were undertaken to build experience relevant for treaty implementation, countries may be inclined to retain institutions built up during the pilots. If so, and if these institutions work to constrain investment choice, gains from the proposed flexibility mechanisms will be reduced. The characterization of an approval process filtered by an additional layering of political selection is also at odds with the least-cost assumptions that underlie most quantitative estimates of benefits related to the Protocol's flexibility mechanisms. Potentially, most efforts to value the economic effects of the Protocol are based on a flawed view of how the implemented treaty might work.

The remainder of the paper is organized in the following way. Section 2 contains background information on the origins of the AIJ program; section 3 reviews studies concerning the motivations for investing in AIJ projects. A conceptual model of the investment decision process and a derived applied model are given in Section 4. In Section 5, we discuss the data that used to estimate the model. Estimates of the applied model are presented in section 6 and related alternatives are considered in section 7. Section 8 concludes.

2. Origins of the AIJ Program

Motivation for a treaty limiting greenhouse gas emissions stems from evidence that the global climate is warming and the strengthening suspicion that human activity is a significant contributing factor. The mechanism for this contribution relates to the greenhouse effect. Briefly, as the earth constantly receives energy from the sun and radiates energy back into space, water vapor, clouds and long-lived gases, including carbon dioxide, work to reduce the outflow of radiated light, creating an energy imbalance known as the greenhouse effect. In 1861, John Tyndall speculated that the accumulated release of carbon dioxide from combustible fossil fuels might increase the energy imbalance, resulting in a warming of the earth's surface. Later, the

Swedish physicist, Svante Arrhenius (1896) provided a formal model of the phenomenon. Arrhenius predicted a gradual warming of the climate, but did not view the consequences as threatening. The concept was revived and given urgency in a paper by Revelle and Suess (1957) that stressed the potential risks and uncertainties associated with a continuing buildup of greenhouse gases. Subsequently, a series of debates in the scientific community led to political concerns, resulting in a 1989 UN resolution that initiated the process of negotiating an international treaty to protect the global climate by limiting greenhouse gas emissions. The framework for doing so was eventually established by the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) in December 1997; the Protocol entered into force in February 2005.[3]

The cost of reducing emissions varies greatly among countries, though the effects of greenhouse gas emissions on climate change are uniform regardless of where the gases are emitted. Early drafts of the treaty soon settled on restricting the richest countries to historical emission levels as the primary mechanisms for limiting emissions, but debate continued on how to control abatement costs.[4] In the course of negotiation, the Government of Norway suggested that a mechanism be introduced to allow partnerships between countries that would achieve emission reductions at lower cost (Carraro, 1999; Dixon and Mintzer, 1999). Broadly, the approach allowed those countries facing emission limits to receive credit for investments made elsewhere that reduce global emissions. The concept came to be known as joint implementation and was subsequently adopted into the treaty negotiating documents (articles 4.2 and 3.3 of the UNFCCC) that are now part of the Protocol.[5]

The notion of solving pollution problems through international cooperation had precedent but key aspects of the climate proposal related to joint implementation were unique.[6] The proposed measures included caps (assigned amounts) on emissions for the richest countries

[3] As of September 2006, 166 countries had ratified the treaty, including 34 Annex I countries that represent about 62% of 1990 emissions.

[4] Early policy discussions centered on whether permitted emission levels should be based on history or whether common ownership rights applied (Bertram, 1992). Proposed approaches included carbon taxes, national quantitative restrictions and tradable quotas. See Whalley and Wigle (1991) for an early quantitative assessment of policies under debate.

[5] The UNFCCC delegates later made more specific the term Joint Implementation. Under current usage, JI refers exclusively to projects hosted in the 36 developed countries and economies in transition listed in Annex I of the Kyoto Protocol. Projects hosted in non-Annex I countries are referred to as Clean Development Mechanism (CDM) projects.

[6] Examples of international cooperative action include the 1976 Convention Concerning the Protection of the Rhine River against Pollution by Chlorides and the 1985 Vienna Convention for the Protection of the Ozone Layer (Hanafi, 1998).

that could be supplemented when jointly implemented projects resulted in certified reductions. Both assigned amounts and newly created offset credits could be traded. The supplemental credits, measured in tons of carbon, were to be calculated by comparing actual project emissions against a hypothetical counterfactual known as a baseline.[7] This framework, based on trade and the opportunity to supplement fixed emission allocations with project-based offsets, evolved into the "flexibility mechanisms" of the Kyoto Protocol.

Delegates, advocates and researchers debated the benefits and costs of a system of tradable emission allowances that were not strictly capped. Delegates worried that weak controls and imprecise baselines might allow countries that had pledged reductions to purchase water-downed credits cheaply from developing countries, thereby attenuating the environmental benefits of the treaty.[8] In addition, delegates from developing countries expressed concern that donor countries would meet emission reduction targets by redirecting existing aid flows to joint implementation projects (Ghosh and Puri, 1994; Parikh, 1995).[9]

At subsequent negotiations in Berlin, delegates agreed that pilot projects could help inform the debate on practical issues surrounding joint implementation. The agreement, known as Decision 5 of the UNFCCC, provided broad guidelines for establishing a voluntary AIJ program that reflected the then-current state of debate. It declared that all AIJ projects should benefit the climate in real measurable ways, that each AIJ project should be agreed upon by host and investor governments, and that any financing from investor-government funds must be additional to planned aid flows -- a condition termed "financial additionality". Moreover, to prevent the stockpiling of projects under lax baselines, the decision explicitly precluded the accrual of credits under AIJ projects. Because of this, emission reductions from AIJ projects cannot be credited against Kyoto obligations, even under the condition that the projects meet eventual standards.

The rules set out in the Decision influenced the expectations and motivations for AIJ projects in standard ways for all participating countries. In addition, participants forged a common reporting standard to record key characteristics of projects implemented under national

[7] See Heister, Karani, Poore, Sinha and Selrod (1999) on early World Bank experiences with baselines.
[8] Gulbrandsen and Andresen (2004) discuss the role played by nongovernmental organizations in this debate.
[9] Grubb, Vrolijk and Brack (1999) provide an account of arguments and concerns related to the flexibility mechanisms voiced by delegates during negotiation of the Protocol. See also criticisms in Cullet and Kameri-Mbote (1998).

AIJ programs.[10] Both features help make comparisons among AIJ projects feasible. Even so, as discussed below, differences among the national programs emerged, giving rise to differing incentives and procedures.

3. Related Studies

In the next section we develop a conceptual model of how project investments came about under the AIJ program. Before doing so, it is useful to briefly review results from studies that discuss theoretical and practical motivations for carbon project investments and the country-specific processes by which AIJ project were approved.

Among related studies, the largest group comprises studies that estimate the potential benefits of the Kyoto Protocol's flexibility mechanisms. Without exception, the studies find that the costs of reaching greenhouse reduction goals are greatly reduced by rules that allowed spatial and temporal flexibility. By way of example, model results by Bernstein, Montgomery and Rutherford (1999) suggest that flexible trading rules could reduce the price of carbon permits – which can be seen as the marginal cost of emission reductions – by a factor of seven in the European Union and by a factor of sixteen in Japan.

Generally, the numeric studies focus on incentives created by differences in average abatement costs among countries and model the resulting demand for permits arising from project investments. Benefit measures are calculated by comparing predictions of market-clearing prices for emission permits under alternative scenarios.[11] Most often, the mechanism by which project investments are approved is not explicitly developed, although in some cases transaction costs are expected to differ according to the types of partnerships formed.[12] Even so, there is an implicit assumption in most studies documenting the benefits of flexibility that project investors will be free to pursue least-cost opportunities.

