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Knowledge Base Determinants of Technology Sourcing in the Clean Development Mechanism Projects

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KNOWLEDGE BASE DETERMINANTS OF TECHNOLOGY SOURCING IN THE CLEAN DEVELOPMENT MECHANISM PROJECTS

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Abstract

The Clean Development Mechanism (CDM) is one of the three greenhouse gas emission reduction and trading instruments of the Kyoto Protocol (KP). The CDM allows governments and business entities from developed countries to offset their emissions liabilities by reducing or avoiding emissions in developing countries, where it is often cheaper to do so. Examples of CDM projects include the installation of various renewable energy producing facilities, cutting the GHG emissions in industry and waste management, or projects focused on improving energy efficiency. From the sustainable development perspectives CDM has been alleged as a new channel of transfer and diffusion of climate friendly technologies (CFT) in developing countries. However we are evidencing that the majority of the CDM projects deploy local sources of technology, which challenges the North-South technology transfer paradigm established under the sustainable development agenda of the KP. This paper is an attempt to explain technology sourcing patterns in CDM projects through employment of knowledge base determinants. On the basis of an empirical analysis we conclude that in countries with a stronger knowledge base in CFT, CDM project implementers tend to go for local and combined technologies and less for foreign technologies.

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) [1] and its Kyoto Protocol (KP) [2] initiated an innovative approach in addressing climate change by introducing emission trading schemes involving both developed and developing countries. Three market-based instruments of KP namely, Emission trading (ET), Joint implementation (JI) and Clean Development Mechanism (CDM), are designed to allow flexibility and cost effectiveness in meeting greenhouse gas (GHG) reduction targets. While ET and JI capture GHG cutting activities in countries with emission reduction targets, CDM is designed to implement emission reduction initiatives in developing countries that do not have these targets. In other words CDM allows governments and business entities from developed countries to offset their emissions liabilities by reducing or avoiding emissions in developing countries, where it is often cheaper to do so. The objective of the CDM as defined in Article 12 of KP is twofold: 1) to assist developed country parties in achieving compliance with their emission limitation and reduction commitments under the Protocol, and 2) to assist developing country parties in achieving sustainable development. Under the sustainable development agenda CDM projects, besides delivering various social and economic benefits, are expected to transfer climate friendly technologies (CFTs) and expertise to developing countries. Therefore, the CDM scheme has been viewed as an effective means of subsidizing technological advancement of developing economies and, subsequently, placing them towards a more climate friendly growth trajectory.

Examples of CDM projects include the installation of various renewable energy producing facilities as well as projects geared towards the reduction of GHG emissions in chemical, cement, waste management and other industries through changing the processes or improving energy efficiency. Like with many environmental technologies, GHG cutting technologies and related expertise are either not widely diffused, or even new to developing countries (Aslam, 2001; Forsyth, 1998). On the other side, economical and technological frontrunner countries have big advantages in this aspect. Large amounts of R&D investment and special national programs such as promoting renewable energy and waste management practices, combined with stricter environmental standards have moved them to the technological frontier (Newell, 1997; Blackman, 1999). With the start of the CDM it was expected to observe large flows of technologies and expertise flowing from the technologically developed North to the South. Therefore from an international development perspective CDM has been alleged as a new channel of international transfer and diffusion of green technologies (e.g. see Wilkins, 2002; Aslam, 2002).

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[1] UNFCCC entered into force on 21 March 1994. It has now been ratified by: 41 Annex I Parties, which includes OECD and EU Member countries and 16 other countries (mostly European countries with transition economies); and 148 non-Annex I Parties, including most developing countries.

[2] Kyoto Protocol of the UNFCCC is an agreement regulating global greenhouse gases emission trading. It was designed in 1997 and entered into force in February 2005 and has been ratified by 35 Annex I Parties and 120 non-Annex I Parties. Until now it has been the only agreement regulating emission trading scheme of the global scale.

However, real experience with CDM projects has not always supported this seemingly logical expectation. Studies harvesting technology transfer statistics from CDM projects report technology transfer happening for only roughly one third of the projects (Haites *et al*, 2007, Seres 2008, Dechezlepretre *et al.,* 2008). Our examination of a sample of 497 projects showed that less than half of them involved various degrees of foreign technology participation (Appendix A). More specifically, 94 projects (19%) fully relied on foreign technology; 109 projects (22%) reported a combination of foreign and local technologies or joint work of local and foreign engineers on the installation design. Given the high promises of technology transfer, it is striking that in over half (or 56%) of the projects reviewed by us the whole package of technology deployed was of local origin.

Furthermore, companies from developing countries such as China, Malaysia, Taiwan and South Africa were identified as technology providers for projects in other developing countries (Appendix B). In 282 projects technology was supplied by companies from developing countries, while technology providers from developed countries, the so-called Annex 1 countries, took part in 175 projects[3]. This development has been rather surprising especially in the light of the technology transfer promises stressed in the policy agenda. These figures might suggest that in the concept of the CDM based "North-to-South" technology transfer the capabilities of the "South" have been somewhat underestimated. Therefore it might be reasonable to put forward the argument to stress the importance of the local technological knowledge in developing countries in addressing goals of the Kyoto Protocol in general, and technology transfer in CDM projects in particular.

Talking about technology transfer, the countries that have experience with technologies are supposed to have accumulated knowledge in this technology which would make them less dependent on the acquisition of technology from abroad. In this paper we distinguish two types of technological knowledge. First, the knowledge about how to produce and operate the technology; this involves skills of people dealing with this technology, knowledge embedded in the machines, and knowledge gained through optimization of these machines. Second is scientific knowledge associated with formal R&D in certain technologies, which usually takes place either at companies developing these technologies, or at universities and public research labs. Both types of knowledge, practical and scientific, are building blocks of the country level knowledge base. However they might have different effects when it comes to decision-making about where to acquire technology from for a new project.

We endeavoured to shed some light on this perspective by firstly investigating the available scientific and operational expertise of project host countries, which is appropriated by the

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[3] information about origin of technology providers in 68 project was not available

‘technological knowledge base’ concept. Secondly, we analyze the relationship of this knowledge base with the technology sourcing patterns in CDM projects.

The aim of the study is exploratory and as to the best of our knowledge this perspective has hardly been applied in CDM related research. The central research question addressed in this study is whether existing technological knowledge in the country shapes the technology sourcing patterns in CDM projects. Because it is a very specific case of climate friendly technologies, we had to focus on the technological knowledge base in this narrow technology group. Furthermore, in this paper we treat the concept of knowledge base as a two-dimensional concept representing practical and scientific knowledge in the CFT area of each country. Sub-questions addressed in this study refer to each of these dimensions and are formulated as follows: What is the role of practical knowledge associated with the application of CFTs in the country in determining technology sources in CDM projects? What is the role of scientific knowledge in this process? How different are the roles of each knowledge type?

