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Who hosts the Clean Development Mechanism?

Determinants of CDM project distribution

Abstract

The Clean Development Mechanism (CDM) aims to enhance the efficiency of the Kyoto Protocol by providing greenhouse gas emission credits from projects in developing countries. Its unequal distribution among host countries gives rise to both concerns of equity and the question about the volume of carbon credits that can be generated by offset mechanisms. It is expected that more advanced developing countries with greater abatement potential host more CDM projects. The econometric analysis of CDM project distribution finds that economic development and growth, fossil fuel, and renewable energy generation, as well as links to developed countries and institutional quality positively affect the number of projects hosted. Furthermore, more advanced developing countries pursue a higher share of projects without any direct involvement from developed countries.

by

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1 Introduction

Project-based offsets from greenhouse gas (GHG) emission reductions in developing countries aim to enhance the cost-effectiveness of climate policy regimes. Countries with no emission targets and low abatement costs can sell emission credits to countries with emission targets and higher abatement costs. The Clean Development Mechanism (CDM) and Joint Implementation (JI) feature as project-based offset mechanisms in the current Kyoto protocol. In addition, such offset mechanisms are expected to have a significant role in future agreements. Legislation by the European Union for the post-2012 Emission Trading Scheme already provides a basis for the use of GHG offsets (European Union 2009) and GHG offsets are foreseen in American cap and trade legislation currently under discussion.

The Clean Development Mechanism is the first global project-based offset mechanism for GHG abatement transfers from developing to developed countries. Established in 1997 and having become fully operational in late 2004, there are now over 2000 projects that have been registered by its Executive Board. Their distribution among developing countries is, however, substantially unequal, with a few large countries like India, China, and Brazil hosting up to hundreds of projects and other countries only a few or none at all. This paper asks: which developing countries host the CDM and what factors determine the number of projects hosted?

Arguing that there is substantial support for project-based GHG abatement among business, governments, and some environmental groups Pizer (2006) calls for ideas how to improve and expand these mechanisms. While there is a substantial debate on the environmental integrity of GHG offsets and how to improve it (cf. Michaelowa 2007a, Olmstead and Stavins 2009, Schneider 2007, 2009, Wara and Victor 2008), the question, who is and will be providing these GHG offsets has been discussed rarely in the academic literature (cf. Silayan 2005, Jung 2006). However, discussions at the Conference of the Parties to the Kyoto Protocol show that it is of considerable concern to negotiations (UNFCCC 2009). At the fifteenth Conference of the Parties in Copenhagen in late 2009 decisions were taken to promote project development in countries that so far host less than ten registered projects.

The distribution of CDM projects among host countries has an impact on the political acceptability of the mechanism, as profits from sales of Certified Emission Reductions (CERs) from CDM projects are often substantial. Stavins (2003) reviews the literature on market-based environmental policy instruments, i.e., the use of taxes and cap-and-trade systems including offset mechanisms, instead of direct government regulation. He finds that while market-based environmental policy instruments allow for cost-effective abatement, distributional concerns are important regarding the public acceptance of such policy instruments.

CDM projects can be pursued unilaterally without the cooperation of a developed country partner (henceforth unilateral CDM) and bilaterally or multilaterally with the cooperation of at least one developed country partner (henceforth simply bilateral CDM). Unilateral and bilateral CDM projects may be attractive to a different set of countries as logistic and technical requirements differ. Hence, it will be investigated whether there are "two ways to clean development".

The institutional and technological level of development of the host country is likely to have a key influence on its attractiveness for CDM. Institutions fitting to a country's context are found to foster economic development and growth by Rosenstein-Rodan (1943) and Gerschenkron (1962) as well as more recently by Rodrik (2003, 2007). In a more formal paper, Acemoglu et al. (2006) discuss that countries closer to the technological frontier benefit more from technological innovation, while countries further away from the frontier gain more from technology adoption. Given that technology for GHG abatement is in general fairly advanced, it is likely that the least developed countries face considerably technological barriers to hosting CDM projects.[1] Even if technology is imported, skills for maintenance are likely to be scarce. Thus, generally more advanced developing countries should host a higher number of CDM projects relative to their abatement potential. Regarding these more advanced developing countries, their affinity towards bilateral and unilateral CDM can be expected to differ. The bilateral CDM is supposed to be more attractive to countries relying heavily on technology transfer and foreign direct investment, while the unilateral CDM is supposably more attractive to countries being able already to set up and maintain their own technologies for GHG abatement.

The few econometric studies focusing, at least partly, on the distribution of CDM projects (Dolsak and Bowerman 2007, Dinar et al. 2008, Wang and Firestone 2009) have so far taken into account only the bilateral CDM. The distribution of unilateral CDM, which,

[1] Regarding the question: which climate regimes are best with respect to spillovers of abatement technology within and across countries? see Golombek and Hoel (2006).

as argued above, is likely to be more attractive to a different set of countries, has not been analyzed econometrically on a cross country level so far.[2]

In the following theoretical framework (Section 2), the global market for GHG permits is described first discussing its particularities due to its establishment solely by politics. Second, attention is drawn to the perspective of a potential project developer on the CDM. Third, determinants of the distribution of CDM projects across host countries are discussed.

Section 3 provides the description and operationalization of the data. It outlines as well the empirical strategy of using count regression models to analyze the dataset. Significant differences among the determinants for bi- and unilaterally pursued projects will are found in the analysis in Section 4. The discussion provides a comprehensive summary and the conclusion a short outlook on policy implications.

2 Theoretical Framework

2.1 Global GHG Market and the CDM

In the Kyoto Protocol (UN 1998) of 1997 developed countries agreed on binding commitments of GHG abatements from 2008 until 2012. Three market mechanisms were introduced to reduce the costs to reach the commitments. Without the Kyoto Protocol, or any comparable institutional arrangement, there would be neither the CDM nor any other form of GHG trading. Thus, the politically established rules and regulations of the GHG market are necessary for the supply and demand of GHG permits and codetermine the incentives for producers and consumers of such permits.[3]

Setting up a framework for the analysis of the determinants of hosting CDM projects, it is important to understand the particularities of the above mentioned market first. To start with the overall demand for GHG permits, it should be noted, that it is independent of the price for GHG permits, as binding commitments specifying the amount of GHG abatement

[2]The attractiveness of the unilateral CDM has so far only be analyzed qualitatively by Lütken and Michaelowa (2008) in a comprehensive way.

[3]The term permits is used for all Kyoto Protocol units, such as Assigned Amount Units (AAUs), Emission Reduction Units (ERUs) and Certified Emission Reductions (CERs).

have been signed by developed countries listed in Annex 1 of the Kyoto Protocol (henceforth Annex 1 countries). Hence, the demand curve is inelastic. [4]

Illustrating the market for GHG abatement until end 2012 in a stylized graph, Figure 1 thus shows a perfectly inelastic demand curve for overall GHG abatement, i.e., the fixed Kyoto commitment. A second demand curve despicts the demand that is relevant for international permit trading. It is called the residual demand curve and obtained by subtracting those abatement options, which can be pursued within Annex 1 countries without emissions trading, from the total Kyoto commitment. The residual demand curve is as well rather inelastic since these options are limited (Lütken and Michaelowa 2008).

Marginal abatement costs (mac) for developing countries (mac CDM curve) are shown to be considerably lower than for developed countries (mac Annex 1 curve). This simplification is based on estimations of abatement potential showing that there are considerably more low cost abatement options available in developing countries than in developed countries (Barker et al. 2007, Wetzelaer et al. 2007) (IPCC 2007, p.11). Furthermore, constant marginal abatements costs for a given technology (Wetzelaer et al. 2007) imply a stepwise upward sloping mac curve. Once all abatement options for a given technology are exhausted, marginal abatement costs rise discontinuously to the level of the next best technology for abatement. At its capacity constraint cc, showing that the overall abatement potential by developing countries is not unlimited (cf. Ellis and Kamel 2007, Jahn et al. 2004, Lütken and Michaelowa 2008, Point Carbon 2009) the mac curve for the CDM suddenly stops.[5] To reduce GHGs beyond what can be imported from developing countries,

[4]For simplicity it is assumed that all countries in demand of GHG permits comply with their targets. If some countries were to comply only when the price for GHG permits is low, the demand curve might become less inelastic.