As experience emerged about project-based investments from pilot programs, a small group of case-based studies examined the self-declared motivations of early private sector

[10] Convention participants assigned an advisory committee, the Subsidiary Body for Scientific and Technological Advice (SBSTA) to establish reporting guidelines and to compile and publish the reports on an on-going basis.

[11] See Nordhaus and Boyer (2000) and Weyant (2004) for reviews of modeling approaches and results, as well as citations in Stevens and Rose (2002). Painuly (2001) reviews numerical models that address project-based investments in developing countries Muller and Mestelman (1998) review related laboratory-based experiments.

[12] See the discussion and references in Woerdman (2001).

participants. [13] This set of analyses includes a study by Michaelowa, Dixon and Abron (1999) that looks at what motivated early AIJ participants; a study by Larson and Parks (1999) that surveys a broad group of early pilot participants about investment rationales; and a discussion of private sector participation in the US AIJ program by Lile, Powell and Toman (1998).

The studies identify a variety of factors motivating early participants, including a desire to influence policy, that are only indirectly linked to market incentives. Nevertheless, the studies also find that many participants anticipated future regulations on greenhouse gas emissions and hoped to position themselves in ways that would prove useful as policies became clear. For some, this meant finding ways to reduce future regulatory costs, while others looked toward opportunities that might arise from new markets for carbon off-sets.

Separate from the issue of what motivated the firms to participate in pilot projects is an examination of the national processes by which proposed investments were approved. Michaelowa, Begg, Parkinson and Dixon (1999) examine the application and approval process for AIJ projects in eleven investor countries.[14] Their description suggests that policy considerations influenced the projects that comprise the AIJ experiment in significant but not exclusive ways. They find that most countries established panels drawing on staff from three to eight ministries with sometimes competing objectives. In addition, six of the eleven study countries explicitly imposed additional criteria to reflect domestic policy goals. Nevertheless, in all cases, non-government participants were able to influence the process, primarily by their decision to submit proposals.

The already cited study by Lile, Powell and Toman examines the approval criteria for projects submitted to the United States Initiative on Joint Implementation (USIJI) Evaluation Panel. The authors report an evaluation process that allowed seven departments and agencies to influence the approval process. Even so, the authors characterize the evaluation process as technical in nature and focused on the development of practical implementation methodology and implementation lessons.

[13] Not all pilot programs fell under the AIJ umbrella and its uniform reporting system. See an early review of pilot schemes in Sonneborn (1999).

[14] The countries are Australia, Belgium, Canada, France, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland, and the United States.

4. A Model of Project Investment

In this section, we build a conceptual model of the AIJ investment process, motivated by the descriptive literature from section 3. The key feature of the conceptual model is that it distinguishes between investments choices that are exclusively motivated by uncertain profits and those that are additionally constrained by an approving agency's preferences. We then specify an applied model used to test predictions of the conceptual model.

4.1. Conceptual Model

As a starting point, consider an irreversible investment in a joint implementation project where the profit flow, $\pi(t)$, associated with an investment I follows the stochastic process:

$$d\pi = \phi(s)\pi_0\, dt + \sigma(s)\pi_0\, dt \qquad 1)$$

where dz is an increment in a Wiener process; and where the growth parameter, ϕ, and the dispersion parameter, σ, depend on exogenous state variables, s. It is assumed that the investment is sufficiently long-lived to be represented by the infinite-horizon value function:

$$v(s_t) = E\int_t^{\infty} \pi_m e^{-\delta(m-t)} dm \qquad 2)$$

where E is the expectations operator, δ is a discount rate and where 2) is conditional on the restriction given in 1). Dixit and Pindyck (1994, 144-45) show that associated with this investment evaluation problem is a critical level, $v^*(s)$, that exceeds the combined present value of the investment and any option value associated with postponing an irreversible investment. In passing, it is important to point out that factors that reduce uncertainty decrease the option value associated with delay. We return to this topic later.

Now suppose that an interested firm considers a fixed number of investment opportunities. By repeating, for each project, the valuation in 2), the firm can match an evaluation, v^i, with each project, I^i. After ranking the projects, the firm will consider that set of projects, $\Omega(s_t)$ where $v(s_t) \geq v^*(s_t)$. The firm may consider additional restrictions, given by vector c.[15] With this in mind, the firm choice problem can then be written as:

[15] For example, the firm may want to limit total investments by sector, by classes of technology or by country because of portfolio risk considerations.

$$Max_I \; P(I;c) \; s.t. \; I \in \Omega(s_t) \qquad 3)$$

where P represents the firm's decision process for evaluating risk and profit.

Next, suppose the firm must also seek approval from an agency that has its own objective function, derived from a set of broad policy objectives, characterized by the vector, $z(t)$. Further, assume that, through a ranking process analogous to the firm's ranking process, the agency derives its own set of desired investments, $\Psi(z_t)$. If the agency only approves investments from its desired set, the choice problem now becomes:

$$Max_I \; P(I;c) \; s.t. \; I \in \{\Omega(s_t) \cap \Psi(z_t)\} \qquad 4)$$

That is, the set of feasible investments is reduced to the subset of investments that the firm desires and that the agency will approve. Designating the solution to 3) as P^* and the solution to 4) as P', it follows that $P^*(s) \geq P'(s,z)$, since the reduction in feasible projects cannot improve the solution to the maximization problem.

4.2. Statistical Model

Given the foregoing discussion, we represent the firm-ranking outcomes with the continuous index, η and represent the unobserved ranking process as a linear function of the state variables that determine the set $\Omega(s)$. For reasons that are discussed later, we identify the projects as a flow from investor country to host country, where i represents the country in which the investing firm resides, and where h represents the country hosting the project. We model the desirability of the firm to invest as a function of the state variables:

$$\eta_{ih}^* = n_0 + \sum_j n_j s_j \qquad 5)$$

where the n are parameters associated with the j state variables. It should be kept in mind that projects are pair-wise groupings, and relevant state variables may be specific to the investor, to the host, or to a relationship between members of the dyad.

The latent relationship given in 5) is not observed, although investment outcomes are. The observed investments rank above the determined critical value so that:

$$\eta_{ih} = 1 \text{ if } \eta_{ih}^* = n_0 + \sum_j n_j s_j > 0 \text{ ; otherwise } \eta_{ih} = 0. \qquad 6)$$

When project investment decisions are not otherwise constrained, equation 6) adequately depicts the representative firm. However, as discussed, investment outcomes are potentially limiteded by authorizing agencies, so a mechanism to take account of this influence needs to be included in the applied model.

As a starting point, we assume the variables that determine the approving agency's preferences, z, relate to broad national policy objectives concerning the relationship between host and investor countries. It is likely that these objectives not only influence the project-ranking process, but are also reflected in many other aspects of bilateral political relationships. One objective indication of preferences is the expenditure of public funds in the form of bilateral aid. Coincidentally, because the classifications of UNFCC participants correspond to classes of economic development (developed countries, transitional economies and developing countries), the possible pair-wise combinations of OECD donors and aid recipients corresponds to the potential flow of investment (from investor to host) anticipated under the AIJ program. Consequently, using bilateral aid as a proxy for unobservable agency preferences is attractive conceptually and practically, and we make use of this in the applied model.