Technology sourcing statistics in CDM projects calls first for theoretical grounding of the raised research questions, and second, for a more empirical setting in which macro level factors associated with a knowledge base can be operationalized. Our attempts to explain it through knowledge base indicators have a number of compelling reasons. First, in the current debate of the post Kyoto perspective there is a need for a better understanding of technological development aspects, especially with respect to developing nations (Kline *et al*, 2004). Second, despite high political interest in this area, CDM literature does not adequately address such perspectives as technological capabilities and learning, technological change, and catching-up. Our task is to fill this gap by bringing together and analyzing empirical data on technology sourcing in CDM projects and country level CFT specific technological capability and knowledge indicators.

The paper is structured in the following way. The second part of the paper provides more of the choice justification from the standpoint of the literature gap and discusses the theoretical concepts that ground the approach adopted in this study. The third part is methodological; it describes the data sources, construction of variables, provides descriptive statistics and econometric techniques. Econometric results are presented in the fourth part. Discussion, conclusions and implications appear in the last two sections of the paper.

2. Theoretical grounding and main arguments

In order to understand why CDM project initiators in certain countries or technology sectors rely on local technologies and others on foreign, we tried to see what the concepts of technological knowledge base and technological capabilities can offer us. The importance of the knowledge base of a country in its economic development and catching-up has been extensively highlighted in the economics literature. The idea of the knowledge economy has found imperative recognition in the policymaking domain and led to a paradigm shift in the whole concept of economic development (Foray and Lundvall, 1996, Abramowitz, 1989). Now it is widely acknowledged that technological capabilities and knowledge base are important strategic assets in boosting economic growth on national, sectoral, and firm levels. Besides, technological capabilities are a necessary prerequisite, both in the creation and diffusion of technologies. At the same time it would be incorrect to ignore the importance of technology transfer. Many studies have demonstrated that knowledge arrives with foreign direct investment. Therefore the idea of complementarity of foreign technology import with domestic technological effort as a most optimal recipe for promoting technical change and catching-up in developing countries has been repeatedly highlighted by development economists (Radosevic, 1999).

In the context of climate change mitigation the role of technology is acknowledged both by supporters and detractors of the Kyoto protocol. Early adoption and learning in climate friendly technologies have been suggested as the most efficient ways of combating climate change (Thorn, 2008). Therefore it is very important to develop and diffuse the knowledge over the world, especially in developing countries whose rapid industrialization is threatening to outweigh all current efforts on mitigation of climate change. Being the largest framework of collaboration with developing countries under climate change initiatives, CDM is seen and hoped to be a channel for the transfer of environmentally sound technologies (Philibert, 2005).

However, over the last years another perspective seems to be emerging: developing countries not as receivers of the technology but as producers of it (see e.g. study by Brewer, 2008). Within this perspective there is a need to analyse the (current and future) active technological role of developing countries in mitigating climate change. Developments in the global renewable energy sector within the last few decades show the active positions of some developing countries in promoting renewable energy technologies. For example, favourable state policies made India the fourth and China the fifth global largest wind energy producers in 2007 (Lewis and Wiser, 2007). With the purpose to achieve energy independence, the Brazilian government pushed development of bioethanol production in the country, which made Brazil the second largest producer and the global leader in export of biofuel (Lemos, 2007). Besides, developing countries produce somewhat over 40% of the global renewable electric capacities without counting for large-scale hydropower (REN21, 2008). Certainly, these capacities are not spread equally across developing countries. Some countries are capable to implement a full technology development cycle: starting from R&D in green energy technologies till the manufacturing and exploitation, while others do not even have generation capacities. Having these prospects in its background, the present study attempts to analyse the current state of the technological knowledge base of developing countries and its implications for CDM experience on the basis of empirical evidences and data.

We searched the literature on CDM to see if any attempt had been made to address this issue. There is a vast family of literature including policy papers, assessment studies, conceptual propositions, models and case studies building a dispersed discourse around the "CDM and technological development" topic. This literature addresses such issues as technology selection, transfer barriers and potential, spillover, possible scenarios, etc. (e.g. see Schneider *et al.* 2008; Kaneko, 2006; Aslam, 2002; Millock, 2002). Yet the number of quantitative studies based on empirical data is still limited due to the rather short history of CDM implementation experience. However, it looks like more studies are on their way and preliminary results are fostering a new discourse. Recently there emerged a first wave of studies analyzing determinants of technology transfer patterns in CDM projects (Haites *et al*, 2006; De Conninck *et a*l, 2007; Seres, 2007; Puyeo Velasco, 2007; Dechezlepretre *et al,* 2008). These authors used different sized samples of CDM projects and built statistics on whether projects involved local or foreign technology and expertise, hence produced counts of technology transfer evidences. Then they analyzed what factors are associated with technology transfer statistics. These studies highlight that technology transfer occurrence is positively associated with larger projects, availability of foreign partners and affiliation of project host with foreign company, smaller countries and those with larger GDP. Also, technology transfer seems to be associated with certain types of technologies only. [4]

With respect to the focus of our paper interesting points have been revealed in studies by Puyeo Velasco (2007) and Dechezlepretre *et al (*2008). The first authors investigated the impacts of renewable energy endowments and/or potential of host countries on technology transfer patterns in the CDM. One of the findings of the study was that large hydropower generation capacities are negatively associated with technology transfer occurrence in CDM projects. This was explained by the fact that in CDM host countries with hydro-electricity production capacities the technology is already there, thus there is no need to transfer it from abroad. This was an appealing point for our study as it associates local availability of technology with practical experience related knowledge.

Dechezlepretre *et al (*2008) included in their model the country-level technological capability index (also called ArCo) developed by Archibugi and Coco (2004) in order to identify its influence on technology transfer events in CDM projects. While it demonstrated that country level technological capability is positively associated with sourcing the technology from abroad, mixed results were obtained after controlling for different sectors, showing strong positive significance for energy and chemical industries and a negative influence in agriculture. These results are interesting, both in terms of getting insight, as well as in revealing potential challenges in the application of such a broad technological capability indicator as the ArCo index for this specific case. The ArCo index represents the country's overall technology and knowledge potential and is composed of country level science, technology, education, and other indicators. The group of technologies applied under the CDM includes a number of

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[4] Technology transfer is more likely for agriculture, HFC, N2O projects and less likely for Biogas, Biomass energy, Cement, Coal bed/mine methane, Energy efficiency own generation, Energy distribution, Fossil fuel switch, Fugitive, Hydro, Landfill gas, and Reforestation.

environmental technologies such as renewable energy, energy efficiency, waste management, etc. This group represents rather a narrow niche and their R&D related and diffusion dynamics differ from those of conventional technologies and products[5]. Therefore the country's capacity in these technologies could be different from the overall technological development level and aggregated S&T capacities. In a few aspects our study builds on observations and the model of Dechezlepretre *et al (*2008). However we have tried to be more specific in defining the technological knowledge base indicators relevant to the CDM technologies and investigating their influence in technology sourcing statistics in CDM projects.

