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Abstract

Technology development and transfer is an important feature of both the United Nations Framework Convention on Climate Change and its Kyoto Protocol. Although the Clean Development Mechanism (CDM) does not have an explicit technology transfer mandate, it may contribute to technology transfer by financing emission reduction projects using technologies currently not available in the host countries. This paper analyzes the claims of technology transfer made by CDM project participants in their project design documents. Roughly one-third of all CDM projects accounting for almost two-thirds of the annual emission reductions involve technology transfer. Technology transfer varies widely across project types and is more common for larger projects and projects with foreign participants. Equipment transfer is more common for larger projects while smaller projects involve transfers of both equipment and knowledge or knowledge alone. Technology transfer does not appear to be closely related to country size or per capita GDP, but a host country can influence the extent of technology transfer involved in its CDM projects.

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1. Introduction

Technology plays an essential role in both mitigation of and adaptation to climate change.[1] Technology development and transfer has thus been included in both the United Nations Framework Convention on Climate Change and its Kyoto Protocol.

Article 4.1 of the Convention requires all Parties to promote and cooperate in the development, application and diffusion, including transfer, of GHG mitigation technologies.[2] Articles 4.3 and 4.5 stipulate that developed country Parties should provide new and additional financial resources to support the transfer of technology and take all practicable steps to promote, facilitate and finance the transfer of, or access to, environmentally sound technologies and know how to developing country Parties. Article 11.1 of the Convention further prescribes that financial resources shall be provided for the transfer of technology on a grant or concessional basis.

Article 10(c) of the Kyoto Protocol reiterates the requirement of all Parties to cooperate in the development, application, diffusion and transfer of environmentally sound technologies that are in the public domain.[3] Article 11.2 of the Protocol repeats the commitment of developed country Parties to financial resources for technology transfer.

Initiatives to fulfill these commitments include creation of an Expert Group on Technology Transfer to provide advice to Parties, establishment the Technology Information Clearing House (TTClear) by the Climate Change Secretariat, and initiation of technology needs assessments by many developing country Parties.[4]

Although the Clean Development Mechanism (CDM) does not have an explicit technology transfer mandate and is not identified as a means of fulfilling the technology transfer objectives of the Protocol, it may contribute to technology transfer by financing emission reduction projects using technologies currently not available in the host countries. This paper examines the technology transfer claims for CDM projects.

Section 2 provides background information on technology transfer and the Clean Development Mechanism. The data sources and results of our analyses are presented in section 3. Conclusions are provided in the last section.

2. Background

2.1 Technology Transfer

In its Special Report on Methodological and Technological Issues in Technology Transfer, the Intergovernmental Panel on Climate Change (IPCC) defines technology transfer “as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions.”[5]

This definition covers every relevant flow of hardware, software, information and knowledge between and within countries, from developed to developing countries and vice versa whether on purely commercial terms or on a preferential basis. The IPCC acknowledges that "the treatment of technology transfer in this Report is much broader than that in the UNFCCC or of any particular Article of that Convention."[6]

This paper analyzes the claims of technology transfer made by CDM project participants in their project design documents. In Section A.4.3 of the project design document, technology to be employed by the project activity, the project participants are requested to "include a description of how environmentally safe and sound technology and know-how to be used is transferred to the host Party(ies)."[7] The glossary of terms does not define "technology transfer".[8]

Given the large number of registered and proposed projects, it is not practical to define "technology transfer" and then ensure that any claims are consistent with that standard definition. However, it can be inferred from the claims that project participants overwhelmingly interpret technology transfer as meaning the use of equipment and/or knowledge not previously available in the country for the CDM project. The arrangements for the technology transfer, whether on commercial or concessionary terms, are never mentioned.

In summary, the technology transfer claims are not based on an explicit definition but generally assume that technology transfer means the use of equipment and/or knowledge not previously available in the country for the CDM project. Five project design documents reviewed claimed technology transfer for technology already available in the country. Since the focus of the Kyoto Protocol is on technology transfer between countries those cases were classified as involving no technology transfer.

2.2 CDM Projects

The participants must complete a project design document that describes the proposed CDM project. An independent "designated operational entity" (DOE) must validate a proposed project to ensure that it meets all of the requirements of a CDM project. As part of the validation process the DOE must solicit public comments on the proposed project. This paper analyzes the technology transfer claims in the project design documents of 854 proposed projects for which public comments had been solicited prior to 20 June 2006.

The 854 proposed projects include over twenty different categories of greenhouse gas emission reduction actions. The analysis investigates whether the percentage of projects for which technology transfer is claimed varies by project category. A CDM project may be implemented by project participants from two or more countries or by project participants from the host country alone – a "unilateral" project. Small projects may use simplified baseline and monitoring modalities.[9] The analysis investigates whether the incidence of technology transfer claims differs for unilateral and small-scale projects.