[5]The Marrakesh Accords to the Kyoto Protocol (UNFCCC 2002) specify that the use of the CDM shall be supplemental to domestic emission reductions, but this has never been quantified. However, some buyers such as the EU have set a limit on the use of CDM. This limit could be illustrated by a line parallel and to the left of the residual demand curve. However, the exact position of this CDM limit relative to the capacity constraint is uncertain given that there is already considerable uncertainty about the potential GHG abatements that developing countries can deliver via the CDM. If it were to the right of the capacity constraint, there would not be any effect. If it were to the left, it might help to drive prices down closer to marginal costs due to some type of Cournot competition. Yet, even if current limits were stricter than the capacity constraint, the possibility of banking emission reductions for post-2012 commitments would make the current limits less effective. Accordingly, Point Carbon (2009) predicts that there will be excess demand for CERs until 2012, when the current commitment period ends. Not taking banking into account Capoor and Ambrosi (2009) still

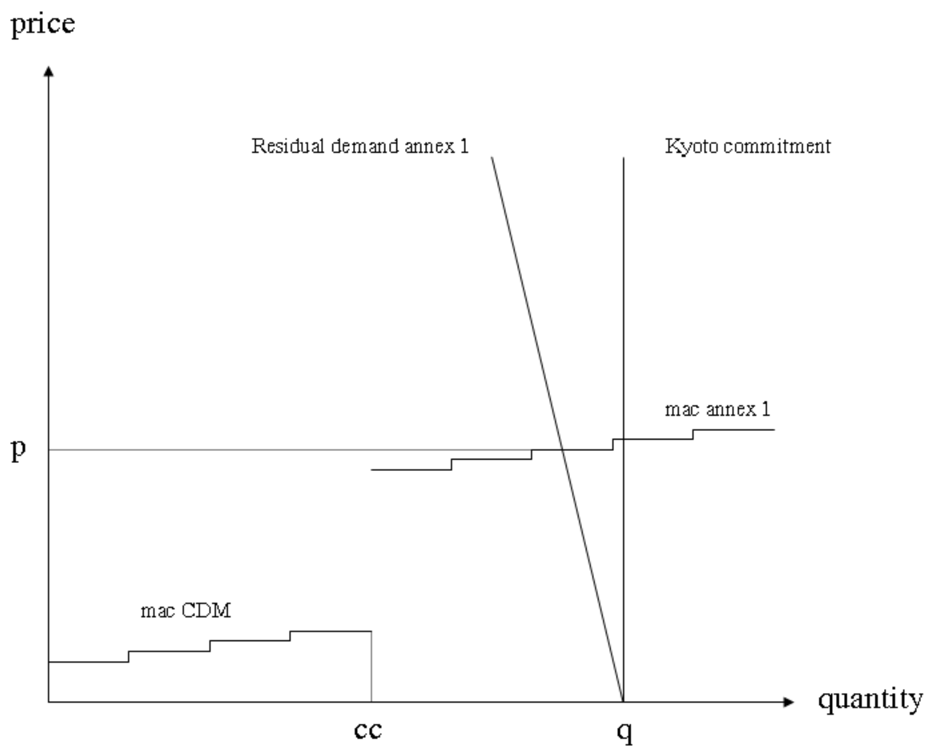

Figure 1: market for greenhouse gas abatement

emissions have to be reduced in developed Annex 1 countries. This is shown by the mac curve jumping up to the level illustrated as mac Annex 1.

The market price for emission reductions is determined by the intersection of the overall mac curve and the residual demand curve for GHG abatement. Figure 1 shows that the price for greenhouse gas permits is mostly determined by marginal abatement costs and demand in Annex 1 countries and does only depend to a very limited amount on emission reductions from the CDM.

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expect supply to roughly equal demand. Furthermore, demand for abatement via the CDM is expected to increase in the future with more countries obeying to emission constraints and stricter emission constraints for countries that already have reduction commitments in place (Tvinnereim et al. 2009). Hence, it is fairly unlikely that current limits on the use of CDM induce competition among hosts of CDM projects and thus affect the price of emission reductions from the CDM negatively. Furthermore, the price of traded emission reductions from CDM projects has always been fairly close to the price of comparable European Union Allowances (EUAs) valid in the EU-internal emissions trading scheme (EEX 2009).

Empirically the reference price of a ton of CO_2 abatement has been established by the price for European Union Allowances (EUAs). EUAs can be readily used to fulfill a firm's emissions obligations under the EU emissions trading scheme and are traded on European exchanges. Regarding the CDM, Certified Emission Reductions (CERs) from a project can either be bought directly from project developers through forward contracts (primary market) or, once issued, from an exchange (secondary market). EUA and secondary CER prices move very much in line as one would expect (cf. EEX 2009, Tvinnereim et al. 2009). A slightly lower price for secondary CERs compared to EUAs can be explained by the fact that firms have to reduce some emissions within the European Union.[6]

For primary CERs a substantial discount compared to EUAs is found in Figure 2. [7] [8] Registered projects can still fail to produce the emission reductions that were expected at the date of purchase. Therefore, primary CERs are sold at substantially lower prices than exchange traded EUAs, but the discount has become smaller over time.

Furthermore, Figure 2 shows that the price for primary CERs has been relatively stable. Although some small movements, roughly following the EUA price, can be observed, the price that a given project developer receives is even less prone to fluctuations. Emission reduction purchase agreements (ERPAs) for CDM projects generally specify a fixed price for all CERs issued from a CDM project until 2012 (Michaelowa 2009).[9] Thus, even though some small movements in the CER price can be seen over time, the revenue received by project developers is relatively constant for the lifetime of a project.

Summing up this brief discussion on the markets for GHG abatement, it has been illustrated that the overall demand for GHG permits is fixed as specified in the Kyoto protocol and that CER prices follow closely the reference price established by EUAs. Furthermore, it can reasonably be assumed that project developers take prices for CERs and abatement costs as given.

[6] The fact that the gap has not widened suggests that there has not been excess supply of CDM relative to its import limits driving down prices.

[7] Figure 2 shows the price of low-risk forward CERs, which are high priced primary CERs. Data is taken from the monthly GTZ CDM Highlights 2005-2009.

[8] Prices are shown only until the end of 2008, which corresponds to the time frame of the subsequent econometric analysis.

[9] Initially, as long as prices for EUAs were rising many ERPA specified the CER price to be a fixed percentage of the EUA price. After the first substantial fall in EUA prices the price for CERs was normally fixed in the ERPA. Nowadays price floors and ceilings are becoming more common.

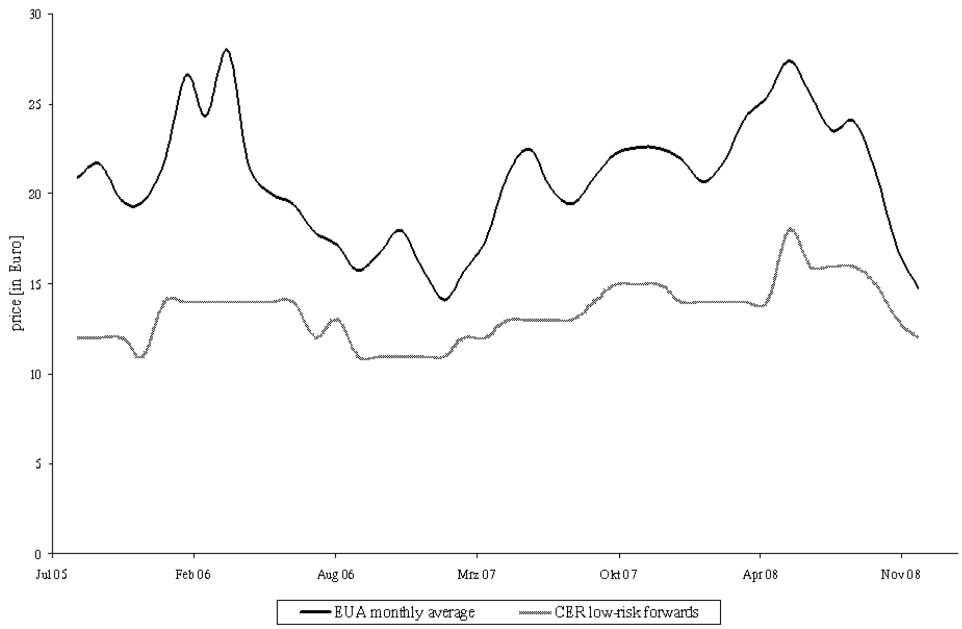

Figure 2: EUA and low-risk forward CER prices per ton of CO_2 (European Climate Exchange 2009, GTZ 2005-2009)

2.2 Implications for the behavior of potential CDM hosts

The analysis now turns to the question when a potential CDM project will actually be pursued. To establish and clarify ideas for the empirical analysis, a hypothetical example at the firm level will be given now. Specific hypotheses on the determinants of hosting CDM projects at the country level will be established in the next section.