Another distinct feature of our study is in the conceptual approach of the technology sourcing idea in CDM. The aforementioned studies focused on explaining the technology transfer occurrence (in other words foreign technology application) cases and investigated factors influencing the foreign technology choice. In contrast, the angle of our study is rather on projects using local technologies and factors affecting this alternative. We suggest that behind this choice there is a history of evolution and diffusion of the technology, accumulation of knowledge in this technology in the CDM project host country; this in turn is currently shaping CDM related developments in the country. Therefore our research questions call for understanding the knowledge base in the country in order to understand why in most of the cases project developers go for local technologies rather than foreign ones. In order to address the research questions we first needed to define the proxies that could serve as measures for applied and scientific knowledge; second, to identify data-sources and extract data constituting these proxies for each analyzed country; third, to bridge these data to CDM projects statistics and carry econometric analysis.

3. Data and Methods

Data sources

In this study we are trying to explain the technology sourcing patterns in a sample of CDM projects registered during the first two years after the Kyoto Protocol enforcement. Information and data regarding each project are accessible through the so called Project design documents (PDD) which are available for download on the UNFCCC website[6]. Although these documents do not have the explicit objective to present detailed information about the origin of technology deployed in the project, in most cases we were able to extract information about the technology type, origin, and technology providers. In some cases it was necessary to supplement the revision of the project documents with checking additional documents from the UNFCCC, to consult other internet resources, or through direct communication with experts involved in CDM

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[5] For example the literature on environmental innovations highlights supremacy of state inducement factor (special policies) over market forces (like demand or competition) in success of environmental technologies.

[6] Access to CDM project documents is on http://cdm.unfccc.int/Projects/projsearch.html

projects. From the PDDs we acquired very detailed information about project location, its size in terms of annual reduction of carbon emission, the project operator, its affiliation status, partners, credit buyer information, etc. Project list and time frame regarding registration were obtained from the online database of UNEP Riso (2007).

The initial list of CDM projects included 497 projects located in 42 countries. During the analysis we had to exclude 37 observations due to missing data on project and/or country level. Thus the final sample has 460 observations and covers 36 countries (see Appendix A). India, Brazil, Mexico and China are the largest project recipient countries hosting 76.3% of projects within the sample. Other countries have between one and fourteen projects. As for the technology origin, 257 projects (55.9%) count application of purely local technology, 94 projects (20.4%) involve a complete package of foreign technology, and 109 cases (23.7%) report combination of local and foreign technologies.

Various country level data for constructing independent and control variables were acquired from the International Energy Agency (IEA), United States patent and Trademark Office (USPTO), United Nations Commodity Trade Statistics Database (COMTRADE), Science Citation Index Expanded (ISI/SCI-E) of the Institute for Scientific Information, and World Development Indicators (WDI) of the World Bank.

Constructing variables

Dependent variable: Technology origin

The present study has been designed to examine the origin of technology deployed in CDM projects. On the basis of the observations obtained through PDD documents we used three categories for technology sources: *local*, *foreign*, and *combined*, to indicate the ‘Technology origin’ variable. Our application of multi categorical variables differs from approaches in other studies that use binary variables to indicate technology transfer evidence or absence of it (Dechezlepretre *et al.* 2008; Haites, 2006; Seres 2008). Compatibility of their indicators with ours is in the definition of the technology transfer these authors apply. In their papers technology transfer is allied with the import of equipment and/or knowledge from abroad. In our case we are studying technology origin (local versus foreign) and in quite a large number of cases (109 projects) it was impossible to judge whether the technology and expertise applied in the project was completely of either local or foreign origin. Therefore in addition to the categories *local* and *foreign* we introduced the category *combined* for the projects that involved a combination of local and foreign technology and/or expertise. Examples of combined cases are when local engineers do the technical design of the facility, but the machines to equip the facility are bought from abroad. Opposite cases often happen when foreign companies specialized in CDM projects bring their design but involve local companies in supplying the parts for technological lines. In some projects, technology partially consisted of local and foreign equipment blocks compiled and put together (e.g. imported automated control system and locally produced power generator, or local biogas digesters and imported power cogeneration unit).

Independent variables: Country’s knowledge base indicators

The country and sector specific technological knowledge base is a complex multidimensional concept including such aspects as the diffusion level of the technology which reflects the knowledge in application of the technology, availability of technology related R&D, production expertise in the country’s specific sectors, availability of educational institutions, and technical potential in this area. Dealing with a CDM case requires looking into the indicators exclusively related to the generation and application of climate friendly technologies. Over 90% of CDM projects deal with renewable energy production, energy saving and biogas recovery technologies. Therefore we focused on the collection of data on these specific sub-sectors. Table 3 below presents the constructs that we applied to indicate the CDM technologies specific knowledge base in each country.

The first factor, the diffusion level of climate friendly technologies, is associated with production capacities and practical experience in climate friendly technologies. The assumption here is that the higher diffusion level of the technology represents better practical knowledge in this technology in the country. We suggest two proxies to measure it: the production of electricity from renewable energy sources and the share of export of these technologies.

Table 1. Indicators proposed to measure knowledge base specific to CDM technologies

Constructs for CDM technologies knowledge base	*Data and measurements*	*Source of data*
Diffusion level of climate friendly technologies	• Share of energy from hydro, wind, solar, geothermal, biomass in total primary energy supply • Share of climate friendly technologies in the flow of total export of goods	International Energy Agency UN Commodity Trade Statistics Database
Scientific effort in climate friendly technologies	• Share of scientific articles in climate friendly technologies in total pool of scientific articles • Number of patents in climate friendly technologies by inventor	Science Citation Index expanded US PTO database

The amount of electricity produced by renewable sources, and its share in the total energy mix of the country are fairly good indicators of the country’s experience and hence knowledge, in application of renewable energy technologies. Evidently, larger renewable energy generation capacities are associated with a higher diffusion level of renewable energy technologies in a country which in turn is associated with larger operational knowledge in these technologies.

The logic behind using the Export performance indicators is somewhat similar. Countries with higher shares of export in certain technologies are the ones that produce these technologies. Production requires strong and sophisticated knowledge that is constituted by engineering knowledge, knowledge embedded in machines, and often R&D. Therefore we argue that the country’s performance in export of climate friendly technologies is a good indicator of the local knowledge in these technologies.

From the International Energy Agency (IEA) database we obtained the data on electricity generated from renewable energy sources and calculated its share in the total national energy production mix (Total primary energy supply, TPES) for 2005. This gave us our first independent variable ‘Renewable energy share’. Similarly we calculated the share of climate friendly technologies in the total value of exported goods (‘Export of CFT’). The source for the export data was the UN Commodity Trade Statistics Database that uses the Harmonized Commodity Description and Coding System (HS1996). The OECD has well defined typologies of technologies and specifying codes for environmental technologies in various sectors (Steenblik, 2005a, b). We restricted our search to codes covering the energy sector, such us energy production and saving (see annex III for codes used). Our methodological choice is again based on the dominance of energy technologies in overall CDM projects portfolio.