In particular, we assume that governments' ordering of preferences, as revealed in the provision of bilateral aid, correspond to the ranking approving agencies apply as they consider which projects to approve. Therefore, in a way analogous to the firm's preference function, we model the agency's ranking of projects, α, proxied by bilateral aid, as a linear function of the k state variables that determine the set, $\Psi(z)$ and a set of fixed parameters, a. After appending two random error terms, ε_η and ε_α the applied model can therefore be written as the probit:

$$\eta_{ih} = \left(n_0 + \sum_j n_j s_j + \varepsilon_\eta > 0 \right) \text{ subject to } \alpha_{ih} = \left(a_0 + \sum_k a_k z_k + \varepsilon_\alpha > 0 \right) \qquad 7)$$

By assumption, both error-terms are distributed normally, that is, $\varepsilon_\eta \sim N(0,1)$ and $\varepsilon_\alpha \sim N(0,1)$. Potentially, the error terms may also exhibit a non-zero correlation, ρ. Written in this way, the model belongs to a class of selection problem discussed generally by Heckman (1979), and in the probit form by van de Ven and van Pragg (1981).

When agency selection occurs, the choice set is reduced to the intersection of $\Omega(s_t)$ with $\Psi(z)$. As a consequence, we expect to see AIJ investments only when we also observe bilateral aid flows between investor and host; that is, there should be no instances when AIJ investments

take place between countries without bilateral aid flows. Moreover, we also expect to find a non-zero correlation between the two error terms in the statistical model in a way that is consistent with the truncation of potential outcomes. Alternatively, when investment decisions are not subject to agency selection – that is, when firms optimize over $\Omega(s_t)$ -- we expect no correlation between the error terms of the statistical model and any observed correspondence between investment flows and aid flows is attributed to coincidence.

5. Data Description

5.1. AIJ Investments

Our dichotomous measure of AIJ investment is taken from data on AIJ projects reported to the UNFCCC and compiled by the SBSTA. As of February 2002, the UNFCCC reported on 156 projects. Among these, we include in our sample the 147 projects in which a letter of intent was signed with the host country. The projects began between 1992 and 2001 and were distributed among 22 investor countries and 42 host countries (table 1).[16] For our initial analysis we focus on the 65 unique investor-host partnerships that evolved over the study period; that is, for our preferred model we define an investment event as the joint agreement by an investor country and a host country to participate in any number of AIJ projects. We do so for two reasons.

First, this approach is more in keeping with descriptive studies that suggest agency preferences, sometimes tied to national policy objectives, were influential in screening outcomes. The related point of interest then is whether the agency approval hurdle is cleared for any given potential partnership, rather than how frequently it is cleared. Second, and importantly, in the few instances where the number of bilateral projects in a partnership is large, for example between Sweden and Estonia, many projects are replications of a common approach and distinguished primarily by differences among second-tier counterparts.[17] Consequently, it is not clear that giving greater weight to this type of investment adds to the analysis. Even so, it is possible to modify the statistical model to make use of the data in count form and we do so to check that our results are robust. We return to this topic later.

[16] The Bonn Decision, taken in 1995, gave rise to several new national programs. However, the Decision also brought several established programs into the common AIJ framework. Consequently, some projects under the Dutch, Norwegian, Swedish and US programs were negotiated prior to the Bonn decision.

[17] Many of the projects between Sweden and Estonia involved up-grading public heating systems. These projects were organized under a common national framework, although local government counterparts differed among projects.

By any measure, investment partnerships were rare relative to potential partnerships. To see why this is so, consider that when the AIJ program was established, 193 countries participated in the UNFCCC.[18] Implicit in Decision 5 is the expectation that investments would originate from the 24 wealthier Annex II countries.[19] Excluding the Holy See, this makes for 4,032 potential pair-wise combinations. We are constrained by data to consider a subset of countries, although the subset is large. We include 22 investor countries and 136 potential host countries in our study.[20] Consequently, there are 2,992 dyads in our sample. Defining non-events as the 2,927 investor-host combinations for which no AIJ project is observed during the study period, the 65 investment events in the sample are rare relative to the potential pairings and comprise about 2% of the observations.

5.2. State Variables Affecting Investment Choice

To a degree, investments related to Kyoto carbon markets have risk and profit characteristics that are similar to other direct investments by foreign countries in transitional or developing countries; however, credits produced by the project have value because they can be used, potentially, to meet treaty or related regulatory obligations. In turn, this component of value depends critically on the specific institutions that govern their creation and use. Therefore, in our specification of the state variables that determine $\Omega(s)$, we consider two classes of variables.

The first includes general factors that influence the level of profit and the associated risk for all types of investments flowing into host countries. These variables describe a general investment climate and include variables related to policies, expected profitability and a variety of risks.[21] Factors that make up the investment climate are summarized by the ability of countries to attract international investors and we use total foreign direct investment (FDI) as our indicator of the general investment climate. Our measure is calculated by averaging the net inflows of foreign direct investment as a share of GDP reported by the World Bank (2006) over the study period,

[18] The 194 parties to the Convention during the study period include all member countries of the United Nations plus the Cook Islands, the Holy See, and Niue, a former territory of New Zealand and one non-country member, the European Union.

[19] The name Annex II arises from the country-list annexes of the Framework Convention. Annex I contains the list of 36 countries, mostly OECD countries and transitional economies, that initially pledged to limit emissions. Annex II is the subset of wealthier Annex I countries. Prior to ratification, the list of countries capping emission changed and that eventual list of 39 countries is listed in Annex B of the Protocol.

[20] A list of countries included in the study Is given in annex table 1.

[21] See Chakrabarti (2001) for a review of the FDI literature.

1992-2001. Because this measure is an aggregate, it can be observed independently of bilateral investment flows.

The second class of state variables relate to institutions that are more specific to emission trading. All things equal, it is likely that AIJ investing firms preferred to gain experience in host countries where local institutions could lower costs, reduce risk or otherwise give additional value to carbon credit streams flowing from joint implementation projects. Likewise, because investor-country regulations were expected to influence how earned credits could be used, it is also likely that domestic investor-country institutions were important to observed investment outcomes. At the same time, because the AIJ pilots preceded the eventual treaty, investors had to anticipate how future institutions might evolve. In the applied model, we assume that related commitments by governments, extant during the study period, provide an indication of the capacity of host and investor countries to put implementing institutions in place; we use these to proxy investor judgments. We construct commitment indicator variables for investor and host countries based on their participation in five international agreements: the Convention on Biological Diversity, the Montreal Protocol on Substances That Deplete the Ozone Layer, the United Nations Convention on Climate Change and the United Nations Convention on the Law of the Sea. To measure whether environmental issues are a policy priority, we also consider whether a country had an environmental strategy and a biodiversity action plan in place during the study period (World Bank, 2002). To identify countries with relatively strong institutions, we count the cumulative number of years between 1992 and 2001 that the environmental commitments were in place. Host and investor countries were separately ranked according to this cumulative measure and countries falling into the top of three respective quantiles were designated as highly committed to policies consistent with Kyoto objectives.