Consider the circumstances under which firm i in country j will host a CDM project. First, a potential project must be available and feasible, and second, this potential project must generate profits. Let π_{ij} denote the profit for the firm and $cc_{ij} = f(potential, feasibility)$ its capacity constraint, i.e., the availability of a CDM project ($potential$) and that it can actually be pursued ($feasibility$). The problem of the firm can be written as $max\ \pi_{ij} = \overline{p} \cdot q_{ij} - \overline{mac_t} \cdot q_{ij}\ s.t.\ q_{ij} \leq cc_{ij}$. The expression above reflects that the price $\overline{p}$ that a project developer receives is fixed in the Emission Reduction Purchase Agreement (ERPA) and that marginal abatement costs mac_t are constant for a project of given technology t. Furthermore, the amount of GHG abatement q_{ij} cannot exceed its capacity constraint cc_{ij}. As both prices and marginal abatement costs are fixed for a given firm only two possibilities exist given the capacity constraint: (i) profits from the CDM project strictly exceed profits from alternative investments and (ii) profits from the CDM projects are strictly lower than those of alternative investments. In case (i) the CDM project will be pursued given that the capacity is greater than zero. As profits are then strictly increasing in q, the firm will invest until the capacity constraint holds with equality. In case (ii) no investment will be seen.

The example above is thought to clarify two important points. First, the decision in a firm is perceived to be a discrete decision between investing in a CDM project or not, and not a decision about how much to invest. This is also due to the fact that CDM investments are mostly supplemental investments to projects that would have taken place anyway, and not investment projects on their own. [10] Hence, the size of the project is predetermined. Furthermore, if there is a possibility to host a CDM project, there is a very high probability that it will indeed be hosted. The reason is that revenues are very likely to exceed costs as the reference price is the relatively high price for European Union Allowances and abatement costs are comparatively low in developing countries. Second, whether the investment possibilty of a CDM project is available in the first place depends on the capacity constraint, which is a function of CDM potential and feasibility. With this in mind specific hypotheses on the determinants of hosting CDM projects on the country level can now be made in the following section.

2.3 Hypotheses

In the following paragraphs the current literature related to the distribution of CDM projects is shortly reviewed. Then, the example of a firm's decision to host a CDM project in the previous section is used to further clarify which factors can be expected to determine a country's provision of CDM projects. Finally, this cumulates into the formulation of specific hypotheses.

Literature on the topic is still not extensive. From a theoretical perspective Jung (2006)

[10] CDM investments are supplemental investments in the sense that an underlying economic activity, which emits GHG, needs to be already in place or planned. For example, the supplemental investment could be an investment in the substitution of GHGs in the manufacture of products as well as an investment in a hydro power plant instead of coal power plant.

and Silayan (2005) build indicators for the potential supply of CDM credits and Jahn et al. (2004) as well as Michaelowa (2007b) for the unilateral CDM in particular. They argue that certain levels of infrastructure, human capital, and financial capital are needed to host CDM projects. Oleschak and Springer (2007) consider similar factors for assessing the general risk of investing in the CDM.

Focusing on cooperation between developing and developed countries within the bilateral CDM Dolsak and Bowerman (2007) and Dinar et al. (2008) provide first empirical studies. The first study finds positive associations between the level of cooperation in the CDM and trade volumes, colonial ties and CO_2 emissions; the second adds good governance and impact vulnerability of climate change. Using a gravity model for international permit trading Wang and Firestone (2009) find CO_2 emissions to matter most. Regarding the unilateral CDM no econometric studies exist.

A significant amount of investment into CERs stems from the public sector in developed countries, or is bundled into funds by the World Bank. Therefore, one may expect that spending patterns follow to some extend those of development aid. Furthermore, some countries may well substitute funds from Overall Development Assistance to climate change mitigation (Michaelowa and Michaelowa 2007). Studied first by McKinlay (1978) and McKinlay and Little (1979) historical links between countries, political interests, and recipient need are known to matter.

Having briefly reviewed the literature, and keeping the results of the hypothetical decision to invest in CDM in the previous section in mind, a more general framework for forming hypotheses on factors influencing the distribution of CDM projects among host countries is now provided. More specifically, the probability to host CDM projects is perceived to be a function of CDM potential, feasibility, and profitability, i.e., *CDM = f(potential, feasibility, profitability)*. CDM potential covers the overall availability of CDM projects, feasibility the removal of possible constraints to hosting CDM projects, and profitability the decision between investment in CDM and a possible alternative investment.

As all three dimensions cannot be measured directly hypotheses will be formed on those factors which are expected to influence CDM potential, feasibility, and profitability. All of them influence the probability to host a project positively. Hence, factors that influence one or more of these three dimensions positively, should in turn have a positive impact on hosting CDM projects. A natural limitation is that only the total effects of these factors on hosting CDM projects can be estimated, which is, however, the goal of the paper. Nevertheless, Table 1 will provide an overview on the composition of total effects at the end of the section.

Regarding CDM potential it has already been mentioned that CDM projects are to a large extent supplemental investments to economic activities that are already pursued or would have taken place anyway. This implies that for the opportunity to host a CDM project an underlying economic activity must already be in place or planned. Hence, the level of economic activity and the growth rate of an economy are expected to influence the possibility to host CDM projects.

Furthermore, going more into detail, the energy structure of an economy can be expected to matter. The more energy is produced by firing fossil fuels the more CO_2 emissions can potentially be mitigated. In addition, the more potential for renewable energy sources exist, the easier one can mitigate GHGs.

Before discussing the feasibility of CDM projects one should remember that projects can be pursued both unilaterally and bilaterally. A CDM project is considered to be unilateral if there has been no participation from a developed country with emission targets (Annex 1 country) in the project (Michaelowa 2007b). Therefore all know-how and finance must stem from the developing country. Bilateral projects, in turn, are characterized by some sort of cooperation between entities in the developing and in the Annex 1 country. The level of cooperation can range from a mere forward agreement to buy CERs to financing the project and providing the technology. Determinants may especially differ in their impact on removing constraints to pursue projects unilaterally and bilaterally.

CDM projects generally apply fairly advanced technical solutions to mitigate GHGs. Therefore, substantial technical knowledge is required both for the realization and the maintenance of the project. In addition, the application procedure for project registration by the UN is fairly complex. Furthermore, management skills are needed to ensure the availability of investment capital and proper implementation of the project. These requirements (Oleschak and Springer 2007, Jahn et al. 2004) imply that relatively more advanced developing countries are more likely to host CDM projects. Further, as bilateral projects can potentially benefit from the transfer of technology (Dechezleprêtre et al. 2008, 2009) and knowledge, the level of development is expected to matter more for unilateral projects.

Another key requirement for the feasibility of projects is that sufficient capital is available for financing (Michaelowa 2007b). If credit markets are efficient, projects will be undertaken as long as they are economically viable. However, nearly all the empirical evidence points out that credit markets are far from being efficient in developing countries for firms (Bertrand et al. 2002, Fisman 2003, McMillan and Woodruff 1999) and in general (Bell 1988, Besley 1995). Furthermore, CDM project developers have to demonstrate that GHG emission reductions from their projects are additional to business as usual. This implies that projects should not be economically viable without the additional revenue through the sale of CERs. If expectations of the financial sector on the future price of CERs are uncertain and below the finally realized prices this implies that even with efficient capital markets project supply will be limited. Going one step further the likely result is that a lot of financial resources stems from own funds (see also Jahn et al. 2004, Michaelowa 2007b). Given that bilateral project developers have possibly better access to sources from developed country partners, domestic capital availability it expected to matter more for unilaterally pursued projects.

The closer links between a potential host country and developed buyer country are, i.e., by being a former colony or being open to trade in general, the more likely it is that the developing country benefits from financial and technical help of developed countries. This should increase the feasibility of CDM projects. Furthermore, if a developing country already has close links to developed countries, costs for the sale of CERs are likely to be lower. This should matter especially for unilateral CDM. However, stronger links to developed countries could also lower search costs of finding a partner for bilateral CDM. Hence, it is unclear for which type of project they should matter more. In general, for both types of projects, one can expect developing countries that have strong links to developed countries to be more likely to host CDM projects.

Besides the availability of infrastructure, capital for investment, and strong links to developed countries political freedom, or democratic governance, may be important for the feasibility of hosting CDM projects. Sen (1999) writes that "the reach and effectiveness of open dialogue are often underestimated in assessing social and political problems". Therefore, following Sen, the more open and democratic a country is, the easier it is to communicate the threads of global warming and what can be done about it. Democracy may hence raise the awareness of climate change and GHG abatement options via the CDM. This effect may matter more for unilateral projects, as for bilateral projects the initiative to develop a project could come from abroad. In addition to this direct link, good governance and investor security, mainly via security of property rights, may as well be beneficial for the capacity to host CDM projects. Hence, more democratic developing countries are likely to host more CDM projects.