The second group of variables represents the purely scientific or R&D related knowledge base of the countries, which can be measured through the number of patents filed and scientific articles published in the fields of climate friendly technologies. Although many inventions are never patented in developing countries, patents can represent a valid proxy for a form of codified knowledge generated by profit seeking firms and organizations (Archibugi and Coco, 2004). Patent count is a widely applied indicator for measuring innovativeness of country, company or industry. And no one would argue that innovation is a result of intensive knowledge application, while a patent is a document for codification of scientific knowledge.

We used the USPTO database to search data on each country because this office receives a greater number of foreign patent applications than any other patent office (Archibugi and Coco, 2004). The patent IPC codes for specific renewable energy technologies have been sourced from Johnstone et al (2008). Others covering such technologies as landfill gas recovery and energy efficiency were identified by us. The complete list of IPC codes used in the search is presented in the annex II. As it was expected, patent counts demonstrated a significant difference in performances between such countries like Israel and South Korea and the rest of the group. Roughly one third of the countries counted zero patens in climate friendly technologies. Due to this problem we had to convert the continuous variable into a dummy by introducing two new categories: “zero and low performers” and “medium and high-performers”. The grouping approach was based on using the median as a threshold for splitting the whole group of countries. Thus the variable ‘Patent in CFT’ indicates if a particular country belongs to the medium and high performers group (=1).

Armenia, Bangladesh, Bolivia, Cambodia, Guatemala, Honduras, Moldova, Mongolia, Morocco, Nepal, Nicaragua, Pakistan, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador	Zero and low performers (below median group)
South Africa, Argentina, Philippines, Mexico, China, Cyprus, India, Sri Lanka, Colombia, Peru, Brazil, Jamaica, Nigeria, Egypt, Indonesia, Malaysia, Viet Nam, Israel , Republic of Korea	Medium and high performers (above median group)

Another important source of codified knowledge is scientific literature (Archibugi and Coco, 2004). Scientific publications represent the knowledge generated in universities, research centers, and other publicly, as well as privately funded research organizations. Therefore the number of publications is another definite proxy for scientific knowledge in a country and/or in particular field. Narrowing down to a field of climate friendly technologies we could evaluate the knowledge base of each country in these technologies.

The variable indicating the share of scientific articles on climate friendly technology studies in the total number of scientific articles (‘Publications in CFT’) was obtained from publication counts from the Science Citation Index Expanded (SCI-E) database in ISI Web of Science. This database is known to be the most comprehensive and validated, and believed not to be heavily discriminating against developing countries (Archibugi and Coco, 2004). For the search strategy we employed a lexical query consisting of a small set of keywords. Themes of publications have been visually revised to ensure relevance to the topic. Several articles have been excluded based on the irrelevance of the journal's subject area.

Control variables

Additional variables taken into consideration by us in the econometric analysis are project specific characteristics and country specific variables. In selecting them we referred to suggestions by other studies on CDM driven technology transfer.

Project specific variables such as the size, ownership status of the project operator company, i.e. subsidiary or foreign partner, and existence of similar projects in a host country have been taken into consideration. Previous quantitative studies have established that there are economies of scale in technology transfer: All other things being equal, transfers in large projects are more likely (Dechezlepretre et al.2008; Haites, 2007; Seres 2008). Following this we included a project size variable (‘Project size’) in the model. It is necessary to note that the project size is measured by annual amount of CO2 equivalent emission reduction. Furthermore, these studies established that the probability of transfer is 50% higher when the project is developed in a subsidiary of a company from an Annex 1 country (Dechezlepretre et al. 2008). We have recorded the information about the evidence of host projects being a subsidiary of a foreign partner and introduced the subsidiary dummy indicator (‘Subsidiary’). Besides this, the previous study also established that the probability of involvement of any sort of foreign technology decreases with the number of projects using the same type of technology in the country (Dechezlepretre *et al*, 2008). Following this finding we controlled for these factors by introducing the variable ‘Similar projects’, which indicates the number of CDM projects in the same technology for each country.

Country specific variables included in our econometric model are country size, income level, trade and local renewable energy resource endowment. Country size is treated in our model through Log of population (‘Population’ variable). It captures the effect of country size on the propensity to import the technology. Theoretically, large countries have a more diversified industrial base, which means higher chances of having technology domestically available. A similar argument goes for the GDP per capita (‘GDP/cap’) indicator. Countries with a higher level of wealth production tend to have a better technological base, and are likely to have technologies in their domestic market. However the observations on these variables in other studies based on varied size samples of projects showed mixed results (Seres, 2007, Haites *et al*, 2006, Dechezlepretre *et al,* 2008).

Previous studies on technology transfer in CDM were in line with general economic literature in providing empirical evidence that transfer of technology is associated with higher FDI and international trade activities (Pueyo Velasco, 2007; Dechezlepretre *et al*, 2008). To capture this effect we introduced the variable ‘Trade’, which is the sum of the trade value of exports and imports of all commodities during the years 2002-2005 divided by the country’s GDP. The control variable related to FDI was avoided for the following reasons: first, participation of the foreign capital is already captured by the subsidiary dummy variable; second, the FDI/GDP indicator showed a high correlation with other variables, which may distort the regression results.

Table 4 summarizes the information on variables that we have applied, their descriptive statistics and expected effect on the outcome. Table 5 presents the correlation coefficients among all variables. A correlation test helps to detect a possible problem of multicollinearity in the regression and to select the control variables to be included in the final model. This test resulted in omitting some of the control variables that we initially planned to have in the model[7]. The independent variables essential for our study were deliberately kept. Nevertheless, the results of the correlation test did not show a high correlation among the independent and control variables and thus there was no multicollinearity problem.

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[7] FDI inflow, availability of credit buyer, and GDP growth that were suggested by other studies appeared to have high correlation with the rest of the variables risking possible multicollinearity problems. Therefore we excluded them in the econometric analysis.

Table 2. Definition of variables and summary statistics

Variables	*Description*	*Mean*	*Std. Dev.*	*Exp outcome*
Technology origin	Dependent variable technology origin; Categorical variable containing {Local, Foreign, Combined}.	-	-	-
Project size	Log of the size of the project (expected annual reductions in ktCO2eq)	3.709	1.507	-
Subsidiary	= 1 if the project host company is the subsidiary of a foreign partner, 0 otherwise	0.220	0.414	-
Similar projects	Natural Log of the number of projects already using the same type of technology within a host country	2.613	1.325	+
Trade	sum of annual values of exports and imports of all commodities divided by the value of GDP (average for 2002-2005)	0.489	0.320	-
Population	Natural Log of total population in million (2005)	5.449	1.672	+
GDP/cap	GDP per capita (2005) in thousand USD	3.418	3.346	+
Publications in CFT	Share (%) of scientific articles in climate friendly technologies in a national pool of scientific publications	0.515	0.276	+
Patents in CFT	=1, if country has more than 1 patent in climate friendly technologies, =0, if country has zero or 1 patents	0.893	0.308	+
Export of CFT	Share (%) of climate friendly technologies in total value of exported goods, average of 2002-2005	1.402	0.826	+
Renewable energy share	Share (%) of renewable energy in the national total primary energy supply for 2005.	0.543	0.567	+
N = 460				