As discussed in section 4, uncertainty over investment outcomes generates incentive delay otherwise desirable investment. This is especially true of long-lived carbon investment projects that depend especially on government institutions. Consequently, we include in the investment equation measures related to the capacity of host governments to sustain and carry-out processes leading to eventual carbon offset certification. In particular, we include a measure of government efficiency that relates to the quality of services provided by host governments and the political independence of their bureaucracies. We also include a measure of political stability that relates (inversely) to the likelihood that the government will be destabilized or toppled by external or internal violence. The measures used in the study are described in Kaufmann, Kraay and

Mastruzzi (2005).[22] Finally, we also include a dummy variable set to one for Norway, the Netherlands, Sweden and Switzerland, where subsidies were provided to domestic project participants (Michaelowa, Dixon and Abron, 1999). All things equal, the subsidies are expected to have lowered the investment threshold criteria for firms in the four countries.

5.3. State Variables Affecting Agency Choice

As discussed, the applied model considers whether the same factors that determine bilateral aid flows also determine agency rankings of AIJ projects in the applied model -- that is, both aid and agency approval are a function of a set of common state variables, z . Consequently, estimation of the applied model requires both a measure of bilateral aid and measures of the determinants of aid.

For the first measure, we calculate an average value of real bilateral aid for the period 1992 to 2001 for each investor-host dyad. These are based on from pair-wise data on Net Official Development Assistance (ODA) to recipient countries from OECD country members as reported to the Development Assistance Committee (2006). Observations on country pairs are set to zero when no official aid is reported over the study period. For the base model we use a dichotomous measure that indicates whether aid was given during the period. In subsequent analysis we consider a continuous measure.

Specifying the variables determining the bilateral aid component of the applied model is more challenging. Although an extensive literature surrounds the question of why countries provide aid, there is little agreement on how to characterize the determinants. Following Dudley and Montmarquette (1976), most studies start with the assertion that observed aid flows can be explained by donor-country demand for specific outcomes that foreign aid helps to achieve and by recipient country characteristics that determine aid effectiveness. Nevertheless, in practice, applied studies ascribe a wide range of benign and predatory objectives to donor countries.[23] A material consequence has been an expanding list of potential determining factors. For our purposes, we use a selective but representative set of variables meant to capture the following host country characteristics: need, size, hegemony, democratic institutions, civil order and bureaucratic integrity. Other studies using these or similar variables include Frey and Schneider

[22] Because indicators were not available for all study years, averages for 1996, 1998, 2000 and 2002 were used.
[23] See, for example, Pronk (2001), and Petras and Veltmeyer (2002).

(1986), Wall (1995), Alesina and Weder (2002), and Collier and Dollar (2002). In particular, we use the following statistical measures.

We take as our indictor of need, average per capita income for the period, measured in 1995 $US. Because large countries are expected to have strategic importance, average host-country population is included. Motivated by the presumption that donor countries want to influence the policies of neighbors and important trade partners, we include two fixed effects: one based on proximity and a second to indicate that the host and investor country have entered into bilateral or regional trade agreements.[24] Because most donors have voiced support for democratic principles, we include an indicator of the openness and accountability of host governments to their citizens, referred to in the tables as "voice and accountability". Poorly performing bureaucracies and corruption are expected to diminish the efficacy of aid and discourage donor support. To capture this we include measures to indicate host countries with bureaucracies of above-average quality (government effectiveness) and where public and private sectors levels of corruption are below average (corruption). Political instability due to external or internal violence and armed conflict is expected to diminish the effectiveness of aid and we include this measure in our selection equation. At the same time, donors may also take a lack of civil order as an additional measure of need so that relationship between aid and civil order is ambiguous. The measures on income and population are averages for 1992-2001 (World Bank, 2006). The trade agreement and proximity variables are constructed. The institutional measures are described in Kaufmann, Kraay and Mastruzi (2005).

6. Empirical Results

A simple prediction of the conceptual model is that, because donor-country agencies prefer projects that help achieve national policy objectives that are also pursued through bilateral aid, AIJ projects will be observed together with bilateral aid flows. At the same time, because firms are motivated to invest for separate reasons, not all countries receiving aid are expected to host projects. Among the 2,992 investor-host relationships in our sample, this simple prediction holds over study period averages. (See table 2.) Moreover, in all but five of the 147 AIJ projects, bilateral aid was given during the year that the project was launched.[25] Even so, it is possible that

[24] A dummy variable was set to one for investor-host dyads when both countries were members of the Commonwealth, ASEAN or NAFTA and for dyads containing an EU investor-country and a host country participating in the Phare program.

[25] See annex table 2 for more detail.

the observed pattern is incidental, especially since bilateral investor-host relationships are rare in the data while bilateral aid relationships are not. Consequently, as a first step in our analysis, we impose on the data the selection model described in section 4, which provides a statistical description of the selection and investment process.

Selection model

Estimation results for the applied model developed in section 4 are given in table 3.[26] Overall, expecations based on the conceptual and applied models hold. The estimated parameters of both the investment and selection equations of the model are statistically significant for the most part and take the anticipated sign. Moreover, an expected correlation between the two equations is found that is statistically significant. A related Wald test, reported in the last row of table 3, suggests that the two equations are not independent.

Results from the investment equation suggest that both investor and host country policies matter. The willingness of investor countries to offer subsidies and the commitment of investor countries to international environmental agreements are both significant determinants of predicted AIJ investments. Countries that put in place an attractive investment climate and share investor-country commitment to international environmental agreements are more likely to host AIJ investments, according to the estimation results. Countries that rank high in terms of political stability are also more likely to host AIJ investments. Government effectiveness is positively associated with AIJ investment flows, but not in a statistically significant way.

Turning to the determinants of bilateral aid, the results suggest that need plays a role, with the probability of aid increasing as per capita income falls. Country size matters as do trade ties and proximity. Among the institutional measures, political stability and institutions that tend to expand political participation are positively and significantly related to expanded aid flows. Less stable governments were able to attract more bilateral aid, all things being equal, as were governments that scored poorly on indicators of corruption.[27]

The marginal effects of the investment determinants of are given in table 4. These are calculated at mean values; marginal effects for dichotomous variables are calculated from discrete changes. Generally, the probability changes are small in an absolute sense, although they are

[26] For the estimates given in table 3, potential heterogeneity in the investment error term is accounted for by including information on the project count for each investor-host dyad. However the related adjustment to the estimated standard errors is not crucial for the reported parameter tests. See annex table 3.

[27] Other studies also find no evidence that corruption stalls aid flows. See especially Alesina and Weder (2002).

significant relative to the five percent predicted probability of investment. The results indicate that the marginal effects of several investor and host attributes are of similar scale. Strong commitment to international environmental treaties and policies resulted in a two to three percent increase in predicted investment among potential partners. Surprisingly, the ability to attract direct investment generally had a quantitatively small effect on investment, even though the underlying parameter was statistically significant. More important was the related measure of political stability, which generated the largest marginal effect.

7. Alternative Estimates

7.1. Count data

In this section we take up the question of whether results reported earlier depend significantly on our decision to view investment events as dichotomously measured partnerships. As an alternative, we consider the number of projects observed or project counts with the consequence that our applied models are expected to relate to different probability distributions.[28] In a way that is analogous to our earlier analysis, it is possible to test whether the observed pattern of project counts is an outcome that is statistically unlikely and related to bilateral aid in the context of these alternative distributions.