With respect to the profitability of projects one should bear in mind that once an opportunity to host a CDM project arises and potential investors are aware of it, profits are very likely to be positive - as marginal abatement costs are low and prices for CERs are predetermined by relatively high priced European Emission allowances - and hence the project will be pursued. Nevertheless, one might expect that the faster an economy is growing the more potential alternative investments with even higher expected profits exist, and hence investments in CDM becomes less likely.

Having discussed the impact of explanatory variables on CDM capacity and profitability expected total effects of variables on hosting CDM projects are summarized in Table 1. Only the total effects can and will be estimated later. The direct and indirect effects on CDM potential, feasibility, and profitability cannot be identified.

Table 1: Composition of total effects

Determinant	**Specific Effects**	**Total Effects**
economic development	+ potential + feasibility *(++ unilateral)*	+ *(++ unilateral)*
growth	+ potential o / - profitability	o / +
fossil fuel energy generation	+ potential	+
renewable potential	+ potential	+
investment capital	*(+ feasibility; unilateral)*	*(+ unilateral)*
links to developed countries	+ feasibility	+
political & economic freedom	+ feasibility *(++ unilateral)*	+ *(++ unilateral)*

The level of economic development is expected to be positively related to CDM potential. As economic development is thought to remove constraints to unilateral CDM projects, a stronger effect is predicted for unilateral projects. Growth of GDP is as well expected to relate positively to CDM potential, though it might as well be that in faster growing economies the CDM becomes relatively less attractive as investment opportunity. As the later effect is thought to be small one would expect some positive relation in overall. Fossil fuel energy generation and renewable potential are expected as well to relate positively to CDM potential. Availability of investment capital is thought to remove credit constraints especially for unilateral projects and therefore to increase feasibility. A significant positive difference is expected in comparison to bilateral projects. Links to developed countries and political and economic freedom are both expected to increase feasibility of CDM projects and should hence relate positively to the number of CDM projects hosted.

In addition, one may expect that determinants differ for the number of projects and for whether a country hosts no project or at least one. The preceding paragraphs have hypothesized effects mainly with regard to the number of projects hosted. Regarding the question whether there will be at least one project anecdotal evidence suggests that especially for bilateral projects only very few determinants matter: CDM investors from a developed country may have some connection to a developed country for various reasons. For example, a developed country investor happens to spend his holidays in Kenya and discovers some potential for a biogas projects. Then this project may actually be pursued, given the country is sufficiently secure for the investor. However, regarding the question whether more than one project will be pursued countries are very likely to differ among the dimensions of CDM potential and feasibility. With respect to the unilateral CDM more determinants are expected to matter. Especially the level of economic development should matter as all technical know-how has to stem from within the developing country.

3 Data and Empirical Strategy

3.1 Data and Operationalization

The analysis is restricted to those 140 non-Annex-1 countries that had ratified the Kyoto protocol and had it in force until December 2008. This is a natural limitation, since only these countries are allowed to host CDM projects.

The number of projects per country is used as the dependent variable in the estimation. More specifically, the count includes all projects that have passed validation and were filed for registration at the CDM Executive Board until the end of 2008. An alternative measurement would be to count only those projects that have passed registration. As the decision to register projects is, however, politically contamined (Flues et al. forthcoming), the first measure is cleaner. Furthermore, using the number of projects instead of the amount of emission reductions has several theoretical as well as practical advantages that will be explained below.

Theoretically, it can be seen as a measure of discrete firm decisions aggregated to the country level. This is in line with the data geerating process and will be explained in more detail together with the estimation strategy in the following subsection. In addition, the number of projects per country is applied as a measure in the UNFCCC in discussing "underprovision" of CDM projects (UNFCCC 2009, p.10, paragraph 53).

Practically, the number of projects is a more robust measure. The amount of emission reductions is heavily skewed by very large industrial gas projects, such as HFC-23 replacement projects, which generate multiples in terms of credited emissions reductions, as these gases are extremely harmful in terms of global warming. [11] Given that only a limited number of countries has applied industrial gas replacement projects, using the amount of emission reductions would give a biased picture. Second and relatedly, the number of projects is less prone to outliers as the amount of emission reductions generally depends on project size, which differs significantly, especially among countries with only few projects. In turn, this could give the wrong impression that a small country with just one large CDM project is heavily engaged in the CDM in general.

Both theoretically and practically it is less obvious which measure should be applied when the amount of emission reductions would be used as dependent variable, and confusion would likely occur. There would be reason to only take those emission reductions into account which will occur until 2012 when the current Kyoto protocol ends, as it is unclear what will happen to emission reductions afterwards. However, this would penalize more recent projects, and market expectations are that the CDM will continue in one form

[11] The global warming potential conversion factor for HFC-23 relative to CO_2 is 11,700 (Forster et al. 2007, p.212).

or the other, and hence emission reductions from these projects do not become worthless. Alternatively one could apply the amount CERs from registered projects, which can differ substantially from the amount of expected CERs due to unforeseeable technical difficulties or manipulated mitigation calculations. Yet, the expected amount of CERs, which firms believe to realize, is what matters for the decision of a firm to invest, even if numbers have been cooked, as project developers should know their menu. Taking the plain number of projects takes the whole benefits of a project over its lifetime into account and is thus theoretically more appealing as well as less error prone than taking the amount of emission reductions.

Finally, projects are distinguished on being pursued bilaterally and unilaterally. Following Michaelowa's (2007b) distinction, projects that have initially no credited buyer indicated in the UNEP Risoe Center's (2009) CDM Pipelines are coded as unilateral.[12] The remaining projects are coded as bilateral.

All independent variables have been measured either in 2004, i.e., immediately before CDM projects could be registered by the UNFCCC, if they are generally considered to be fairly stable, or as an average over the years 2000 to 2004 if they fluctuate. Economic development is thus measured in 2004 by the natural logarithm of GDP per capita in constant US Dollars and taken from the World Bank's (2008) World Development Indicators (WDI). Growth is measured as well on a per capita basis and taken from the same database as an average from 2000 until 2004.

Fossil fuel energy generation is measured as intensity in 2004 in millions of kWh per GDP. As GDP per capita and population itself are treated as explanatory factors on their own, it is here the relative difference in the use of fossil fuels that is of interest. Data originates from the Energy Information Administration (2009).

Renewable energy potential is measured by existing renewable energy generation in 2004. Potential and existing renewable energy generation are not the same. However, the existing use of renewable energies provides a reasonable proxy of how much renewable energy can be produced economically. It is seen as a measure for the ease by which re-

[12]The UNEP Risoe Center (URC) updates credit buyer information for projects that have been planned and pursued unilaterally, but provide information on buyers of issued credit later. For this reason earlier versions of the CDM pipeline have been used to identify unilateral projects.

newable energy generation can replace fossil fuel energy generation. An alternative would be to rely on more geographical measures of renewable energy potential.[13] Measures that include explicitely policies of host countries have not been used, as policies are likely to be endogenous to the use of CDM. Renewable energy generation is as well retrieved from the Energy Information Administration (2009) and measured as intensity.

The availability of capital for investment in CDM is measured by gross fixed capital formation (GFCF), i.e., the amount of net new investment in fixed capital assets within a country. It indicates the ability within a potential host country to invest in capital intensive goods, like the CDM, and provides an overall measure of capital availability to potential CDM project hosts. More direct measures of capital availability, like domestic credit to private sector, would neglect the substantial amount of relationship based informal credits (Bertrand et al. 2002, Fisman 2003), which help to finance enterprises in developing countries. Hence, it is more compelling to use the average of GFCF over the years 2000 to 2004 per GDP, taken from the WDI (World Bank 2008), as a general indicator of access to capital for financing CDM projects.

Links to developed buyer countries are specified using a set of variables. Trade per GDP, often used to indicate the openness of an economy, is thought to measure how much a country trades in general. One the one hand one might expect more open economies to be more likely to trade as well GHG and on the other hand more open economies are generally considered to have closer ties with developed countries, i.e., the potential buyer countries. A more specific measure would be to include only the trade with those countries that actually buy emission reductions. However, there is considerable uncertainty about the exact demand for CERs from specific developed countries and correlations between general openness and trade with potential buyer countries are extremely high. Therefore, the plain measure of trade per GDP, taken as an average from 2000 to 2004 from the WDIs (World Bank 2008) is used. To measure ties, nevertheless, more directly colonial status is used as a second variable to measure country links. It is a dummy variable taking the value of one for being a former British, Spanish, Dutch, German or French colony. Most buyers are from these former colonial powers. Data originates from International Correlates of War (ICOW) dataset (Hensel 2006). Finally, received aid per capita in 2004, taken from the WDIs is employed as a third variable bearing in mind that a considerable amount of aid is allocated strategically. All in all, trade per GDP, colonial status, and aid flows are thought

[13] Results do not change much when using altitude, length of rivers and shoreline.

to be a comprehensive measure of links between industrialized and developing countries.