Table 3. Correlation matrix of variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Technology origin	1.00									
(2) Project size	0.15	1.00								
(3) Subsidiary	0.57	0.19	1.00							
(4) Similar projects	-	-	0.03	1.00						

	0.11	0.31								
(5) Trade	0.32	0.10	-0.03	-0.25	1.00					
(6) Population	-0.36	-0.02	-0.25	0.50	-0.44	1.00				
(7) GDP/cap	0.29	-0.00	0.33	-0.09	0.23	-0.57	1.00			
(8) Publications in CFT	-0.30	-0.15	-0.32	0.20	-0.10	0.41	-0.47	1.00		
(9) Patents in CFT	-0.05	-0.08	-0.02	0.47	-0.16	0.60	0.01	0.17	1.00	
(10)Export of CFT	0.08	0.04	0.29	0.15	-0.06	-0.24	0.43	-0.43	0.02	1.00
(11)Renewable energy share	0.16	-0.01	0.20	-0.14	-0.11	-0.35	0.17	-0.45	-0.09	0.45

Multinomial Logit Model estimation

The dependent variable indicating technology origin in each project is a categorical variable with three possible outcomes: local, foreign and combined (Table 6).

Table 4. Distribution among outcome categories of the dependent variable “Technology origin”

Outcome categories	*Frequency*	*Percent*	*Cumulative.*
Local	257	55.87	55.87
Foreign	94	20.43	76.3
Combined	109	23.7	100
Total	460	100	

In the cases of the categories of non-ordered nature like this it is appropriate to use multinomial logistic regression model (Greene, 2003; Long and Freese 2006). The multinomial logit essentially works as a simultaneous estimator of separate binary logit for each pair of outcome categories. When using this model, one category of the dependent variable is chosen as the comparison, or reference category. In general for J alternatives, only J–1 binary logits need to be estimated.

In the multinomial logit model we assume that the log-odds of each response follow a linear model:

$$\eta_{ij} = \log \frac{\Pr_{ij}}{\Pr_{iJ}} = \alpha_j + \beta_j \mathbf{x}_i, \qquad (1)$$

where α_j is a constant and β_j is a vector of regression coefficients, for j = 1, 2, …, *J*-1. This model is analogous to a logistic regression model, except that the probability distribution of the response is multinomial instead of binomial and we have *J*-1 equations instead of one. The *J*-1 multinomial logit equations contrast each of categories 1, 2, …, *J*-1 with category *J*, whereas the single logistic regression equation is a contrast between successes and failures.

We need *J*-1 equations to describe a variable with *J* response categories and that it makes no difference which category we pick as the reference cell, because we can always convert from one formulation to another. In our case with *J* = 3 categories, 'foreign' was assigned to be the reference category, thus we contrast categories 1='local' versus 3='foreign', and 2='combined' versus 3='foreign'. The missing contrast between categories 'local' and 'combined' can be obtained in terms of the other two, since

$$\log(\Pr_{i1}/\Pr_{i2}) = \log(\Pr_{i1}/\Pr_{i3}) - \log(\Pr_{i2}/\Pr_{i3}) \qquad (2)$$

The multinomial logit model may also be written in terms of the original probabilities $\Pr_{ij}$ rather than the log-odds. Starting from equation (1) and adopting the convention that $\eta_{iJ} = 0$, we can write

$$\Pr_{ij} = \frac{\exp\{ \eta_{ij} \}}{\sum_{k=1}^{J} \exp\{ \eta_{ik} \}} \qquad (3)$$

for j = 1, …, *J*. To verify this result we exponentiate equation (1) to obtain $\Pr_{ij} = \Pr_{iJ} \exp\{\eta_{ij}\}$. Note that the convention $\eta_{iJ} = 0$ makes this formula valid for all j. Next sum over j and use the fact that $\sum_j \Pr_{ij} = 1$ to obtain $\Pr_{iJ} = 1/\sum_j \exp\{\eta_{ij}\}$. Finally, use this result on the formula for $\Pr_{ij}$. Note that Equation (3) will automatically yield probabilities that add up to one for each i.

4. Results

The multinomial logit model was estimated using Stata version 10. The results of the regression are presented in table 7. Both models show the estimates of the choice of local technology and combined technology sources over the default category of foreign technology. Model 1 includes the results for the control variables only, whereas Model 2 also incorporates the independent variables. This table shows only the estimates for each category against the default category (foreign origin). To check whether there is a different effect of the independent variables on the different choice of technology origin, we can use odds ratios (*e^b and e^bStdX*) presented in table 8. This table decomposes the effect of the independent variables on the technology source into binary choice models. If the value of the binary choice is greater than 1, it indicates an effect of independent variable on selecting one technology source over another; a value smaller than 1 indicates an effect in the opposite direction. Statistical significance of the result can be judged by the significance of the associated coefficients (*B*) presented in the same table.

Table 7. Multinomial logit estimated

	Model 1		Model 2	
	Local	Combined	Local	Combined
Project size	-0.388*** (0.105)	-0.419*** (0.127)	-0.529*** (0.121)	-0.453** (0.137)
Subsidiary	-1.976*** (0.469)	1.978*** (0.427)	-2.210*** (0.513)	1.759*** (0.447)
Similar projects	0.579*** (0.145)	0.695*** (0.169)	0.362* (0.157)	0.546** (0.177)
Trade	-2.774*** (0.719)	0.873* (0.455)	-1.610* (0.805)	0.898* (0.511)
Population	0.121 (0.117)	-0.089 (0.146)	0.724*** (0.208)	-0.123 (0.213)
GDP/cap	0.030 (0.047)	-0.032 (0.061)	0.114* (0.071)	-0.087 (0.086)
Publications in CFT			1.726* (0.689)	0.162 (0.839)
Patents in CFT			-2.291** (0.778)	0.629 (0.747)
Export of CFT			1.031*** (0.242)	0.364 (0.246)
Renewable energy share			0.569* (0.333)	0.475* (0.322)
_cons	2.078*** (0.837)	-0.418 (0.911)	-1.519 (1.290)	-0.894 (1.163)
Log likelihood	*-296.46*		*-273.97*	
Prob > chi2	*0.0000*		*0.0000*	
Pseudo R2	*0.3496*		*0.3990*	

a. foreign origin is the comparison group
b. *significant at 10%; **significant at 5%; *** significant at 1% level
c. Robust standard errors in parentheses
d. N=460

The results in tables 7 and 8 show that the scientific contribution in terms of publications in climate friendly technologies in a country is expected to have a positive effect on the preference for local over imported technologies (5% significance) and on combined over imported technologies (10% significance) in CDM projects. Results for the comparison between combined and imported technologies do not show statistical significance; therefore we are not able to draw strong conclusions.

The results for the influence of patenting activities show a strong negative effect on using purely local technology and to the contrary seem to be strongly associated with a preference for combined technology over local. A positive association is also observed for “Foreign over Local”, though the result is slightly less statistically significant. We note that the magnitude of the coefficients make it clear that countries with high patenting activities give slightly higher preference to combined sourcing over foreign. The results on local and foreign technology sourcing show the opposite of our expectations and require careful interpretation.