The characteristics of the host country might affect the incidence of technology transfer for CDM projects. A larger (larger population or larger economy) host country might already use a technology and/or have the expertise for a given project type. Similarly, a richer host country, higher per capita GDP, might already use a technology and/or have the expertise for a given project type. The analysis investigates whether the incidence of technology transfer claims is affected by such host country characteristics.

A host country can incorporate technology transfer requirements into its criteria for approval of CDM projects. In addition, characteristics of a host country, such as tariffs or other barriers to imports of relevant technologies, perceived and effective protection of intellectual property rights, and restrictions on foreign investment, can have an impact on technology transfer. The analysis investigates whether technology transfer differs significantly across individual host countries.

3. Data and Analytical Results

3.1 Data Sources

The primary source of data on CDM projects is the "CDM_Projects" sheet of *The CDM Pipeline* for 20 June 2006 (Fenhann, 2006).[10] It lists the host country (column D), the project type (column F), the methodology used (column G), the estimated annual emission reductions (column H), the estimated emission reductions to 31 December 2012 (column K), and countries that have agreed to buy credits generated by the project (column O) for each of 860 registered and proposed projects.[11] Our analysis uses the same project types. Small-scale projects are identified from the methodology used.[12] Projects with no credit buyer are classified as "unilateral" projects.

Our analysis excludes six of the projects for the following reasons: one project is duplicated, project design documents are not available for two projects, and the information in the project design documents for three projects did not enable us to determine technology transfer was or was not being claimed.[13] Three of these projects are N_2O destruction projects in Egypt, South Africa and South Korea; half of the N_2O projects but only 15% of the estimated annual emission reductions for N_2O projects.

The project design document (PDD) of each project was reviewed for claims of technology transfer.[14] Statements relating to technology transfer were generally found in sections A.4.2, A.4.3 or B.3 of the PDD. To ensure that all statements relating to technology transfer were identified each PDD was searched for the word "technology". In many cases the PDD explicitly states that the project involves no transfer of technology.[15] For other projects, the PDD makes no mention of technology transfer.

Where claims for technology transfer are made, they were coded for the nature of the technology transfer activity (imported equipment, training local staff, etc.). The codes distinguish transfer of both equipment and knowledge from transfer of equipment or knowledge alone. If a project claims several forms of technology transfer, all of the claims were coded.[16]

Data on the population and GDP of each host country were obtained from the Climate Analysis Indicators Tool (CAIT) (World Resources Institute).[17] The population and GDP are for 2000, with GDP being converted to international dollars using purchasing power parity (PPP) exchange rates. The data come from the 2003 *World Development Indicators* report prepared by the World Bank. The GDP is divided by the population to get the GDP per capita for each host country.

Host countries were grouped into size categories based on population. Host countries were also classified into the per capita income categories – Least Developed Countries, Other Low-Income Countries, Lower Middle-Income Countries, and Upper Middle-Income Countries – defined by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD, 2005).

3.2 Technology Transfer by Project Type

Table 1 shows the number of projects and average project size (estimated annual emission reductions) by project type. It also shows the percentage of the projects and the estimated annual emission reductions for which technology transfer is claimed. About half of the categories have fewer than 10 projects, but a few – biomass energy, hydro, and industrial energy efficiency – have over 100 projects each. The average project size varies widely across categories from less than 10 ktCO_2e per year for energy efficiency service and transport projects to 5,421 and 4,585 ktCO_2e per year for N_2O and HFC reduction projects. The overall average is 175 ktCO_2e per year.

The percentage of projects in each category that claim technology transfer averages 33% and ranges from 0% to 100%. That is easy to understand when a category includes only a single project, as in the case of tidal and transport. But none of the 22 cement projects make a technology transfer claim, while over 80% of the 91 agriculture and 13 HFC destruction projects claim to involve technology transfer.

Projects that claim some technology transfer represent 66% of the estimated annual emission reductions.[18] Since this is much higher than the 33% of projects that claim technology transfer, it indicates that projects that claim technology transfer are, on average, substantially larger than those that make no technology transfer claim. This is true for most project types as well. However, the fugitive emission reduction and coal mine/bed methane projects that claim technology transfer are much smaller than the average for that category. And geothermal projects that claim technology transfer are smaller than the category average.

Technology transfer claims for unilateral and small-scale projects by project type are summarized in Table 2. Over 68% of all projects are unilateral projects, but they account for only about 32% of the annual emission reductions. This means that the average size of unilateral projects, 83 ktCO_2e/yr, is less than half that of all CDM projects. About 25% of the unilateral projects claim technology transfer as compared to 33% of all projects. The projects that do claim technology transfer are larger than the average for unilateral projects, accounting for 42% of the emission reductions.