Political freedom is measured in 2004 by an average of the Freedom House and Polity IV Indices on a ten point scale, with ten indicating most democratic (Teorell et al. 2008).[14] Freedom House is an amalgamated measure covering both political rights and civil liberties, including the freedom of private businesses. Polity IV, measures both autocracy and democracy. The combined measure has been suggested by Hadenius and Teorell (2005), who show that it is more reliable. Although it would be possible to focus on more detailed measures, it is not clear theoretically which political rights or civil liberties should matter more. Hence, the composite measure is applied.

Further control variables are population, measured in 2004 (World Bank 2008) and the time until the Kyoto Protocol has been ratified (UNFCCC 2008). Alternatively the time until a Designated National Authority (DNA) for the CDM has been established has been applied.[15] Ratification of the Kyoto Protocol and establishment of an DNA are extremely high correlated ($\rho = 0.98$). Establishment of a DNA could however be endogenous in that it is only established once investors already have plans to invest in the CDM. Ratification of the Kyoto Protocol is, however, a more complex issue and as Bernauer et al. (forthcoming) have shown, international factors have a much stronger impact on international environmental treaty ratification than domestic factors. It can hence be considered as fairly exogenous to the CDM and is therefore used throughout the regression analysis. Furthermore, both population and ratification of the Kyoto Protocol can be regarded as proxies for the exposure of countries to the CDM.

Additionally, a country's security for investors, measured in March 2004 by the Institutional Investor Magazine's country credit rating (retrieved from: Engelen 2004), is used as a control variable in a few specifications. The same hold for the average of FDI inflows (World Bank 2008) from 2000 to 2004.

[14] In the analysis Teorell et al.'s (2008) version that includes a few imputed values for Polity IV has been used.

[15] Designated National Authorities have to certify that a CDM project does not harm sustainable development in the host country. They are required for hosting CDM projects.

3.2 Empirical Strategy

The empirical analysis of the determinants for hosting CDM will mainly apply count regression models. First, count models are consistent with the nature of the dependent variable, i.e., being a count of projects per country. Second, count models follow naturally from the data generating process. Potential projects are thought to occur randomly over time conditional on explanatory factors. Firms face discrete choices on hosting CDM projects or not. Over time and space these choices occur repeatedly and can be aggregated.

Going back to the example of the firm considering hosting a CDM project in the theoretical framework helps to illustrate the data generating process. Denoting $Y = 1$ the development of a project, the probability that a project is developed given a set of explanatory variables accounting for CDM potential, feasibility, and profitability gathered in vector x can be written as $Prob[Y = 1|x]$.[16] Specifying this probability further to be a function of the explanatory variable vector x, and a random error ε accounting for all unobserved explanatory variables uncorrelated with x one can write $Prob[Y = 1|x] = Prob[x'\beta + \varepsilon > 0]$, which gives an expression for the single conditional probability that a potential project is pursued. Over time, this situation occurs repeatedly. [17] Hellerstein and Mendelsohn (1993) show that a repeated discrete choice model gives rise to a count model, i.e., in the most simple case a Poisson model with mean $\lambda = exp(x'\beta)$ [18]. Hence, when observing the total number of CDM projects in a given time interval, it is reasonable to treat this number as originating from a Poisson or related, e.g., Negative Binomial, distribution. Finally, the main question to be addressed in this paper is what the determinants of CDM capacity are across host countries. Thus, when evaluating aggregate data the number of projects pursued in a given country has to account for its exposure to a country's size, assuming that larger countries have simply more possibilities to pursue CDM projects. The adding-up property of a Poisson distribution states that when N independent random variables i are Poisson distributed their sum is distributed with $\lambda_N = \sum i^N \lambda_i$. Accounting for a country's size can hence be done straightforwardly using population. (for details see Hellerstein 1991).

[16]Note, that only the total effects of the determinants will be estimated. Direct effects on capacity and profitability can not be identified as both suffer from severe measurement problems.

[17]As an example, a CDM project in the energy sector might occur, when a new power plant needs to be build, and due to funding via CER sales the decision is made to build a hydroelectric power plant instead of a coal plant. After some time, there is need to replace another old power plant or to build a further new one, as the economy has grown.

[18]Hellerstein and Mendelsohn (1993) discuss additional technical details, e.g., which assumptions lead to a Poisson or a Negative Binomial model.

More detailed, in addition to single equation count models hurdle models will be estimated as the processes generating zero counts, i.e., not hosting a CDM project at all, and generating a positive number of counts may differ. A primary look at the data reveals that only 54 of 115 countries analyzed host at least one project. Likelihood-ratio tests will be performed to establish empirically whether determinants differ indeed for the number of projects and for hosting at least one project.[19] Furthermore, Negative Binomial models accounting for potentially unobserved heterogeneity will be estimated and compared to Poisson Quasi-Maximum Likelihood (QML) models. Once again likelihood ratio tests will be used to discriminate between models. To test whether there are indeed two ways to "clean development" estimation will be done separately for bi- and uni-lateral projects. Differences in coefficients will be evaluated using a robust seemingly unrelated variance-covariance matrix (Weesie 1999). If significant differences are found this will support that there are indeed two ways to "clean development". Furthermore, if there were common unobserved factors that both biased coefficients for uni- and bi-lateral project hosting these would be cancelled out using differences. Hence, estimates on the differences between uni- and bi-lateral projects should be more robust.

4 Analysis

Table 2 shows the distribution of the dependent variable, i.e., the cumulated count of validated CDM projects per host country that have applied for registration until December 2008. Only less than half of all 115 countries analyzed[20] host at least one CDM project. Bilateral projects are slightly more prominent than unilateral projects. For all project types the variance is extremely high, with many countries not hosting any project and a few large countries a lot.

[19] In principle, one could think of a correlated hurdle model as well, where the errors for participation in the CDM and for the number of CDM projects are correlated. This would be the case if some common unobserved variable would both influence participation and the number of projects. However, given that participation in the CDM is already perceived to be rather random, it is unlikely that such an unobserved variable exists. Furthermore, the correlation parameter is considered to be rather imprecise by Winkelmann (2004), who estimates the uncorrelated count model in such a circumstance.

[20] 25 tiny countries, often island states, having ratified the Kyoto Protocol are not included in the analysis due to missing data on independent variables. Hence, any predictions do not carry over to these small (island) states.

Table 2: Cumulative number of projects per host country until December 2008

	all		bilateral		unilateral	
Mean (S.D.)	15.6	(74.30)	8.0	(49.93)	7.6	(41.50)
Max	612		529		413	
Countries Total	115		115		115	
Countries (at least one project)	54		47		38	

In a first step the data is analyzed without drawing attention to the large number of zeros. This is thought to provide a baseline for later comparisons with hurdle models, which specificially take the process of generating zeros into account. Given the high variance of CDM projects Poisson QML, which are robust to misspecification of variance, and Negative Binomial models, which can account for unobserved heterogeneity resulting, e.g., from overdispersion and excess zeros, are fitted. Results will only be discussed briefly as the main attention is on the analysis of the hurdle models, which are more in line with theory and shown to fit the data better.

For unilateral projects[21] a better fit is clearly achieved when accounting for overdispersion, though the increase in fit for bilateral projects is only marginal as can be seen in Table 3 comparing the log-likelihoods (ll). Correspondingly, results change only slightly for bilateral projects. For unilateral projects mainly the size of the coefficients for growth and political freedom diminish while most other coeffiecients do not change a lot. As a general picture positive effects of the level of GDP, growth, and political and economic freedom are seen for both bi- and uni-lateral projects, though they do seem to matter more for unilateral projects. Trade is seen to matter positively only for bilateral projects while aid does so only for unilateral projects. The control variables for population and the time until ratification have the expected signs and are most of the time significant. Restricting the coefficients to be equal for both bilateral and unilateral projects significantly worsens model fit. The log-likelihood of the combined Poisson QML model (not shown) decreases to -230.91. Equality of coefficients using can be rejected below the 1 percent level using a

[21] China requires that CDM projects have a developed country partner. A dummy for China is therefore introduced when comparing unilateral and bilateral project hosting to capture any China specific effect.