Table 8. Effect of independent variables on the choice between different technology origins

		Local over Combined	*Local over Foreign*	*Combined over Local*	*Combined over Foreign*	*Foreign over Local*	*Foreign over Combined*
Publications in CFT *SD=0.28*	*B*	1.561**	1.722*	-1.561**	0.162	-1.722*	-0.162
	e^b	4.761	5.598	0.21	1.176	0.179	0.851
	e^bStdX	1.538	1.609	0.65	1.046	0.622	0.956
Patents in CFT *SD=0.31*	*B*	-2.917***	-2.287**	2.917***	0.629	2.287**	-0.629
	e^b	0.054	0.102	18.488	1.877	9.848	0.533
	e^bStdX	0.406	0.493	2.462	1.215	2.027	0.823
Export of CFT *SD=0.82*	*B*	0.667**	1.031***	-0.667**	0.365*	-1.031***	-0.365*
	e^b	1.948	2.805	0.513	1.44	0.357	0.694
	e^bStdX	1.734	2.344	0.577	1.352	0.427	0.74
Renewable energy share *SD=5.68*	*B*	0.009	0.05624*	-0.00886	0.04738	-0.05624*	-0.0474
	e^b	1.009	1.0578	0.9912	1.0485	0.9453	0.9537
	e^bStdX	1.052	1.3763	0.9509	1.3087	0.7266	0.7641

b = raw coefficient
e^b = exp(b) = factor change in odds for unit increase in X
*e^bStdX = exp(b*SD of X) = change in odds for SD increase in X*

Results on the effect of the country’s export of renewable energy and CFTs on the preference of local technology over imported show a positive, stable and strong significance in the regression model. A slightly smaller (5%) significance, but still positive coefficient is associated with preference of combined over imported technologies. This logically supports the idea that availability of the technology on the local market decreases the propensity of bringing similar technology from abroad.

Countries' renewable energy production data showed a rather modest but positive effect towards a preference of local over imported technologies. This can be stated with the acceptable confidence level (10% significance). The result for combined vs. imported technologies didn't show results with sufficient significance level; therefore we restrain ourselves from using it for further interpretation.

It would also be informative to present the results for control variables. Project size –the first micro (project) level variable- showed consistency in negative influence on choice of both local and combined over imported technologies. This confirms findings of previous studies saying that larger CDM projects mostly rely on foreign technology and smaller projects source local technology (Seres, 2007, Haites *et al,* 2006, Dechezlepretre *et al,* 2008). We would add that smaller projects rely almost equally on local or combined sources of technology (though with very tiny preference on combined option) rather than exclusively on foreign technologies.

Results for subsidiary effect show that project implementers that have an affiliation with a foreign company strongly prefer combined technologies over purely local and purely foreign technologies. This effect is also strong in the choice of foreign technologies over local ones. This observation is also in line with findings of previous studies.

The existence of other, similar projects increases the propensity of using local and combined technologies over foreign ones. This is probably due to the local availability of technologies which leads to a higher number of projects in the same technological sector. It has to be noted that the coefficient for combined technologies is slightly higher, meaning that project developers have a slightly higher preference for combined over purely local sourcing.

Talking about the effect of macro level economic indicators, our model 2 showed a statistically significant positive effect of the country size and somewhat less significant effect (both statistically and in terms of coefficient) of income level on the preference for local over foreign and combined technologies. Results for other categories are not statistically significant and the effect of the country size on the choice between combined and imported technologies can not be predicted assertively. Thus our results regarding the role of the size and economic performance of the country seem to be in contrast with previous studies (Seres, 2007, Haites *et al,* 2006, Dechezlepretre *et al,* 2008) proposing a peripheral nature of these indicators in explanation of technology transfer statistics.

The finding on the role of trade openness of the country is quite consistent with previous studies. Trade indicators show a rather strong association with the application of combined technologies (to more extent) and foreign technologies (to lesser extent) and has a negative association with the application of purely local technologies. Hence, this result also confirms the argument that trade openness makes the import of technologies for CDM projects easier.

5. Discussion and conclusions

In this study we tried to examine whether the technological knowledge base of a host country determines the technology sourcing patterns in the CDM projects. Since the initiation of the CDM scheme, trends in CDM projects have been showing reliance mostly on local sources of technology. This was in contrast with the expected large technology transfer from developed economies who possess far superior expertise in environmental technologies. Thus our task was to investigate factors that can explain these developments. A logical line that was pursued in this study suggested that the developing countries already have climate friendly technologies locally available, and CDM became another enabler for their commercialization. We investigated macro level data indicating locally available expertise in these technologies and tried to use this data in explanation of technology sourcing trends in CDM project. Distinction was made between applied and scientific expertise and role of each was investigates in technology origin preferences in CDM projects. It is always a challenge to explain micro level developments through macro level factors, so in this study we tried to justify the choice and make arguments as plausible as possible.

With our empirical results we can declare that countries with more experience in applying and producing climate friendly technologies have a higher probability in using local and combined technologies in CDM projects. This is certainly established through the export indicator, which represents a country’s capacity to manufacture equipment, machines and trade them abroad. This implies that if the country produces and exports technologies there is rarely a need to import technologies for CDM projects. The results for renewable energy generation data also allow us to highlight the importance of practical experience and availability of local expertise in making the choice for local technologies in new projects. Thus our results suggest a positive influence of local knowledge associated with CFT application in selecting the local source of technology in CDM projects.

However, the results for scientific knowledge are quite intricate, which gives room to a range of speculations. While scientific effort in terms of publications seems to associate positively with local and mixed technology sourcing, patenting activities show a positive association with mixed and foreign technologies, but a negative one with local technologies. It is quite a challenge to give a complete explanation. The reason behind a high preference for combined technology could possibly be that countries with high patenting statistics like Israel, South Korea and Cyprus implement more joint projects with overseas partners who bring foreign technology along. However, these countries seem to have frequent cases of import of complete set of technology for the CDM project. This factor could be associated with more active trade activities and sometimes the smaller size of these countries.

If we take the perspective of the countries where CDM projects rely mostly on local technology, there might be a few explanations related to how the patent institute functions there. One argument could be that the patent institute possibly is not very well established in a number of developing countries (Correa, 2005) In the countries where it is established it might not be fully enforced, or the local technology developers rely on other mechanisms to protect their technology (Lesser, 1991) which might cause the large occurrence of zero- and one-patent countries in our sample. However there might be additional explanations and we would suggest further investigation of this issue.

Another important point that has to be considered in our analysis lies in the difference between applied and scientific knowledge. This difference has direct implication from a technology lifecycle perspective. Applied or experience related knowledge is the one associated with diffused, economically proven and mature technologies, while patents and publications basically represent new technologies that still need to prove their economical viability and often these new technologies never reach their adoption and diffusion stage . It is necessary to bear in mind that here we analyze the application of technology in CDM projects which represent the commercialization stage of technology lifecycle. In this stage a technology that has already proven its cost effectiveness and marketability in the local market, would be deployed in a project. Therefore it is fairly reasonable to observe clear and strong positive results for applied knowledge data, and to obtain mixed results for patents and publication data. The later may suggest that availability of theoretical knowledge and scientific developments may not always translate into their practical deployment.