As a first step, we consider a mixed regime model. In this model, the probability of an event characterized by the set of investment determinants alone is compared to a mixed regime model in which the probability of project investment is decreased by an additional process. In particular, we estimate two zero-inflated models in order to test whether the mixed-regime model given in 4) can be set aside in favor of a standard Poisson or negative binomial regression consistent with 3). In contrast to selection models, it is possible, in the context of the mixed regime models, to test directly whether the probability of an investment is impinged upon by an additional process related to bilateral aid. Following Greene (1994), we used Vuong's (1989) non-nested test to make this determination. The test results, given in table 5, suggest that the mixed regime models better explain the project count data than do either the Poisson or the negative

[28] As discussed, investment relationships are rare in our data. Moreover, when relationships are observed, the number of investment projects is generally low. Both characteristics are suggestive of the Poisson and negative binomial distributions, which are associated with many forms of count data.

binomial regression model alone.[29] We take this as evidence that the AIJ investment process was influenced by the same factors that describe bilateral aid flows.

Though the mixed regime models are conceptually similar to selection models, there are differences related to how errors associated with the two processes are specified. With this in mind, we estimate an alternative model which retains the same probit selection structure as in the dichotomous model, but which uses a heterogeneous Poisson component, consistent with count data, for the investment equation (Greene 1997). Key estimation results are given in table 6.

In general, the results from the count-based model are consistent with the dichotomous model discussed earlier. The estimated correlation between the Poisson and selection equations is statistically significant, suggested that the two components of the model are not independent. Because the model has been recast in terms of the project count data, the parameters associated with the investment equation take on a different scale. Even so, for the most part, variables that were statistically significant determinants of investment outcomes in the dichotomous model are significant for the count model as well and take on the same signs. The single exception is the subsidy variable, which remains positively associated with investments but not statistically so.

The bilateral aid selection equation remains in probit form and consequently, the parameters retain the same scale. Generally, the estimated parameters coincide with the estimates from the dichotomous model, with the exception of the corruption measure, which is no longer statistically different from zero.

7.2. An alternative model of transaction costs

Evidence from the previous sections suggests that the selection models, motivated by descriptions of AIJ approval procedures, are consistent with the data. Moreover, in the case of the zero-inflated count models, the role of determinants associated with bilateral aid in reducing AIJ investment is tested and found to be significant. Generally however, selection is asserted in the estimated models rather than directly tested.[30] In this section, we develop a related model that does not necessarily imply selection. The model is motivated by evidence of high transaction costs in related markets and potentially provides an alternative explanation for observed investment flows. Later, we discuss the implications of this alternative explanation for policy.

[29] Detailed estimation results are given in annex table 4.
[30] Heckman (1979) discusses this general point.

In particular, we consider the role transaction costs play in emerging tradable permit markets. Broadly, transaction costs are expected to be present in most economic transactions and a key characteristic of developed economies are the multiple institutions that reduce transaction costs and related performance risk (North, 1987). This holds true especially for emission trading systems, where costs and uncertainties associated with finding reliable partners and gaining regulatory approval can be high. Stavins (1995), for one, argues that market-based regulatory approaches are often less cost-effective than anticipated because of transaction costs of varying kinds. In addition, there is evidence, primarily from the United States, that the success of tradable permit approaches depends significantly on containing transaction costs.[31]

For many reasons, transaction costs were likely high for AIJ projects. The national pilot programs were experimental in nature so that many of the practical problems of establishing partnerships, negotiating outcomes and establishing contracts had to be solved without prior experience or recognized conventions. Moreover, because agreement on Kyoto's flexibility mechanisms had not been reached, there were limited incentives to build up public institutions that might reduce such costs.

The implications of high transaction on AIJ and Kyoto project markets are related to studies showing that bilateral ties related to language, culture and history can significantly affect private investment choices and also bilateral aid flows (Kogut and Singh, 1988). Consequently, it may be that observed patterns of AIJ pilot investment reflect the joint consequences of deep-seated bilateral relationships that reduce project transaction costs and encourage flows of bilateral aid. This may be reflected in the implied preferences of agencies charged with approving AIJ projects, but may also be linked more fundamentally in private transaction costs as well.

How this influences the statistical model depends on the mechanism by which cultural ties affect costs. If, because of their effect on transaction costs, an absence of traditional bilateral ties works to eliminate otherwise desirable investments, the selection model still applies, although the role of aid takes on an alternative interpretation. In this instance, any limiting actions taken by approving agencies reflects the effects of latent long-lived cultural ties, for which bilateral aid serves as a convenient instrument. Alternatively, it may be that the role culture plays in determining investment is less crucial and can be considered as one of several factors determining

[31] See Cason and Gangadharan (2003) and references therein.

profitability. This is the approach taken in studies focusing on the composition of foreign direct investment.

Asserting that investment is feasible, even when bilateral ties are absent, greatly simplifies the statistical model. Statistical difficulties related to selection can be set aside and a simple dichotomous model can be defined in which the same set of determinants used to represent s in the earlier analysis are expanded to include bilateral aid as a proxy for bilateral ties. However, as a practical matter, the absence of bilateral aid predicts perfectly the absence of joint implementation in the current data. It is therefore necessary to redefine the bilateral aid variable in a way that distinguishes among varying levels of strength in bilateral ties. We do this by ranking the investor-host dyads where aid flows are observed by the average share of each donor's total ODA budget. We subsequently sort the dyads into three quantiles. Those countries that fall into the top quantile – that is, those countries that receive disproportionate shares of a particular donor's bilateral aid – are considered to have the strongest bilateral ties.

Because the bilateral components of transaction costs are expected to be deep-seated and long-standing, we treat the relationship between culture and transaction costs as recursive in the statistical model with the consequence that regression methods can be employed. However, one additional complication remains for the recursive statistical model. This has to do with the finding that standard regression approaches can underestimate the probability of an investment event when observed events are rare. For this reason, we make use of a logistic regression approach suggested by King and Zeng (2001) that adjusts for rare-event bias. For comparison purposes, we also report results from a standard probit regression. As with the earlier model, the number of bilateral AIJ projects is used to account for heterogeneity in the residuals of both models.

Results from this exercise are given in table 7. The statistical significance of the estimated parameters of the two models are similar and largely correspond to levels of significance found for the investment equation parameters in table 3. The notable exception is the investment climate parameter which is no longer significant in the recursive models. The added parameter on the bilateral aid, which in this case represents cultural ties that reduce transaction costs, is significant for both the probit and corrected logistic regression models.

Since the two models are derived from different distributional assumptions, the values of the parameters cannot be directly compared; however, estimates from both models can be used to analyze the marginal effects of changes in the investment determinants on the probability of

investment. For the dichotomous determinants in both models, the marginal effects presented in the table correspond to changes in the AIJ investment probability for a discrete (zero to one) change in the corresponding determinant. For the probit model, average marginal probabilities are calculated around the variable means. For the logistic model, reported marginal effects are based on first-difference estimates (assignable probabilities) from stochastic simulations around the 25th and 75th percentile value of the continuous determinants.[32]

Despite potential differences due to how marginal effects are calculated and biases related to a prevalence of non-events in the data, the estimated marginal probabilities from the two recursive models are similar. The marginal probabilities in table 7 are slightly lower than those in table 4. Determinants that are estimated to improve investment probabilities by two to three percent in the selection model are estimated to improve investment probabilities by one to two percent in the recursive models. At the same time, strong bilateral ties, as reflected by a larger share of ODA flows, increase the probability of investment by roughly 2.4 percent in the recursive models.

8. Conclusions

Case studies describe approval processes under the AIJ pilots that allowed general national policy objectives to influence project investment outcomes. Our findings are consistent with this characterization and suggest, more specifically, that AIJ investments were partly determined by the same factors that determined bilateral aid. Quantitative evidence supporting this conclusion is robust and holds up under a series of alternative specifications.