Table 1
Technology Transfer by Project Type

Project Type	**Number of Projects**	**Average Project Size** ($ktCO_2e/yr$)	**Technology Transfer Claims as Percent of**	
			Number of Projects	**Annual Emission Reductions**
Afforestation	0	0	0%	0%
Agriculture	91	53	81.3%	81.5%
Biogas	32	54	37.5%	56.8%
Biomass energy	194	56	21.1%	38.4%
Cement	22	129	0%	0%
Coal bed/mine methane	2	300	50.0%	0.4%
Energy distribution	2	105	50.0%	92.8%
Energy Efficiency households	4	22	75.0%	92.4%
Energy Efficiency industry	109	77	13.8%	18.4%
Energy Efficiency service	10	6	10.0%	19.5%
Fossil fuel switch	32	54	6.2%	8.0%
Fugitive	7	796	42.9%	15.0%
Geothermal	6	257	50.0%	42.6%
HFCs	13	4,585	84.6%	85.0%
Hydro	145	61	14.5%	19.0%
Landfill gas	74	252	64.9%	63.8%
N_2O	3	5,421	100.0%	100.0%
Reforestation	2	36	50.0%	69.1%
Solar	5	11	80.0%	99.0%
Tidal	1	315	100.0%	100.0%
Transport	1	7	0%	0%
Wind	99	72	41.4%	61.8%
Others	0	0	0%	0%
Total	854	175	33.5%	65.5%

Conversely, the projects that have foreign participants are more than twice as large (372 $ktCO_2e/yr$) as the average for all CDM projects. Just over half of the projects that have foreign participants, representing 76% of the estimated emission reductions for those projects, claim technology transfer. Thus technology transfer claims are more common for projects that have foreign participants and for the larger projects that involve foreign participants.

Table 2
Technology Transfer Claims by Project Type for Unilateral and Small-Scale Projects

Project Type	Unilateral Projects		Small-Scale Projects	
	Number of Projects	**Annual Emission Reductions**	**Number of Projects**	**Annual Emission Reductions**
Afforestation	0%	0%	0%	0%
Agriculture	81.9%	88.4%	80.6%	94.2%
Biogas	15.0%	13.4%	25.0%	32.0%
Biomass energy	10.2%	12.5%	22.1%	47.1%
Cement	0%	0%	0%	0%
Coal bed/mine methane	0%	0%	0%	0%
Energy distribution	100.0%	100.0%	50.0%	92.8%
Energy Efficiency households	50.0%	87.2%	75.0%	92.4%
Energy Efficiency industry	7.8%	20.3%	19.2%	6.4%
Energy Efficiency service	0%	0%	10.0%	19.5%
Fossil fuel switch	7.4%	8.5%	7.1%	13.7%
Fugitive	50.0%	10.8%	100.0%	100.0%
Geothermal	50.0%	77.5%	0%	0%
HFCs	66.7%	90.5%	0%	0%
Hydro	11.9%	27.3%	12.4%	12.5%
Landfill gas	69.4%	63.3%	80.0%	72.2%
N_2O	0%	0%	0%	0%
Reforestation	100.0%	100.0%	0%	0%
Solar	75.0%	98.9%	80.0%	99.0%
Tidal	100.0%	100.0%	0%	0%
Transport	0%	0%	0%	0%
Wind	22.9%	48.6%	15.0%	22.6%
Others	0%	0%	0%	0%
Total	25.4%	42.4%	26.4%	41.5%
	Number	**Reductions** (ktCO2e/yr)	**Number**	**Reductions** (ktCO2e/yr)
Total	582	48,298	401	14,502
Percentage of all projects	68.1%	32.3%	47.0%	9.7%

Note: The percentages in the upper panel are the unilateral or small-scale projects that claim technology transfer as a percentage of the unilateral or small-scale projects in the category.

The data for small-scale projects confirm the pattern. Small-scale projects, by definition, are smaller than average (36 ktCO_2e/yr), but 47% of all projects are small-scale projects. About 26% of the small-scale projects claim technology transfer as compared to 33% of all projects. The projects that do claim technology transfer are larger than the average for small-scale projects, accounting for 42% of their emission reductions.

In summary, technology transfer is more common for larger projects; one-third of all CDM projects accounting for 66% of the annual emission reductions involve technology transfer. Technology transfer varies widely across project types. Technology transfer is more common for projects that have foreign participants, possibly because those projects tend to be larger. Unilateral and small-scale projects involve less technology transfer, possibly due to their smaller size. Within any given group – foreign participants, unilateral, small-scale – technology transfer is more common for larger projects.

3.3 Technology Transfer by Host Country Characteristics

Do CDM projects in larger or richer countries rely more on the larger, more diverse stock of technology in the host country and so involve less technology transfer? The data in Table 3 address that question.