This study has demonstrated that technological knowledge in climate friendly technologies to a certain degree can explain the technology sourcing pattern in the CDM; consistent results were obtained with three our of four proxies for knowledge base. Thus with the reference to the research questions we can argue that the present technological knowledge base to certain extent determines technology sourcing patterns in CDM projects, and more specifically the better knowledge base seems to positively associate with preference for local technologies. The role of practical knowledge has proved to be more significant than the scientific knowledge. The general conclusion is that countries with higher experience in development and application of technologies tend to rely more on own technology or collaborate with foreign partners in compiling the technological facility, rather than on purely rely on imported technology.

It is also necessary to mention that this study showed clear indications of a methodological contribution in measuring the knowledge base of the country in the specific niche of climate friendly technologies. Results of the study demonstrated that the knowledge base indicators proposed by us could be used to explain to a certain extent the technology transfer patterns in CDM projects, although the application of them might need some cautiousness[8].

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[8] This is especially true in the case of patent data, which presented two difficulties to us: first in terms of availability, and second in the correct interpretation of its impact in the model.

Along the methodological input, this study contributes to the literature on transfer and diffusion of environmental technologies in developing countries. The novelty of the study is in bringing the case of CDM project related technology transfer, which has not received its deserved attention in this literature stream. Second, and more importantly, it merges the perspective of knowledge base national technological capabilities with a focus on environmental technologies in this literature stream. We stress the importance to investigate the role of environmental and renewable energy policies in building the technological and knowledge base of a country. It is well established that for development, innovation and diffusion of environmental technologies the role of the right state policies is of high importance (Lewis and Wiser, 2007, Lanjouw and Mody, 1993; Jaffe and Stavins, 1995). In the context of technology transfer under CDM, studying renewable and energy policies of developing countries and their role in CDM associated sourcing technologies from abroad or developing them locally, might give interesting perspectives.

Results of the study suggest implications both for developing countries striving to address economic problems, as well as for developed countries which are interested in reaching emission reduction targets. Developing countries with better technical and scientific expertise would not need to depend on foreign technology to initiate CDM projects, which allows avoiding transaction costs associated with importing technology from abroad and decreases the overall investment cost of the project. Besides, local production of the technology is allied with other socio-economic benefits such as employment of local people in manufacturing and other stages of the production chain. Sourcing the local technology or cooperating with foreign technology providers spurs the economic base of the local producers.

What are the implications of the study results for the international policy agenda? First of all, they call for changing the paradigm of technology transfer in climate change mitigation agenda and consider developing countries not as passive receivers of technology, but as producers and innovators. In line of the sustainable development perspective the importance of building effective national innovation system need to be highlighted rather just narrow technology transfer activities. Second, the interest of the developed countries -the purchasers of carbon emission credits generated by CDM projects- is in the economic cost-effectiveness of the project. In the short and long-run, reliance on the developing countries’ expertise and technology would allow to secure higher cost-effectiveness of the investment in projects and to reduce the overall cost of climate change mitigation.

Nonetheless, we see a number of points that represent limitations of the present study. First, in the knowledge base concept and the collection of indicators that have been applied in our study we missed the indicator capturing human capital. A country’s human capital, represented by the pool of scientists, engineers, graduates of technical schools and universities, is an important component of the national level technological capabilities (Achibugi and Coco, 2004; Lall, 1994). However the country level data on engineers, graduates, scientist in energy and environmental technologies was hardly available restraining us from involvement of human capital related factors in our study. Another, albeit less favourable option is to use data on total scientists and engineers provided by UNESCO, National Science Foundation, UNDP Human Development Report, though these sources also lack data on many developing countries[9].

Another limitation of the study emerges from the fact that we use aggregated data on different technologies. First of all it concerns publication, patents, production and export data. In our study we tried to be more specific by focusing on extracting data on the climate friendly technologies' group. What would be even more interesting to do is to break our focus further down and to carry a separate analysis for each technology type. This would require fracturing the sample as well as each variables group according to technology type, but this exercise would envisage more accurate and challenging results.

Despite the limitation, as well as in line with addressing them, the study opens new avenues for further research which may also allow us to understand and explain the trends in CDM based technology transfer in a more comprehensive way. The importance of the stud is that it builds a stepping stone for further research and discussion of a role of developing countries in global climate change mitigation.

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[9] In regards to our study, data were not available for over half of the countries represented in our sample.

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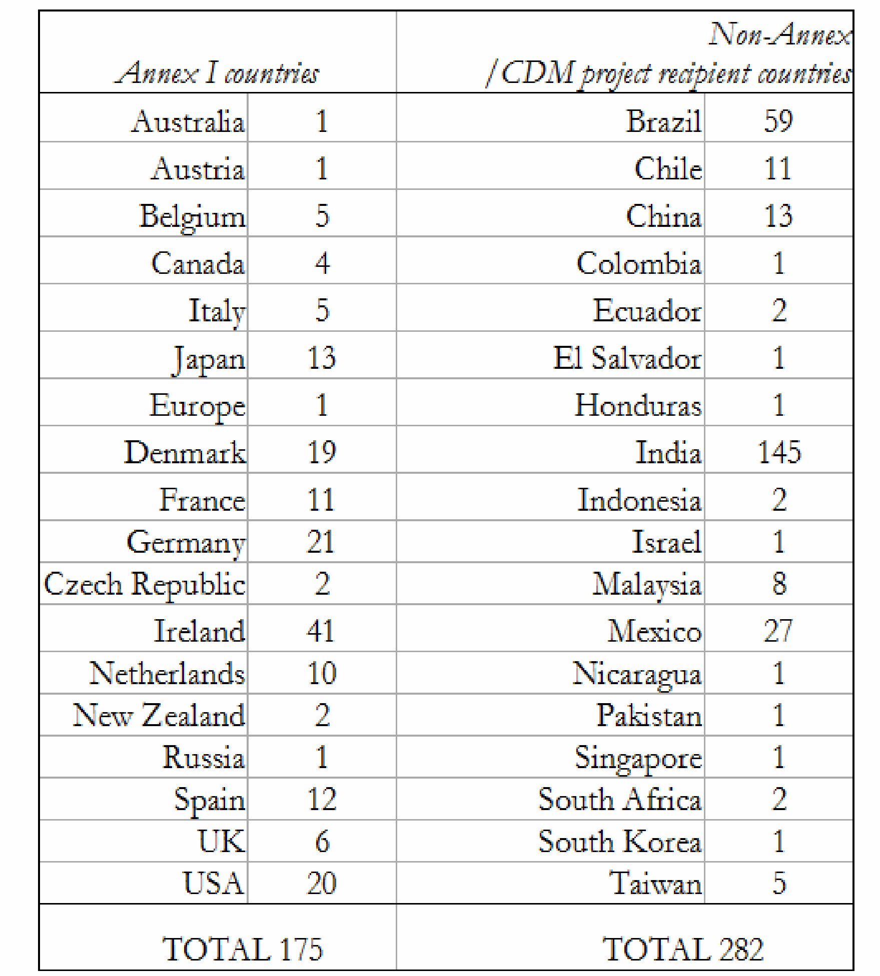
Appendix A. Statistics of technology origin in CDM projects (sample of 460 projects)