As discussed, often-used conceptual models of how markets might work under an implemented Kyoto Protocol are not fully consistent with this depiction of how investments were determined under the AIJ pilots. Further, if the institutional arrangements built up to approve projects under the national pilots are maintained as the Kyoto Protocol is implemented, our findings suggest that the pool of feasible investment projects will be constrained and the potential benefits of the flexibility mechanisms reduced. In a related way, our findings suggest that the national institutions built to approve AIJ projects are inconsistent with the prevalent least-cost models of greenhouse gas abatement used to predict the benefits of the Kyoto Protocol's flexibility mechanisms. Consequently, if AIJ institutions are adopted without modification under the Kyoto Protocol, investment outcomes will differ from those generally anticipated.

[32] See Tomz, King and Zeng (1999).

A more nuanced interpretation of the link between aid and investment is that the selection process reflected in the described behavior of agencies charged with reviewing and approving projects under AIJ is related to a deeper set of bilateral ties that reduce otherwise insurmountable transaction costs. The selection model results are consistent with this interpretation, as are estimates from alternative recursive models. Moreover, since projects without agency approval are not observed, it is impossible to distinguish between the two interpretations. For policy, this distinction is substantive, since it implies that hurdles would remain related to transaction costs, even if agency approval processes were transparent, objective and devoid of policy bias. This, in turn, would suggest that a broader set of institutions are needed to reduce project transaction costs other than those currently embodied in traditional bilateral ties.

Even so, under current conditions, the findings suggest that national policy goals did not exclusively drive the AIJ investment process, leaving room for host countries to influence outcomes by taking up specific policies. Not surprisingly, there is evidence that host-country efforts to put in place institutions fostering a positive general investment climate, political stability and a commitment to international environmental law influenced AIJ investments in a positive way. By implication, countries that take policies that support investment generally and build the specific institutions needed to facilitate Kyoto-related markets will likely see greater investment flows under the Protocol's Joint Implementation and Clean Development Mechanism provisions.

References

Alesina Alberto and Beatrice Weder. 2002. Do corrupt governments receive less foreign Aid? American Economic Review 92 (September), 1126-1137.

Arrhenius, Svante. 1896. The influence of the carbonic acid in the air upon the temperature of the ground. Philosophical Magazine Series 5 (41), 237-276.

Bernstein, Paul M. W. David Montgomery, and Thomas F. Rutherford 1999. Global impacts of the Kyoto Agreement, results from the MS-MRT model. Resource and Energy Economics 21 (August), 375-413.

Bertram, Geoffrey. 1992. Tradeable emission permits and the control of greenhouse gases. Journal of Development Studies 28 (April), 423-446.

Carraro, Carlo 1999. Introduction. In Carraro, C. (Ed.), International Environmental Agreements on Climate Change. Kluwer Academic Publishers, Boston.

Cason, Timothy N. and Lata Gangadharan. 2003. Transactions costs in tradable permit markets: an experimental study of pollution market designs. Journal of Regulatory Economics 23(2), 145-165.

Chakrabarti, Avik. 2001. The determinants of foreign direct investment: sensitivity analyses of cross-country regressions. Kyklos 54 (1), 89-114.

Collier, Paul and David Dollar. 2002. Aid allocation and poverty reduction. European Economic Review 46 (September), 1475-1500.

Cullet, Philippe and Annie-Patricia Kameri-Mbote. 1998. Joint Implementation and forestry projects: conceptual and operational fallacies. International Affairs 74 (2), 393-408.

Dixit, Avinash K. and Robert S. Pindyck. 1994. Investment under Uncertainty. Princeton University Press, Princeton.

Dixon, Robert K. and Irving Mintzer. 1999. Introduction to the FCCC Activities Implemented Jointly Pilot. In Dixon, R.K. (Ed.), The U.N. Framework Convention on Climate Change Activities Implemented Jointly (AIJ) Pilot: Experiences and Lessons Learned. Kluwer Academic Publishers, Dordrecht.

Dudley, Leonard and Claude Montmarquette, C. 1976. A model of the supply of bilateral foreign aid. American Economic Review 66 (March), 132-142.

Frey, Bruno S. and Friedrich Schneider, 1986. Competing models of international lending activity. Journal of Development Economics 20 (March), 225-245.

Ghosh, Prodipto and Jyotsna Puri. 1994. Joint implementation of climate change commitments: opportunities and apprehensions. Tata Energy Research Institute, New Delhi.

Greene, William H. 1994. "Accounting for excess zeros and sample selection in Poisson and negative binomial regression models," Working Paper No. EC-94-10.

Greene, William H. 1997. "FIML Estimation of Sample Selection Models for Count Data," Working Papers 97-02. Stern School of Business, New York University, New York.

Grubb, Michael, Christiaan Vrolijk and Duncan Brack. 1999. The Kyoto protocol : a guide and assessment. Royal Institute of International Affairs, London.

Gulbrandsen Lars H. and Steinar Andresen. 2004. NGO influence in the implementation of the Kyoto Protocol: Compliance, flexibility mechanisms, and sinks. Global Environmental Politics 4(4): 54-75.

Hanafi, Alex G. 1998. Joint implementation: legal and institutional issues for an effective international program to combat climate change. The Harvard Environmental Law Review 22 (2), 441-508.

Heckman, James J. 1979. Sample selection bias as a specification error. Econometrica 47 (January), 153-162.

Heister, Johannes, Patrick Karani, Kerri Poore, Chandra Shekhar Sinha and Rolf Selrod. 1999. The World Bank's experience with the Activities Implemented Jointly Pilot Phase. In Dixon, Robert.K. (Ed.), The U.N. Framework Convention on Climate Change Activities Implemented Jointly (AIJ) Pilot: Experiences and Lessons Learned. Kluwer Academic Publishers, Dordrecht.

Jacoby, Henry D., Ronald G. Prinn, and Richard Schmalensee. 1998. Kyoto's unfinished business. Foreign Affairs 77 (July-August), 54-66.

Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi. 2005. Governance Matters IV: Governance Indicators for 1996-2004. World Bank Policy Research Working Paper Series No. 3630. World Bank, Washington.

King, Gary and Langche Zeng. 2001. Logistic regression in rare events data. Political Analysis 9 (Spring), 137-163.

Kogut Bruce and Harbir Singh. 1988.The effect of national culture on the choice of entry mode. Journal of International Business Studies 19(3), 411-432.

Larson, Donald.F. and Paul Parks. 1999. Risks, lessons learned and secondary markets for greenhouse gas reductions. Policy Research Working Paper 2090. World Bank, Washington.

Lile, Ronald, Mark Powell and Michael Toman. 1998. Implementing the Clean Development Mechanism: lessons from U.S. private-sector participation in Activities Implemented Jointly. Discussion Paper No. 99-08. Resources for the Future, Washington.

McKibbin, Warwick J. and Peter J. Wilcoxen. 2002. The role of economics in climate change policy. Journal of Economic Perspectives 16 (Spring), 107-129.

Michaelowa, Axel, Katie Begg, Stuart Parkinson and Robert K. Dixon. 1999. Interpretation and application of FCCC AIJ Pilot Project development criteria. In Dixon, Robert K. (Ed.), The U.N. Framework Convention on Climate Change Activities Implemented Jointly (AIJ) Pilot: Experiences and Lessons Learned. Kluwer Academic Publishers, Dordrecht.