Average project size rises steadily with country size, with the exception of the 25 to 50 million and 250 to 1,000 million categories. The latter category includes only a single small project. The high average for the 25 to 50 million category is due to South Korea and Argentina, which have large average project sizes. Technology transfer claims are more common than average for CDM projects in countries with a population between 1 and 100 million. This is surprising given the relatively small projects in those countries and the strong association between technology transfer and larger projects.

Technology transfer claims are less common for countries (China and India) with a population over 1 billion. That could be a reflection of the policies of those countries. Or it could be an indication that, as large countries, they have a larger technology base and hence need less technology transfer to implement CDM projects. The projects in China and India that do claim technology transfer are much larger than average.

There does not appear to be a systematic relationship between a host country's per capita GDP and the incidence of technology transfer for its CDM projects. The frequency of technology transfer claims is high for "Least Developed Countries" although the number of projects (11) is relatively small. The frequency of technology transfer claims is quite low for the "Other Low-Income Countries" group. India's projects account for almost 95% of the projects and over 75% of the annual emission reductions for this group. Projects that involve technology transfer are substantially larger than the average for the group.

In short, technology transfer does not appear to be closely related to country size or per capita GDP. The characteristics of projects in some other countries, such as Argentina, India and South Korea, affect technology transfer for the categories that include those countries.

Table 3
Technology Transfer by Host Country Characteristics

	Number of Projects	Average Project Size ($ktCO_2e/yr$)	Technology Transfer Claims as Percent of	
			Number of Projects	Annual Emission Reductions
Country Size (Population)				
Less than 1 million	4	25	0%	0%
1 to 5 million	20	58	45.0%	55.0%
5 to 10 million	41	71	43.9%	42.0%
10 to 25 million	72	118	45.8%	52.1%
25 to 50 million	48	400	56.2%	86.3%
50 to 100 million	95	109	77.9%	84.0%
100 to 250 million	175	157	35.4%	61.5%
250 to 1,000 million	1	7	100.0%	100.0%
Over 1 billion	398	200	15.6%	62.0%
Total	854	175	33.5%	65.5%
Country Groups (Based on per capita GDP)				
Least Developed Countries	11	53	72.7%	93.7%
Other Low-Income Countries	349	99	10.3%	32.6%
Lower Middle-Income Countries	353	234	43.9%	72.0%
Upper Middle-Income Countries	123	151	65.0%	82.1%
Other	18	712	44.4%	87.0%
Total	854	175	33.5%	65.5%

3.4 Technology Transfer for Selected Host Countries

Each CDM project must be approved by the host country government. As part of its approval process the host country government may choose to impose technology transfer requirements. Table 4 presents data on technology transfer for every country that accounts for more that 2% of the number of projects or 2% of the total annual emission reductions. Four countries – Brazil, China, India and South Korea – dominate the totals, accounting for 67% of the projects and 75% of the annual emission reductions.

According to the *Brazilian Manual for Submitting a CDM Project to the Interministerial Commission on Global Climate Change*, the project developer shall include in the description of the project its contribution to sustainable development including its "d) contribution to technological development and capacity-building."[19] Technology transfer is not mentioned directly. Rather the project's contribution to technology development is assessed as part of its contribution to sustainable development. Technology transfer for Brazilian projects is roughly equal to the average for all CDM projects measured in number of projects and annual emission reductions (see table 4).

Table 4
Technology Transfer for Projects in Selected Host Countries

Host Country	**Number of Projects**	**Estimated Emission Reductions** ($ktCO_2e/yr$)	**Average Project Size** ($ktCO_2e/yr$)	**Technology Transfer Claims as Percent of Number of Projects**	**Technology Transfer Claims as Percent of Annual Emission Reductions**
Argentina	9	3,579	398	77.8%	99.4%
Brazil	160	20,471	128	33.1%	74.1%
Chile	23	3,720	162	17.4%	44.8%
China	69	52,996	768	55.1%	75.9%
Honduras	19	446	23	57.9%	57.5%
India	329	26,595	81	7.3%	34.4%
South Korea	12	12,556	1,046	50.0%	88.2%
Malaysia	18	2,343	130	83.3%	94.8%
Mexico	54	7,303	135	85.2%	91.4%
Nigeria	2	4,044	2,022	0%	0%
Philippines	22	388	18	63.6%	72.8%
Other Host Countries	137	14,930	109	49.6%	50.9%
Total	854	149,369	175	33.5%	65.5%

In *Measures for Operation and Management of Clean Development Mechanism Projects in China*, the Government of China requires that "CDM project activities should promote the transfer of environmentally sound technology to China."[20] This is a general provision not a mandatory requirement for each project. Projects in China are much larger than the average for all CDM projects and are more likely to involve technology transfer. About half of the projects in China representing over 75% of the annual emission reductions involve technology transfer (see table 4).