host country name	local	imported	combined	Total
India	141	3	9	153
Brazil	43	7	30	80
Mexico	27	3	42	72
China	18	26	2	46
Chile	11	3	0	14
Malaysia	1	3	7	11
Ecuador	2	6	0	8
Philippines	1	1	6	8
Republic of Korea	1	5	1	7
Colombia	2	4	0	6
Indonesia	2	4	0	6
Argentina	0	5	0	5
South Africa	1	0	3	4
Honduras	1	2	0	3
Moldova	0	0	3	3
Armenia	0	2	0	2
Bangladesh	0	2	0	2
Costa Rica	1	1	0	2
Cyprus	0	2	0	2
Egypt	0	2	0	2
El Salvador	2	0	0	2
Guatemala	1	1	0	2
Israel	1	1	0	2
Morocco	0	1	1	2
Nepal	0	0	2	2
Nicaragua	1	1	0	2
Peru	0	2	0	2
Viet Nam	0	2	0	2
Bolivia	0	0	1	1
Cambodia	0	1	0	1
Dominican Republic	0	1	0	1
Jamaica	0	1	0	1
Mongolia	0	0	1	1
Nigeria	0	1	0	1
Pakistan	0	0	1	1
Sri Lanka	0	1	0	1

Total	257	94	109	460

Notes: initial sample was 497 projects. Due to the missing data 37 observations had to be dropped out of the analysis.

Appendix B. Technology providers' participation in CDM projects



Annex I countries		*Non-Annex / CDM project recipient countries*	
Australia	1	Brazil	59
Austria	1	Chile	11
Belgium	5	China	13
Canada	4	Colombia	1
Italy	5	Ecuador	2
Japan	13	El Salvador	1
Europe	1	Honduras	1
Denmark	19	India	145
France	11	Indonesia	2
Germany	21	Israel	1
Czech Republic	2	Malaysia	8
Ireland	41	Mexico	27
Netherlands	10	Nicaragua	1
New Zealand	2	Pakistan	1
Russia	1	Singapore	1
Spain	12	South Africa	2
UK	6	South Korea	1
USA	20	Taiwan	5
TOTAL 175		TOTAL 282	

Appendix C. Patent data: USPTO

Date of extraction: July 15, 2008
Source: http://patft1.uspto.gov/netahtml/PTO/search-adv.htm
US Patent & Trademark Office, Patent Full Text and Image Database
Searching 1976 to present

BIOGAS	icl/A01C3/02 OR icl/A01C3/04 OR icl/A01C3/06 OR icl/A01C3/08
BIOMASS	icl/B01J41/16 OR icl/C10L5/42 OR icl/C10L5/44 OR icl/C10L1/14 OR icl/F02B43/08
GEOTHERMAL	icl/F24J3$ OR icl/F03G4$ OR icl/H02N10/00
HYDROPOWER	icl/F03B13/06 OR icl/F03B13/08 OR icl/F03B13/10'
LANDFILL	icl/B09B1/00 OR icl/B09C1/00
OCEAN	icl/F03B13/12 OR icl/F03B13/14 OR icl/F03B13/16 OR icl/F03B13/18 OR icl/F03B13/20 OR icl/F03B13/22 OR icl/F03B13/24 OR icl/F03G7/04 OR icl/F03G7/05 OR icl/F03B7/00
SOLAR	icl/F03G6$ OR icl/F24J2$ OR icl/F25B27/00 OR icl/F26B3/28 OR icl/H01L31/042 OR icl/H02N6/00 OR icl/E04D13/18 OR icl/B60L8/00
WIND	icl/F03D1$ OR icl/F03D3$ OR icl/F03D5$ OR icl/F03D7$ OR icl/F03D9$ OR icl/F03D11$ OR icl/B60L8/00 OR icl/B63H13/00

Example 1: "Query all wind patents, German inventor":
icn/DE AND (icl/F03D1$ OR icl/F03D3$ OR icl/F03D5$ OR icl/F03D7$ OR icl/F03D9$ OR icl/F03D11$ OR icl/B60L8/00 OR icl/B63H13/00)

Example 2: "Query all landfill patent, Indian assignee":
acn/IN AND (icl/B09B1/00 OR icl/B09C1/00)

Note: As we did not have full access to a (current) offline version of the USPTO patent database, we used a php/cURL script to automatically extract the numbers from the USPTO website. This method is not recommended for bulk downloads, as you "may be denied access to the server without notice".

Note: We are well aware of the fact that IPC codes in the USPTO database have not been cleaned. E.g., A01C3/02 also appears as A01C003/02. However, due to restrictions placed on the search interface, we could not use both variants in one query. Taking the union of the two might result in double counts.

Appendix D. Export data: Code Description

Renewable energies	
2207.10	Ethanol
2905.11	Methanol
4401.10	Fuel wood, in logs, in billets, twigs, faggots or similar forms
4401.30	Sawdust and wood waste and scrap, whether or not agglomerated in logs, riquettes, pellets or similar forms
7321.13	Cooking appliances and plate warmers for solid fuel, iron or steel
7321.83	Non electrical domestic appliances for liquid fuel
8410.11	Of a power not exceeding 1,000 kW
8410.12	Of a power exceeding 1,000 kW but not exceeding 10,000 kW
8410.13	Of a power exceeding 10,000 kW. 8410.90 — Parts including regulators
8410.90	Hydraulic turbines and water wheels; parts including regulators
8413.81	Pumps for liquids, whether fitted with a measuring device or not; [Wind turbine pump]
8419.11	Instantaneous gas water heaters
8419.19	Instantaneous or storage water heaters, non-electric – other [solar water heaters]
8502.31	Electric generating sets and rotary converters – Wind powered
8502.40	Electric generating sets and rotary converters [a generating set combining an electric generator and either a hydraulic turbine or a Sterling engine]
8541.40	Photosensitive semiconductor devices, including photovoltaic cells whether sssembled in modules or made up into panels; lightemitting diodes
Energy savings and management	
3815.00	Catalysts
7008.00	Multiple-walled insulating units of glass
7019.90	Other glass fibre products
8404.20	Condensers for steam or other vapour power units
8409.99	Parts suitable for use solely or principally with the engines of HS 8407 or 8408; other
8418.69	Heat pumps
8419.50	Heat exchange units
8419.90	Parts for heat exchange equipment

8539.31	Fluorescent lamps, hot cathode
8543.19	Fuel cells
9028.10	Gas supply, production and calibrating metres
9028.20	Liquid supply, production and calibrating metres
9032.10	Thermostats

Source: Steenblik (2005a, b)

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