Michaelowa, Axel, Robert K. Dixon and Lilia Abron. 1999. The AIJ project development community. In Dixon, Robert K. (Ed.), The U.N. Framework Convention on Climate Change Activities Implemented Jointly (AIJ) Pilot: Experiences and Lessons Learned. Kluwer Academic Publishers, Dordrecht.

Muller, R.Andrew and Stuart Mestelman. 1998. What have we learned from emissions trading experiments? Managerial and Decision Economics 19 (June-August), 225-238.

Nordhaus, William D. and Joseph G. Boyer. 2000. Warming the World: Economic Models of Global Warming. MIT Press, Cambridge, MA.

North, Douglass C. 1987. Institutions, transaction costs and economic growth. Economic Inquiry 25 (3), 419 -28.

OECD, 2002. The International Development Statistics (electronic). OECD, Paris.

Painuly, Jyoti P. 2002. The Kyoto Protocol, emissions trading and the CDM: an analysis from developing countries perspective. Energy Journal 22 (3), 147-169.

Parikh, Jyoti. 1995. North-South cooperation in climate change through joint implementation. International Environmental Affairs 7 (Winter), 22-43.

Petras, James and Henry Veltmeyer. 2002. Reverse aid: neo-liberalism as catalyst of regression. Development and Change 33 (April), 281-293.

Pronk, Jan P. 2001. Aid as a catalyst. Development and Change 32 (September), 611-629.

Revelle, Roger and Hans Suess. 1957. Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO_2 during the past decades. Tellus 9, 18-27.

Sonneborn, Carrie L. 1999. An overview of greenhouse gas emissions trading pilot schemes and activities. Ecological Economics 31 (October), 1-10.

Stavins, Robert N. 1995. Transaction costs and tradeable permits. Journal of Environmental Economics and Management 29 (September), 133-48.

Stevens, Brandt and Adam Rose. 2002. A dynamic analysis of the marketable permits approach to global warming policy, a comparison of spatial and temporal flexibility. Journal of Environmental Economics and Management 44 (July), 45-69.

Tomz, Michael, Gary King and Langche Zeng. 1999. RELOGIT: Rare Events Logistic Regression, Version 1.1. Harvard University, Cambridge, MA.

Tyndall, John. 1861. On the absorption and radiation of heat by gasses and vapours, and on the physical connection of radiation, absorption, and conduction. Philosophical Magazine Series 4 (22), 169-194.

van de Ven, Wynand P. M. M. and Bernard M. S. van Praag. 1981. The demand for deductibles in private health insurance: a Probit model with sample selection. Journal of Econometrics 17 (June), 229-252.

Vuong, Quang H. 1989. Likelihood ratio tests for model selection and non-nested hypotheses. Econometrica 57(2), 307-33.

Vrolijk, Christiaan. 2000. Quantifying the Kyoto commitments. Review of European Community and International Environmental Law 9 (November), 285-295.

Wall, Howard J. 1995. The allocation of Official Development Assistance. Journal of Policy Modeling 17 (June), 307-314.

Weyant, John P. 2004. Introduction and overview. Energy Economics 26 (July), 501-515.

Whalley, John and Randall M. Wigle. 1991. Cutting CO_2 emissions: the effects of alternative policy approaches. Energy Journal 12 (1), 109-24.

Woerdman, Edwin. 2001. Emissions trading and transaction costs: analyzing the flaws in the discussion. Ecological Economics 38 (August), 293-304.

World Bank. 2002. Statistical Information Management and Analysis Database (electronic). World Bank, Washington.

World Bank. 2006. Development Data Platform (electronic). World Bank, Washington.

Tables

Table 1: AIJ projects included in the sample, 1992-2001 by host and investor countries.

Investor countries	Projects	Host countries
Australia	10	Chile, Fiji, Indonesia (3), Mauritius (2), Solomon Islands (2), Vietnam
Belgium	1	Croatia
Canada	2	Jordan, Zimbabwe
France	5	Czech Republic, Hungary, Jordan, Mauritania, Zimbabwe
Germany	6	Czech Republic, Jordan, Latvia, Russia (2), Zimbabwe
Italy	2	Jordan, Morocco
Japan	5	China (3), Thailand, Vietnam
Netherlands	16	Bhutan, Bulgaria, Costa Rica, Czech Republic, Hungary (2), Latvia (2), Poland (2), Romania, Russia (2), Slovak Republic (2), South Africa
Norway	6	Burkina Faso, China, India, Mexico, Poland, Slovak Republic
Sweden	51	Estonia (21), Latvia (21), Lithuania (9)
Switzerland	2	Romania, Slovak Republic
United States	41	Argentina (2), Belize (2), Bolivia (3), Chile (4), Costa Rica (7), Czech Republic, Ecuador, Equatorial Guinea, El Salvador, Guatemala (3), Honduras (2), Indonesia, Mali, Mexico (4), Nicaragua, Panama, Russia (4), Sri Lanka, Uganda

Table 2: Bilateral aid and AIJ partnerships

	Bilateral aid, investor to host	
AIJ projects	no	yes
no	347	2,580
yes	0	65

Table 3: Probit selection model results.

Determinants	**Coefficient**	**Std. Error**
AIJ investment equation		
Investor attributes		
AIJ subsidy	0.230[a]	0.058
Investor commitment	0.267[a]	0.066
Host attributes		
Investment climate	0.017[b]	0.008
Host commitment	0.205[b]	0.104
Government effectiveness	0.037	0.093
Political stability	0.329[a]	0.116
Constant	-1.805[a]	0.426
Bilateral aid equation (selection)		
Income	-0.112[a]	0.010
Population	0.210[a]	0.014
Proximity	0.651[a]	0.141
Trade agreement	0.335[a]	0.110
Government effectiveness	0.126[a]	0.016
Political stability	-0.149[a]	0.007
Voice and accountability	0.120[a]	0.038
Corruption	-0.183[a]	0.042
Constant	-1.312[a]	0.182
Independence test		
Correlation estimate, ρ	-0.834	0.060
Wald test, ρ equals zero	$\chi^2(1)=36.52$[a]	

Note: [a] and [b] denote statistical significance at the 1, and 5 percent level, respectively. Potential heterogeneity in the investment error term is accounted for by including information on the project count for each investor-host dyad

Table 4: Average marginal effects.

Investment determinant	**Marginal effects**
Investor attributes	
AIJ subsidy*	0.0261
Investor commitment*	0.0291
Host attributes	
Investment climate	0.0017
Host commitment*	0.0218
Government effectiveness	0.0037
Political stability	0.0329

Note: [a] and [b] denote statistical significance at the 1, and 5 percent level, respectively; * indicates that marginal values are based on a discrete change in the dichotomous determinant. The predicted probability of an investment relationship is 0.0482.

Table 5: Mixed regime test statistics

	Vuong test score
Mixed model versus standard Poisson	2.59[a]
Mixed model versus standard negative binomial	3.53[a]

[a] denotes statistical significance at the 1 percent level.

Table 6: Results from Poisson-selection model.