In the *Eligibility Criteria* for CDM project approval established by the Indian Government, it is prescribed that the "Following aspects should be considered while designing [a] CDM project activity: … 4. Technological well being: The CDM project activity should lead to transfer of environmentally safe and sound technologies that are comparable to best practices in order to assist in upgradation of the technological base. The transfer of technology can be within the country as well from other developing countries also."[21]

The Indian Government has adopted a broad concept of technology transfer, similar to that of the IPCC special report, which includes technology transfer *within* the country.

Technology transfer within a country is excluded from our analysis, although only 5 of the 329 projects in India included a claim for technology transfer within the country. India has a much lower rate of international technology transfer than average whether measured in terms of number of projects or annual emission reductions (see table 4). The projects that do involve technology transfer are larger than the Indian average.

The Korean Designated National Authority for the CDM requires that "environmentally sound technologies and know how shall be transferred."[22] Like China, projects in Korea are much larger than the average for all CDM projects and are more likely to involve technology transfer. Half of the projects in Korea representing almost 90% of the annual emission reductions involve technology transfer (see table 4).

Clearly, a host country can influence the extent of technology transfer involved in its CDM projects. It can do this explicitly in the criteria it establishes for approval of CDM projects. Other factors, such as tariffs or other barriers to imports of relevant technologies, perceived and effective protection of intellectual property rights, and restrictions on foreign investment also can affect the extent of technology transfer involved in CDM projects. In most host countries technology transfer is more common for larger projects.

3.5 Regression Analysis

Regression analysis was performed to test the significance of the variables considered in the preceding sections on technology transfer. The dependent variable takes a value of 1 when a project includes a technology transfer claim, regardless of the nature of the claim, and 0 when technology transfer is not mentioned. With a dependent variable that has a value of either 0 or 1 the appropriate form of regression analysis is logistic regression analysis. The results for three equations are presented in Table 5.

Table 5
Regression Results

Equation	**1**	2		**3**	
Constant	-1.430	-0.254	-0.642	Argentina	1.352
	(-2.16)*	(-0.878)	(-1.61)		(1.50)
Project size	0.000906	0.001007	0.000987	Chile	-1.889
(kt CO2e/yr)	(1.99)*	(2.83)**	(2.80)*		(-2.86)*
Unilateral project	-1.355	-1.368	-0.757	China	0.813
	(-7.06)**	(-7.20)**	(-3.31)**		(2.09)*
Agriculture	4.012	2.843	2.453	Costa Rica	1.206
	(5.69)**	(7.41)**	(5.13)**		(0.79)
Biogas	1.670			Ecuador	1.837
	(2.21)*				(2.22)*
Biomass energy	0.905	-0.270	-0.438	El Salvador	-0.813
	(1.34)	(-0.85)	(-1.10)		(-0.66)

Energy distribution	2.013			Guatemala	1.501
	(1.25)				(2.12)*
Energy efficiency	3.301	2.131	1.059	Honduras	2.225
households	(2.42)*	(1.73)$^{+}$	(0.74)		(4.11)**
Energy efficiency	0.535	-0.642	-0.110	India	-1.449
industry	(0.76)	(1.66)$^{+}$	(-0.22)		(-4.34)**
Energy efficiency	0.369			Indonesia	0.522
service	(0.29)				(0.65)
Fossil fuel switch	-0.281	-1.453	-1.629	Israel	-0.220
	(-0.29)	(-1.85)$^{+}$	(-1.79)$^{+}$		(-0.20)
Fugitive	1.102			Malaysia	2.607
	(1.00)				(3.77)**
Geothermal	1.633			Mexico	1.711
	(1.52)				(3.61)**
HFCs	2.418			Moldova	0.940
	(1.65)$^{+}$				(0.68)
Hydro	0.261	-0.918	-1.577	Morocco	-0.177
	(0.38)	(-2.56)*	(-3.36)**		(-0.15)
Landfill gas	2.555	1.363	1.210	Nicaragua	1.920
	(3.71)**	(3.79)**	(2.81)*		(1.48)
Reforestation	2.075			Peru	1.914
	(1.27)				(1.94)$^{+}$
Solar	3.971	2.806	2.976	Philippines	-0.370
	(3.03)**	(2.41)*	(2.33)*		(-0.65)
Wind	1.958	0.784	1.152	South Africa	2.050
	(2.87)**	(2.32)*	(2.68)*		(2.35)*
				South Korea	0.448
					(0.54)
		Summary Statistics		Sri Lanka	1.046
					(0.88)
Pearson χ^2	296.85	288.14	440.17	Thailand	1.690
					(2.29)*
Number of observations used	848	848	848	Viet Nam	2.307
					(2.12)*
Probability $>\chi^2$	.0000	.0000	.0000		
Pseudo R^2	0.274	0.266	0.406		
Percent classified correctly	78.8%	78.8%	83.4%		

Notes:

Each cell shows the estimated coefficient for the variable together with the “asymptotic z” value, which indicates its statistical significance. Variables significant at the 0.1 level are indicated by “$^{+}$”, those significant at 0.05 level are indicated by “*” and those significant at the 0.01 level are indicated by “**”.