Table 3: Poisson QML and Negative Binomial II Models

	(1)		(2)		(3)		(4)	
	Bilateral Poisson QML		Unilateral Poisson QML		Bilateral NegBin II		Unilateral NegBin II	
VARIABLES	coef	se	coef	se	coef	se	coef	se
economic development	0.376**	(0.118)	0.611**	(0.188)	0.306*	(0.139)	0.666**	(0.196)
economic growth	0.144*	(0.071)	0.397**	(0.058)	0.094	(0.069)	0.266**	(0.075)
capital formation	-0.077**	(0.028)	-0.059	(0.039)	-0.060*	(0.028)	-0.054	(0.037)
trade	0.014**	(0.002)	0.003	(0.008)	0.011**	(0.003)	0.005	(0.005)
colonial status	0.132	(0.149)	-0.004	(0.230)	0.158	(0.211)	0.216	(0.313)
aid	0.003	(0.003)	0.014**	(0.003)	0.002	(0.003)	0.013**	(0.004)
fossil fuel energy gen.	0.530	(0.281)	0.447	(0.342)	0.503*	(0.243)	-0.088	(0.423)
renewable energy gen.	-0.095	(0.133)	0.169	(0.157)	-0.134	(0.154)	-0.253	(0.362)
political freedom	0.175**	(0.057)	0.480**	(0.119)	0.197**	(0.058)	0.335**	(0.096)
population	0.953**	(0.076)	1.473**	(0.135)	0.894**	(0.097)	1.373**	(0.154)
ratification	-0.120	(0.187)	-0.542*	(0.278)	-0.223	(0.226)	-0.753*	(0.360)
lnalpha					-1.625**	(0.700)	-0.705	(0.376)
lr test p-value $\alpha = 0$						0.170		0.000
observations	115		115		115		115	
ll	-147.0		-146.4		-146.6		-126.5	

** p<0.01, * p<0.05, ; Constant, included continental dummies, and dummy for China not shown.

Chow test. Though all the above models do not account for zero counts in any special way, differences in coefficients between bi- and uni-lateral clearly exist.

Table 4 shows the results of the Cloglog-Poisson and Cloglog-Negative Binomial II hurdle models. In the upper part of the table coefficients refer to the strictly positive part of the respective model, while the lower part of the table shows the coefficients for variables that help predicting zero counts.

The Poisson hurdle models in 5 and 6 clearly fit the data better than the single equation models in specification 1 and 2 increasing the log-likelihood significantly by 28.64 and 32.46 respectively. Accordingly, coefficients for zero counts and positive counts differ substantially, as do the coefficients for positive counts and all counts. Hence, the hurdle Poisson models perform better than plain Poisson models.

Comparing the Poisson (5 and 6) to the Negative Binomial (7 and 8) hurdle models no additional increase in fit can be detected. In contrast, their fit is worse and likelihood ratio test do not reject (p-value = 1) that the Negative Binomial models cannot explain the data better.[22] Overdispersion does, hence, not seem to be an issue any more once one explicitly accounts for zero counts. Poisson hurdle models fit the data best.

Using the preferred Poisson hurdle model, specific determinants for hosting CDM projects will now be analyzed in more detail, focusing first on bilateral projects, second on unilateral projects, and finally comparing both. Specification 5 (bilateral project count) shows positive and significant effects for most factors relating to CDM potential. A one percent increase in GDP per capita is associated with a .58 increase in the expected number of projects for countries that host CDM projects. This considerable size of the effect is possibly due to the fact that GDP accounts both for the level of economic activity in a developing country, which in turn accounts for the possibilities of having a potential projects available, and as a proxy for the necessary infrastructure and technical capacity. Growth of GDP also has a positive and significant effect on the number of projects, which is smaller in size. This is reasonable, as it thought to affect the availability of projects positively, and profitability negatively, although to a smaller amount. The intensity of conventional energy generation affects the number significantly positive as well. Renewable energy generation

[22]Maximization of the log-likelihood function for the Negative Binomial models turned out to be difficult. For unilateral projects the Broyden-Fletcher-Goldfarb-Shanno algorithm has been applied (cf. Fletcher 1987).

Table 4: Poisson QML and Negative Binomial II Hurdle Models

	(5)		(6)		(7)		(8)	
	Bilateral Poisson Hurdle QML		Unilateral Poisson Hurdle QML		Bilateral NegBin II Hurdle		Unilateral NegBin II	
VARIABLES	coef	se	coef	se				
economic development	0.575**	(0.109)	0.849**	(0.225)	0.900	(0.738)	1.424	(0.942)
economic growth	0.296**	(0.071)	0.066	(0.135)	0.387	(0.310)	0.054	(0.293)
capital formation	-0.101**	(0.026)	0.075	(0.060)	-0.105	(0.136)	0.062	(0.138)
trade	0.013**	(0.002)	0.009	(0.006)	0.011	(0.014)	0.002	(0.019)
colonial status	0.257	(0.150)	0.824*	(0.371)	-0.087	(1.152)	0.650	(1.313)
aid	0.007	(0.004)	0.012**	(0.004)	0.005	(0.015)	0.015	(0.021)
fossil fuel energy gen.	0.667*	(0.288)	0.686	(0.471)	0.548	(0.838)	0.822	(1.943)
renewable energy gen.	0.535	(0.468)	6.502**	(1.769)	0.510	(2.356)	4.302	(6.455)
political freedom	0.165**	(0.042)	0.551**	(0.096)	0.154	(0.254)	0.430	(0.510)
population	0.929**	(0.068)	1.456**	(0.112)	1.237*	(0.489)	1.485*	(0.593)
ratification	-0.179	(0.148)	-1.439**	(0.423)	-0.230	(1.003)	-1.334	(2.786)
lnalpha					10.713		17.423	
lr test p-value $\alpha = 0$						1		1
observations	47		38		47		38	
ll	-90.03		-87.39		-121.1		-102.1	
economic development	0.107	(0.333)	-0.954*	(0.401)	0.107	(0.333)	-0.954*	(0.401)
economic growth	0.234	(0.165)	-0.198*	(0.081)	0.234	(0.165)	-0.198*	(0.081)
capital formation	-0.063	(0.038)	0.096	(0.053)	-0.063	(0.038)	0.096	(0.053
trade	-0.012	(0.010)	-0.011	(0.010)	-0.012	(0.010)	-0.011	(0.010
colonial status	0.080	(0.642)	-0.833	(0.674)	0.080	(0.642)	-0.833	(0.674)
aid	0.003	(0.005)	-0.012*	(0.006)	0.003	(0.005)	-0.012*	(0.006)
fossil fuel energy gen.	-0.130	(0.633)	0.465	(0.577)	-0.130	(0.633)	0.465	(0.577)
renewable energy gen.	0.328	(0.181)	1.340	(1.117)	0.328	(0.181)	1.340	(1.117)
political freedom	-0.506**	(0.193)	-0.101	(0.092)	-0.506**	(0.193)	-0.101	(0.092)
population	-1.168**	(0.338)	-1.670**	(0.482)	-1.168**	(0.338)	-1.670**	(0.482)
ratification	0.244	(0.480)	0.739	(0.489)	0.244	(0.480)	0.739	(0.489)
observations	115		107		115		107	
ll	-28.33		-26.65		-28.33		-26.65	
total ll	-118.36		-113.94		-149.43		-127.75	

** p<0.01, * p<0.05; Constants, included continental dummies, and dummy for China not shown.

is, however, insignificant. So far, results are as expected.

Turning to the factors relating to the feasibility of hosting CDM projects the picture becomes less clear. Gross fixed capital formation is surprisingly negatively related to the number of bilateral CDM projects. Although it is mainly thought to matter for unilateral projects, one might have expected some small positive effect for bilateral projects as well. The negative sign might be explained by the notion that in very fast growing economies with heavy capital investments the CDM becomes relatively less attractive to other investment opportunities, which will be investigated in specification 9. Trade per GDP, or openness, is significantly positively related to the number of bilateral projects as predicted. Political freedom and civil rights matter positively as well. While country links, measured by aid flows have no significant effect on the number of projects, a postive effect of being a former colony of a large buyer country cannot be rejected at the 10% level. All in all especially trade openness and political freedom affect the number of bilateral projects positively.

The control variables for population and ratification of the Kyoto Protocol have the expected signs, though only population is significant. Furthermore, one cannot reject that the coefficient for population is equal to 1, implying that a one percent increase in population is associated with a 1 percent increase in the number of projects.

Regarding the process generating zero counts fewer significant predictors are found. Besides the control for population only political freedom is statistically significant below the 1 percent level. This result seems reasonable as investors from developed countries, most notably non-private investors, may avoid investing in GHG abatement in less free and bad governed countries. More generally, the rather limited number of significant determinants for zero counts can be seen as a confirmation of the anecdotal evidence that the location of at least one bilateral CDM project is rather random. While the number of bilateral projects follows a clear pattern the question whether at least one CDM project is hosted in a developing country does not follow any clear pattern.

For unilateral projects the level of GDP turns out to be an important determinant too. As expected, the size of the coefficient is even higher for unilateral projects than for bilateral projects as all infrastructure, technology, and human skills have to be available domestically. Growth of GDP has a positive sign, but is not significant as well as is conventional energy intensity. Yet, renewable energy intensity turns up significantly positive. This is not surprising as countries that already have a reasonable amount of renewable energy generation in place are likely to both have the potential for a wider use of renewables, e.g., if water or wind energy is already used there is likely to be potential for more, and possess the technical capacity that is needed to build renewable power plants domestically.