Determinants	**Coefficient**	**Std. Error**
AIJ investment equation		
Investment climate	0.002[c]	0.028
AIJ subsidy	0.405	0.331
Host commitment	0.822[b]	0.344
Investor commitment	1.314[a]	0.313
Government effectiveness	0.083	0.297
Political stability	0.724[a]	0.275
Constant	-6.338[a]	0.580
Bilateral aid equation (selection)		
Income	-0.117[a]	0.044
Population	0.225[a]	0.028
Proximity	0.581[a]	0.136
Trade agreement	0.445[a]	0.143
Government effectiveness	0.125	0.134
Political stability	-0.134[c]	0.071
Voice and accountability	0.140[b]	0.058
Corruption	-0.192	0.137
Constant	-1.505[a]	0.576
Additional parameters		
Standard deviation of Poisson latent heterogeneity term	2.182[a]	0.162
Correlation of heterogeneity and selection errors	-0.495[a]	0.172

Note: [a, b] and [c] denote statistical significance at the 1, 5 and 10 percent level, respectively.

Table 7: Estimation results for models without selection.

	Probit Model			Adjusted Logistic Model		
	Coefficient	Std. error	Average marginal probability	Coefficient	Std. error	Attributable probability
Investment climate	0.013	0.011	0.0004	0.033	0.024	0.0009
AIJ subsidy*	0.308[a]	0.091	0.0123	0.726[a]	0.206	0.0115
Host commitment*	0.246[b]	0.122	0.0086	0.520[b]	0.262	0.0066
Investor commitment*	0.496[a]	0.108	0.0199	1.096[a]	0.153	0.0175
Government effectiveness	0.122	0.077	0.0039	0.232	0.147	0.0021
Political stability	0.293[a]	0.108	0.0093	0.677[a]	0.246	0.0105
High share of bilateral aid*	0.567[a]	0.114	0.0245	1.227[a]	0.185	0.0241
Constant	-2.628[a]	0.411		-5.133	1.247	

Note: [a] and [b] denote statistical significance at the 1, and 5 percent level, respectively; * indicates dichotomous variables. Predicted probability of an investment relationship was 0.012 and 0.013 for the probit and adjusted logistic models respectively.

Annex table 1: List of countries included in the study.

Investor countries	Host Countries					
Australia	Albania	Central African Rep.	Fiji	Kyrgyz Rep.	Nigeria	St. Lucia
Austria	Algeria	Chad	Gabon	Laos	Oman	St.Vincent & Grenadines
Belgium	Angola	Chile	Gambia	Latvia	Pakistan	Sudan
Canada	Argentina	China	Georgia	Lebanon	Panama	Swaziland
Denmark	Armenia	Colombia	Ghana	Lesotho	Papua New Guinea	Syria
Finland	Azerbaijan	Comoros	Grenada	Liberia	Paraguay	Tajikistan
France	Bahamas	Congo, Dem. Rep. (Zaire)	Guatemala	Lithuania	Peru	Tanzania
Germany	Bangladesh	Congo, Rep.	Guinea	Macedonia	Philippines	Thailand
Greece	Barbados	Costa Rica	Guinea-Bissau	Madagascar	Poland	Togo
Ireland	Belarus	Cote d'Ivoire	Guyana	Malawi	Romania	Trinidad & Tobago
Italy	Belize	Croatia	Haiti	Malaysia	Russia	Tunisia
Japan	Benin	Cyprus	Honduras	Maldives	Rwanda	Uganda
Luxembourg	Bhutan	Czech Republic	Hungary	Mali	Samoa	Ukraine
Netherlands	Bolivia	Djibouti	India	Mauritania	Sao Tome & Principe	Uruguay
New Zealand	Bosnia-Herzegovina	Dominica	Indonesia	Mauritius	Senegal	Uzbekistan
Norway	Botswana	Dominican Republic	Iran	Mexico	Seychelles	Vanuatu
Portugal	Brazil	Ecuador	Israel	Moldova	Sierra Leone	Venezuela
Spain	Bulgaria	Egypt	Jamaica	Mongolia	Singapore	Viet Nam
Sweden	Burkina Faso	El Salvador	Jordan	Morocco	Slovak Republic	Yemen
Switzerland	Burundi	Equatorial Guinea	Kazakstan	Mozambique	Slovenia	Zambia
United Kingdom	Cambodia	Eritrea	Kenya	Nepal	Solomon Islands	Zimbabwe
United States	Cameroon	Estonia	Korea	Nicaragua	South Africa	
	Cape Verde	Ethiopia	Kuwait	Niger	Sri Lanka	

Annex table 2: Instances when bilateral aid and project start dates were not cotemporaneous.

Investor	Host	Number of projects	Project start dates	Years in which bilateral aid did occur
Australia	Chile	1	1999	1992-1994, 1996-1997, 2000-2001
Netherlands	Hungary	1	1994	1992-1993, 1995, 1998-20001
Netherlands	Latvia	1	1997	1992-1993, 1995, 1998-2001
Netherlands	Russia	2	1994	1992-1993, 1995-2001
Netherlands	Slovak Republic	2	1999	1992-1993, 1995, 1997, 2001

Source: UNFCCC, World Bank and authors' calculations.

Annex table 3: Probit selection model without heterogeneity adjustment

Determinants	Parameter	Std. error
AIJ Investment equation		
Investment climate	0.017[b]	0.009
AIJ subsidy	0.230[b]	0.104
Host commitment	0.205[b]	0.095
Investor commitment	0.267[a]	0.096
Government effectiveness	0.037	0.094
Political stability	0.329[a]	0.089
Constant	-1.805[a]	0.125
Bilateral Aid equation		
Income	-0.112[a]	0.038
Population	0.210[a]	0.026
Proximity	0.651[a]	0.120
Trade agreement	0.335[a]	0.125
Government effectiveness	0.126	0.127
Political stability	-0.149[b]	0.066
Voice and accountability	0.120[b]	0.053
Corruption	-0.183	0.124
Constant	-1.312[a]	0.499
Independence Test		
Correlation estimate, ρ	-0.834	0.056
LR test, ρ equals zero	$\chi^2(1)=25.00$[a]	

Note: [a] and [b] denote statistical significance at the 1, and 5 percent level, respectively

Annex table 4: Mixed regime model results.

	Poisson - logit		Negative binomial- logit	
Determinants	Parameter	Std. error	Parameter	Std. error
Project investment count				
Investment climate	0.040[b]	0.020	0.051	0.041
AIJ subsidy	1.028[a]	0.230	1.535[a]	0.458
Host commitment	-0.094	0.234	0.548	0.423
Investor commitment	-0.605[a]	0.210	0.612[c]	0.352
Government effectiveness	0.677[a]	0.250	0.696	0.571
Political stability	0.125	0.239	0.277	0.429
Constant	0.221	0.260	-2.205[a]	0.493
Bilateral Aid equation				
Income	0.064	0.194	0.033	0.253
Population	-0.321[a]	0.089	-0.356[a]	0.131
Proximity	-2.244[a]	0.347	-2.902[a]	0.617
Trade agreement	0.653[c]	0.373	0.788	0.586
Government effectiveness	-0.819	0.639	-0.166	1.008
Political stability	-0.505	0.349	-0.488	0.521
Voice and accountability	-0.146	0.253	-0.074	0.346
Corruption	0.943	0.598	0.611	0.788
Constant	8.674[a]	2.062	7.881[a]	2.889
Ln(α)			1.623[a]	0.415
Alternative model tests				
LR test vs. zero-inflated Poisson			$\chi^2(1)=89.30$[a]	
Vuong test vs. standard negative binomial	2.59[a]		3.53[a]	

Note: [a, b] and [c] denote statistical significance at the 1, 5 and 10 percent level, respectively