The predicted “logarithmic odds ratio” or “logit” (L) is calculated as follows:

L = Constant + SUM of (coefficient * observation).
Since L is expressed as a natural logarithm, the predicted probability (P) that a project involves technology transfer is calculated as: $P = 1/(1 + e^{-L})$, where e = 2.71828 is the base for natural logarithms. For example, a unilateral, industrial energy efficiency project in Argentina with an estimated annual emission reduction of 7.6087 kt CO_2e/year yields the following value of L with the coefficients of equation 3:
$L = -0.642 + 0.000987 * 7.6087 + (-0.757) * 1 + (-0.110) * 1 + 1.352 * 1 = -0.1495$. Then
$P = 1/(1 + e^{-L}) = 1/(1 + e^{0.1495}) = 1/(1 + 1.1617) = 0.463$
Since $P<0.5$ the equation predicts that the project does not involve technology transfer, which it doesn't so the project is classified correctly.

The value of the Pearson χ^2 is used to test the null hypothesis that the coefficients of all of the variables are equal to zero. The probability of a χ^2 value greater than the value calculated for each of the equations is less than 0.0000. Thus the null hypothesis can be rejected with a very high degree of confidence, indicating that at least some of the variables are statistically significant. That is confirmed by the tests for the individual variables using the "z" values.

The pseudo R^2 and percent of observations correctly classified are indicators of the explanatory power of the equation. If the equation predicts a probability of technology transfer greater than 0.5 for a project given its characteristics, it is correctly classified if technology transfer was claimed and incorrectly classified if no technology transfer was claimed. Similarly, if the predicted probability is less than 0.5, it is correctly classified if no technology transfer was claimed and incorrectly classified if technology transfer was claimed.

Each equation includes a constant, the project size (kt CO_2e reduced per year) and whether it is a unilateral project. Equation 1 includes variables for the different project types; for example, the agriculture variable has a value of 1 for each agriculture project and 0 for any other project type.[23] As part of the estimation procedure the statistical package drops any variable for which prediction is perfect. For equation 1 it dropped the cement, N_2O, tidal and transport project types.[24]

Results for equation 1 indicate that the probability of technology transfer increases with project size and declines if the project is a unilateral project, which means it rises if the project includes foreign participants.[25] Seven of the remaining 16 project type variables are significant at the 0.1 level or higher. The equation has a pseudo R^2 of 0.27 and correctly classifies almost 80% of the observations.

If the variables are linearly related, collinear, it biases the tests for statistical significance. To analyze this possibility an equation that includes only project size, the unilateral variable and the project type variable was estimated for each of the 21 protect types. The project type variables that yield perfect predictions and those that have very little statistical significance were isolated. As a result, the project type variables for biogas, coal mine/bed methane, energy distribution, energy efficiency services, fugitive, geothermal, HFCs, and reforestation were dropped in addition to the four project types that yield perfect predictions.

Equation 2 includes the remaining nine project type variables.[26] All of the project type variables except biomass energy, are significant at the 0.1 level or higher. Project size and foreign participation continue to increase the probability of technology transfer. Technology transfer is *more* likely for agriculture, landfill gas, solar and wind projects, all of which have technology transfer claims for a large share (60% to 80%) of the projects in Table 1. Technology transfer is *less* likely for fossil fuel switch and hydro projects, both of which have technology transfer claims for less than 20% of the projects in Table 1.[27] These results can be interpreted as a preference for local technology for fossil fuel switch and hydro projects.

Equation 3 adds variables for the host countries.[28] The initial estimation (not shown) dropped 21 of the country variables due to perfect prediction, mostly countries with only one project. When the remaining countries were tested individually the variables for Armenia, Bolivia, Brazil, Colombia and Uruguay were found to have very little statistical significance. Equation 3 was estimated with variables for the remaining 23 countries. Adding the country variables reduces the significance of some of the project type variables, especially energy efficiency households and energy efficiency industry.

The coefficients for 12 of the 23 countries in equation 3 are statistically significant, at the 0.1 level or higher. Technology transfer is *more* likely for projects in China, Ecuador, Guatemala, Honduras, Malaysia, Mexico, Peru, South Africa, Thailand and Viet Nam. Technology transfer is *less* likely for projects in Chile and India. The results are generally consistent with those presented in Table 4, although the coefficients for Argentina and the Philippines are not statistically significant when the project characteristics (size, type, unilateral) are taken into account.