Gross fixed capital formation and trade per GDP both have positive coefficients, but are not significant. However, being a former colony and aid flows from developed countries affect the number of unilaterally hosted projects positively. It seems that ties to developed countries are thus especially important for unilateral projects. Considering that unilateral project developers have to find the customers for their abatements on their own, strong ties to developed countries may help to reduce uncertainty about potential buyers and overall demand. Political freedom also has a strong positive effect as expected. Summing up, being a former colony, receiving more aid, and political freedom affect the number of unilaterally hosted projects significantly positively.

As for bilateral projects it is important to control for population and as well for the time to the ratification of the Kyoto Protocol.

There are more significant predictors of zero counts projects for unilateral projects. Here both the level and growth of GDP negatively affect the probability that a country does not host any CDM project. It is, hence, in the more advanced and faster growing developing economies in which the unilateral CDM is pursued. The result is intuitive in that it is in the more advanced developing countries in which the CDM can be pursued without a direct involvement of a developed country partner. Received aid lowers probability of not hosting any CDM project as well. A possible explanation is that aid flows relate positively to capacity building for the CDM. From the control variables population lowers the chances of hosting no project significantly.

Comparing the coefficients for bi- and uni-lateral projects significant differences are found. Equivalence of all coefficients is clearly rejected by Chow tests below the 1 percent level. Going more into detail and focusing on the number of projects the difference in the level of GDP is marginally not significant with a p-value of .154 using a robust seemingly unrelated variance-covariance matrix, which allows for a likely correlation of bi- and unilateral projects, to compare specifications 5 and 6. When comparing countries without accounting for continental differences (regressions not shown here, can be provided upon request) the level of GDP becomes close to significant with a p-value of .056 showing that GDP matters less within than between continents. Growth of GDP differences are as well marginally significant with a p-value of .094, which may be related to the fact that besides its generally positive effects on CDM potential, growth is generally seen as an important predictor for foreign direct investment, which in turn might help to overcome difficulties in project finance in case of the bilateral CDM. Regarding energy intensities, renewables are significantly (below the 1 percent level) more important for unilateral projects. As already mentioned CDM projects in the renewable energy sector are relatively easy to pursue unilaterally given that a considerable stock of energy generation already stems from renewables, and the necessary know-how is available domestically.

Regarding the variables mostly relating to the feasibility for hosting CDM projects gross fixed capital formation matters significantly (below the 1 percent level) more for unilateral projects as predicted. The difference for being a former colony is marginally significant with a p-value of .065 showing that strong links to potential buyer countries are relatively more important for hosting projects unilaterally. Finally, political freedom is significantly (below the 1 percent level) more important for unilaterally pursued projects, which may be interpreted as saying that good domestic institutions matter more for unilateral projects as well.

With respect to the controls significant stronger effects for unilateral projects are both seen for population and ratification of the Kyoto Protocol.

The probability of zero counts is comparatively lower for unilateral projects in countries with high levels and growth of GDP (significant below 1 percent) and to a smaller amount comparatively higher (significant below 5 percent) for countries with more GFCF. Aid flows lower the probability of a zero count for unilateral projects comparatively (significant below 5 percent) while they increase (significant below 5 percent) it for political freedom. Given that especially for bilateral project the pattern of participating in the CDM is rather unclear, and the size of differences besides the level of GDP are rather small, differences found between bi- and uni-lateral projects should better not be given too much weight.

Summing up the results of tables 2 and 3 it has been found that determinants differ for the number of CDM projects and for participation in the CDM at all. The gains in predictive power from changing from the one to the two equation models are substantial. Further, once hurdle models are employed overdispersion vanishes. In addition, substantial differences are found for the coefficients of determinants for bi- and unilateral projects suggesting that the unilateral CDM is suited comparatively better for relatively more advanced developing countries and former colonies of large buyer countries. Although the level of GDP per capita, colonial status, and political and economic freedom matter for both types of projects coefficients are significantly higher for unilateral projects.

Table 5 introduces alternative specifications, both shown for robustness and to strengthen the overall picture that significant differences among the determinants for hosting bi- and uni-lateral CDM projects exist.

Specifications 9 and 10 interact growth of GDP and GFCF per GDP. The first equation is thought to help understand the rather unintuitive finding of a negative coefficient for GFCF for bilateral projects, while the second is merely thought for comparison to unilateral projects. As suggested it may be that the negative coefficient is due to some interaction between growth and GFCF. At high levels of growth and capital formation the CDM may become relatively less attractive as an investment opportunity when compared to other investments. Hence the interaction between both variables should be negative. Indeed specification 9 reveals a negative and significant (below the 5 percent level) interaction [23] between growth and GFCF for the number of bilateral CDM projects, which is as well stronger for bilateral than for unilateral projects. Therefore, the relatively lower profitability of CDM projects in countries with high growth rates and high capital formation may indeed explain the unintuitive result of a negative coefficient for GFCF in equation 5.

In specifications 11 and 12 country investor risk as measured by the Institutional Investor (II) magazine is introduced as explanatory variable. Country risk assessments have not been introduced before as they are mainly thought to be a composite indicator largely consisting of a country's level and growth of GDP, trade openness, and political freedom (Cantor and Packer 1996, Cosset and Roy 1991) measuring the risk for foreign investors

[23] In our circumstance the relative change in the expected value of the counts given the values for growth and GFCF is of interest. As Winkelmann (2008, pp.71-72) shows the absence of such an interaction effect can be tested directly with a test of the coefficient for growth*GFCF = 0. If the absolute change were of interest, the appropriate test would be less straightforward (See Mullahy (1999) for details.).

Table 5: Alternative Specifications

	(9)		(10)		(11)		(12)		(13)		(14)	
	Bilateral Poisson Hurdle QML		Unilateral Poisson Hurdle QML		Bilateral Poisson Hurdle QML		Unilateral Poisson Hurdle QML		Bilateral Poisson Hurdle QML		Unilateral Poisson Hurdle QML	
VARIABLES	coef	se	coef	se	coef	se	coef	se	coef	se	coef	se
economic development	0.640**	(0.099)	0.864**	(0.231)	0.446**	(0.112)	0.865**	(0.285)	0.549**	(0.166)	0.922**	(0.269)
economic growth	0.742**	(0.180)	0.117	(0.182)	0.231**	(0.074)	0.100	(0.202)				
capital formation	0.014	(0.057)	0.083	(0.070)	-0.116**	(0.030)	0.070	(0.063)	-0.092*	(0.041)	0.048	(0.081)
growth_gfcf	-0.024*	(0.010)	-0.002	(0.005)								
country risk					0.018*	(0.008)	-0.001	(0.016)				
fdi inflows									0.267**	(0.095)	-0.039	(0.222)
trade	0.012**	(0.002)	0.009	(0.006)	0.010**	(0.002)	0.009	(0.007)				
colonial status	0.292*	(0.141)	0.832*	(0.382)	0.179	(0.149)	0.821*	(0.412)				
aid	0.007	(0.004)	0.012**	(0.004)	0.009*	(0.004)	0.012**	(0.004)				
fossil fuel energy gen.	0.637**	(0.217)	0.686	(0.467)	0.633*	(0.254)	0.674	(0.468)	0.401	(0.239)	2.487**	(0.742)
renewable energy gen.	0.863	(0.507)	6.525**	(1.891)	0.483	(0.461)	6.365**	(1.788)	-0.593	(0.439)	3.254**	(1.146)
political freedom	0.141**	(0.035)	0.544**	(0.099)	0.104*	(0.050)	0.548**	(0.125)				
population	0.929**	(0.058)	1.454**	(0.111)	0.857**	(0.074)	1.461**	(0.149)	0.765**	(0.080)	1.342**	(0.142)
ratification	-0.241*	(0.145)	-1.454**	(0.428)	-0.118	(0.130)	-1.434**	(0.431)	-0.104	(0.238)	-0.984	(0.658)
observations	47		38		46		37		46		38	
ll	-87.97		-87.35		-88.23		-87.31		-117.2		-146.2	
economic development	0.285	(0.393)	-0.780	(0.610)	0.236	(0.575)	-0.251	(0.701)	-0.181	(0.233)	-0.614*	(0.262)
economic growth	0.639*	(0.316)	0.825*	(0.409)	0.285	(0.174)	0.025	(0.119)				
capital formation	0.020	(0.048)	0.509**	(0.181)	-0.046	(0.042)	0.304*	(0.122)	-0.029	(0.032)	0.059	(0.044)
growth_gfcf	-0.016*	(0.007)	-0.051*	(0.022)								
country risk					-0.015	(0.044)	-0.090	(0.058)				
fdi inflows									0.273***	(0.088)	-0.118*	(0.064)
trade	-0.016	(0.011)	-0.013	(0.013)	-0.011	(0.011)	-0.005	(0.013)				
colonial status	-0.001	(0.691)	-0.919	(0.861)	-0.156	(0.700)	-1.207	(0.817)				
aid	0.005	(0.005)	-0.028*	(0.011)	0.002	(0.006)	-0.028*	(0.013)				
fossil fuel energy gen.	-0.197	(0.680)	1.234	(0.879)	-0.032	(0.683)	0.621	(1.068)	-1.169.599	(0.608)	0.729	(0.510)
renewable energy gen.	0.401*	(0.188)	2.143	(1.476)	0.468	(0.245)	1.136	(1.533)	0.447*	(0.183)	1.669	(1.125)
political freedom	-0.557**	(0.213)	-0.399*	(0.170)	-0.480*	(0.207)	-0.172	(0.142)				
population	-1.222**	(0.357)	-2.693**	(0.867)	-1.039**	(0.345)	-2.090**	(0.647)	-0.631**	(0.194)	-0.996**	(0.244)
ratification	0.300	(0.509)	1.855*	(0.860)	0.205	(0.695)	1.221	(0.741)	0.622	(0.400)	0.813	(0.491)
observations	115		107		104		99		113		104	
ll	-26.65		-17.50		-25.55		-18.97		-32.41		-30.92	
total ll	-114.62		-104.85		-113.78		-108.28		-149.62		- 177.12	