When host country population, GDP, and per capita GDP were added, individually, to equation 2, population and per capita GDP were statistically significant, but GDP was not.[29] When these variables were added (individually) to equation 3, none was statistically significant. That is not surprising given the results presented in Table 3; the effects of the host country on technology transfer appear to be country specific rather than due to its size or per capita income.

The regression results should be considered preliminary and be interpreted with caution. While the dataset includes a large number of observations, the number for a specific project type or host country is often quite small so the results for those variables should be interpreted carefully. Even where the results appear robust caution is warranted; many of the agriculture projects are similar and include the same foreign participant. A wider variety of agriculture projects could change the results. More observations could change the results for other variables as well, especially for variables that are perfectly predicted in the present analyses.

3.6 Nature of the Technology Transfer

Assigning numerical codes to written statements inevitably involves judgments. We tried to reflect the written statements as accurately as possible. The result, as can be seen in Table 6, is that distinctions between codes can be quite subtle. In the spirit of reflecting the claims of the project participants as accurately as possible, projects were assigned multiple codes where the claims corresponded to different codes.

However, the use of multiple codes created a dilemma. In principle, a project that involves transfer of both equipment and knowledge could receive a code for equipment transfer and a second code for knowledge transfer. That would make it more difficult to assess the relative frequency of projects that involve the transfer of both equipment and knowledge as distinct from either equipment or knowledge alone. Thus sufficient codes were created to allow each project to be coded as involving transfer of equipment only, knowledge only or both equipment and knowledge.

Creating enough codes to classify each project as involving the transfer of equipment only, knowledge only or both equipment and knowledge had the effect of reducing the number of projects with multiple codes; 8 projects were assigned two codes and 19 were assigned three codes. Twenty-four of those projects received multiple codes for knowledge transfer. The other three received codes for knowledge transfer and for "other" technology.

Table 6 shows the frequency of each claim as a percentage of the 286 projects that involve technology transfer and as a percentage of the annual emission reductions of those projects. In calculating the percentages in Table 6 each of the multiple codes is given equal weight, so with two codes each code would receive a weight of 0.5 and half of the project's annual emission reductions.

Almost half (46%) of the projects that involve technology transfer claim both equipment and knowledge transfers, but they account for about one-quarter of the emission reductions (see Figure 1). About one-third of the projects that claim technology transfer involve only equipment, but those projects account for almost two-thirds of the emission reductions. Transfers of knowledge alone involve 16% of the projects accounting for 8% of the emission reductions. Thus equipment transfer is more common for larger projects while smaller projects involve transfers of both equipment and knowledge or knowledge alone.

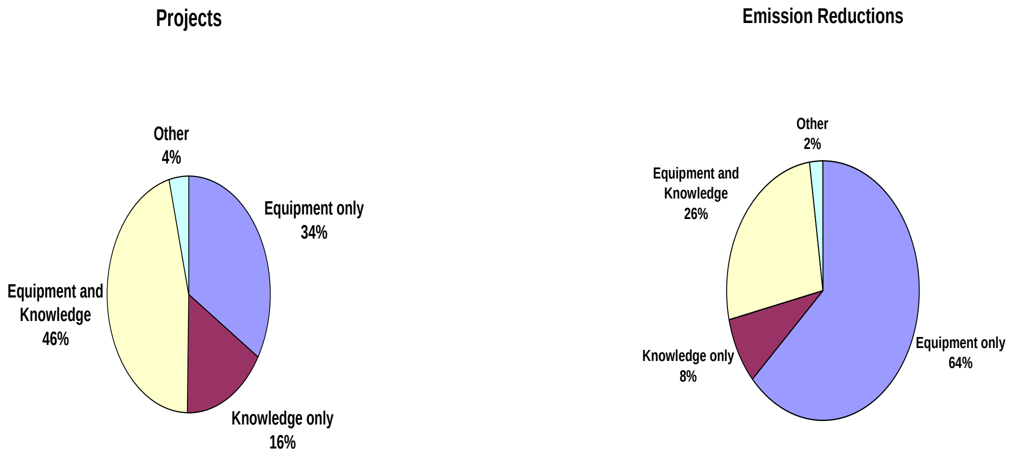
Technology transfer by project type is summarized in Table 7. Given the wide variation in claims of technology transfer across project type noted earlier, it is not surprising that the nature of the technology transfer by project type indicates no obvious patterns. This may be due in part to the relatively small number of projects for some project types.