** p<0.01, * p<0.05; Constants, included continental dummies, and dummy for China not shown.

in a given country. Hence, there should be hardly any additional explanatory power left. The II indicator differs from most other country risk assessments in that it is build entirely from weighted expert assessments by employees of large investment banks (Cosset and Roy 1991). Their assessments are very likely influenced as well heavily by the indicators discussed above. However, if there is some additional "latent" information in the expert assessments that is shared by CDM investors in developed countries, II country risk ratings should show up significant for bilateral projects. It is indeed significant for the number of bilateral projects in specification 11 suggesting that location decisions of the bilateral CDM indeed take comprehensive country risk assessments into account.

An alternative amalgamated way of specifying determinants for hosting CDM projects is shown in specifications 13 and 14. Instead of focusing on a comprehensive set of individual determinants that are likely to affect the capacity to host CDM projects a plain comparison is made based mainly on FDI and GFCF. FDI is thought to matter relatively more for bilateral projects as these do involve foreign investments by developed countries and given that capital for investment in CDM projects is considered to be a scarce resource. For countries with less foreign investments domestic capital is thought to be relatively more important. Hence, GFCF should matter more for unilateral projects. The reason why FDI has not been used in preceding specifications is that is thought to be largely a composite indicator. Studies on the determinants of FDI have found that the level and growth of GDP, low inflation, political stability and ties and so forth matter (Schneider and Frey 1985). Therefore, in specifications 13 and 14 it is only accounted for the level of GDP, energy intensities, GFCF and the usual controls for population and ratification of the Kyoto Protocol. Comparing both specifications it is indeed found that FDI matters significantly more (below the 1 percent level) for the number of bilateral projects, while there is a significant (below the 5 percent level) positive difference for GFCF for unilateral projects as predicted. Although the results confirm in overall, that there are significant differences between unilateral and bilateral project determinants, the fit of these amalgamated models is worse than those of the previously specified models.

5 Discussion

Reviewing the state of the market for emission reductions from the CDM until the end of 2008, as well as the literature, hypotheses on the determinants for hosting CDM projects were derived. It was argued that economic development and growth, as well as the fossil fuel and renewable energy generation, should relate positively to the number of CDM projects hosted. Economic growth was expected to matter more for unilaterally pursued projects as well as domestic capital availability. Links to developed (buyer) countries as well as political freedom were expected to affect the number of CDM projects per country positively.

Results using count data models indicate, that the processes of generating positive project counts differ from the processes determining whether a country hosts at least one CDM project. For hosting at least one bilateral project, only political freedom and population are clearly significant with a positive impact. For the number of bilateral projects hosted, economic development and growth, as well as trade and fossil fuel energy generation matter significantly positive in addition. The condensed interpretation is, that although the number of bilaterally pursued projects is clearly determined by factors relating to CDM potential, feasibility, and profitability the question of participation in the bilateral CDM is comparatively random. For hosting at least one unilaterally pursued project, economic development and growth, as well as aid flows and population, are significant determinants with a positive impact. For the number of unilateral projects hosted, colonial status, renewable energy generation, political freedom, and early ratification of the Kyoto Protocol matter positively in addition. The positive impact of economic development and growth on hosting at least one unilateral project is one indication that the more advanced developing countries pursue the CDM unilaterally.

Differences among determinants for bi- and uni-laterally pursued projects are found as well for the number of projects hosted. Considerable and statistically significant differences in the size of coefficients are found for economic development (more important for unilateral CDM, statistically weak difference) and growth (more important for bilateral CDM), as well as for renewable energy generation (more important for unilateral CDM). Domestic capital availability is comparatively more important for unilateral projects, in addition to former colonial status and political freedom. The same holds for the controls for population and ratification of the Kyoto Protocol. Additional specifications shown for robustness find further differences regarding country risk assessments (considerably higher coefficient for bilateral CDM though statistically weak difference) and FDI (both economically and statistically more important for bilateral CDM). Tests on the overall equality of coefficients are clearly rejected. All in all, the unilateral CDM is more attractive to more advanced developing countries.

Summing up, it has been found that determinants differ for the number of CDM projects and participation in the CDM. Moreover, substantial differences in the coefficients of determinants for bi- and uni-lateral projects exist. The analysis suggests that the unilateral CDM is suited comparatively better for relatively more advanced developing countries.

6 Conclusion

Offset mechanisms like the CDM are perceived to be important building blocks for a global climate agreement succeeding the current Kyoto Protocol. The CDM, being the first global offset mechanism for GHG abatement in developing countries, provides an empirical example of how offset mechanisms can be used to reduce GHG emissions in developing countries. Given that the distribution of CDM projects is fairly unequal, it is of considerable interest to know, which developing countries host the CDM and what factors determine the number of CDM projects hosted. The analysis devotes special attention to differences between determinants for bilateral and unilateral CDM project hosting, finding that there are indeed "two ways to clean development".

Regarding policy, the current study shows that the CDM is an option for the richer developing countries, with the unilateral CDM being more attractive for the even more advanced developing economies. For these countries it can be regarded as an instrument providing the incentives that are needed for abatement of GHGs. However, the CDM is hardly attractive for the least developed countries, where other instruments, e.g., funds from the Global Environmental Facility are certainly required. The CDM might, therefore, be seen as an intermediate solution for relatively advanced developing countries encouraging them to participate in global climate change treaties before agreeing on binding targets themselves.

The option of the unilateral CDM, besides the bilateral one, can be regarded useful in that it allows fairly advanced developing countries to show that they are able to mitigate GHGs on their own given that the right incentives are provided. Furthermore, if CDM projects are pursued unilaterally, relatively more rents should remain in the developing countries, fostering enterprises that potentially produce environmentally more sustainably.

In turn, this makes the CDM more attractive relative to other investment possibilities. However, from an equity perspective, this might be of concern, as it implies that the most advanced developing countries gain the most from the CDM.

Appendix

Table 6: Summary statistics for explanatory variables

variable name	variable measure	mean	s.d.	min	max	source
economic development	logarithm of GDP per capita in 2004 in constant 2000 US Dollars	7.16	1.28	4.64	10.10	World Bank (2008)
economic growth	average GDP growth per capita (2000-2004)	4.28	3.33	-2.1	28.32	World Bank (2008)
capital formation	average gross fixed capital formation per GDP (2000-2004)	22.0	8.32	7.79	57.2	World Bank (2008)
trade	average imports and exports per GDP (2000-2004)	84.3	40.03	26.0	215.02	World Bank (2008)
colonial status	former colony of UK, Spain, France, Netherlands, or Germany	0.64	0.48	0	1	Hensel (2006)
aid	aid per capita in 2004 in USD	49.98	65.76	-133.78	408.7	World Bank (2008)
fossil fuel energy generation	in million kWh per GDP in 2004	0.0004	0.0005	0	0.0025	Energy Information Administration (2009)
renewable energy generation	in million kWh per GDP in 2004	0.0004	0.0011	0	0.0084	Energy Information Administration (2009)
political freedom	average of freedom house and polity in 2004	5.86	2.95	0	10	Hadenius and Teorell (2005)
population	logarithm of population on 2004	15.62	2.02	10.76	20.98	World Bank (2008)
ratification	logarithm of days until ratification of Kyoto Protocol	7.38	0.64	5.22	8.21	UNFCCC (2008)

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