Table 6
Technology Transfer Actions

	Percent of Projects	Percent of Annual Reductions
Transfer of Equipment Only		
Equipment transferred from foreign sources / Import of equipment	33.9%	62.9%
Transfer of Knowledge Only		
Development of local equipment suppliers and/or engineering consultants firms	2.3%	0.9%
Training of local staff members about foreign technology	10.8%	5.8%
Technical capacity building through involvement of local partners, staff, firms	2.7%	1.2%
Technical capacity building by observing external experts implementing project	0.5%	0.6%
Partnership between foreign technology supplier and local entities	4.6%	1.7%
Transfer of Equipment and Knowledge		
Equipment and knowledge transferred from foreign sources	15.0%	8.4%
Combination of indigenous and foreign technology	1.4%	0.4%
Equipment transferred from foreign sources and Development of local equipment suppliers and/or engineering consultants firms	0.4%	0.0%
Equipment transferred from foreign sources and technical capacity building through involvement of local partners, staff, firms	2.8%	9.7%
Equipment transferred from foreign sources and Technical capacity building by observing external experts implementing project	2.8%	2.5%
Equipment transferred from foreign sources and Signing of maintenance and/or operations contract with foreign equipment supplier	1.4%	1.1%
Equipment transferred from foreign sources with Partnership between foreign technology supplier and local entities	0.7%	0.1%
Equipment transferred from foreign sources and knowledge transferred through the development of local equipment suppliers and/or engineering consultants firms; training of local staff members about the foreign technology; and technical capacity building through involvement of local partners, staff, firms	16.8%	2.4%
Other		
Technology transfer facilitated through intermediary entity with long term technical transfer agreement (agreement is independent of project)	2.4%	1.5%
Foreign supplier is granted all rights to implement the CDM project activity	0.2%	0.0%
Project using domestic equipment with foreign management model	1.0%	0.1%

Building local knowledge about CDM	0.3%	0.6%

Figure 1
Summary of the Types of Technology Transfer Claims



4. Conclusions

Technology transfer is not an explicit objective of the Clean Development Mechanism, but it can contribute to technology transfer by financing emission reduction projects using technologies currently not available in the host countries. This paper analyzes the technology transfer claims made by project participants in the project design documents.

A definition of "technology transfer" is not provided to project participants, so each project is free to use its own interpretation of "technology transfer". However, from the claims it is clear that project participants overwhelmingly interpret technology transfer as meaning the use of equipment or knowledge not previously available in the host country for the CDM project. Nevertheless, technology transfer is claimed for some projects with very simple technology (e.g. solar cookers) while no technology transfer is claimed in other projects where it might be expected (e.g. wind power).

Approximately one-third of the 854 registered and proposed CDM projects claim some technology transfer. But these projects account for about 66% of the annual emission reductions, so technology transfer is more common for larger projects. Technology transfer varies widely by project type ranging from none to all of the projects of a given type. Technology transfer is claimed for a higher share of agriculture, landfill gas, solar and wind projects. Fossil fuel switch and hydro projects tend to use local technology. Technology transfer is more common for projects that involve foreign participants than for unilateral projects.

Table 7

Technology Transfer by Project Type

Project Type	Number of Projects	No Technology Transfer	Equipment Only	Knowledge Only	Knowledge and Equipment	Other
1 Afforestation	0					
2 Agriculture	91	18.7% 18.5%	9.9% 0.6%	25.3% 35.9%	46.2% 45.0%	
3 Biogas	32	62.5% 43.2%	3.1% 0.9%	9.4% 12.1%	18.8% 38.4%	6.2% 5.4%
4 Biomass energy	194	78.9% 61.6%	10.8% 15.3%	2.1% 2.8%	5.7% 7.5%	2.6% 12.8%
5 Cement	22	100.0% 100.0%				
6 Coal bed/mine methane	2	50.0% 99.6%			50.0% 0.4%	
7 Energy distribution	2	50.0% 7.2%		50.0% 92.8%		
8 Energy Efficiency households	4	25.0% 7.6%	50.0% 41.1%		25.0% 51.3%	
9 Energy Efficiency industry	109	86.2% 81.6%	3.7% 8.5%	6.4% 9.5%	3.7% 0.3%	
10 Energy Efficiency service	10	90.0% 80.5%	10.0% 19.5%			
11 Fossil fuel switch	32	93.8% 92.0%	6.2% 8.0%			
12 Fugitive	7	57.1% 85.0%	14.3% 4.0%	28.6% 11.1%		
13 Geothermal	6	50.0% 57.4%		16.7% 18.0%	33.3% 24.6%	
14 HFCs	13	15.4% 15.0%	46.2% 62.6%	5.1% 1.6%	30.8% 20.0%	2.6% 0.8%
15 Hydro	145	85.5% 81.0%	7.6% 9.7%	1.4% 1.4%	4.1% 7.0%	1.4% 0.9%
16 Landfill gas	74	35.1% 36.2%	21.6% 17.3%	17.6% 23.2%	24.3% 22.2%	1.4% 1.0%
17 N_2O	3		66.7% 92.9%		33.3% 7.1%	
18 Reforestation	2	50.0% 30.9%				50.0 69.1%
19 Solar	5	20.0%	80.0%			

		1.0%	99.0%			
20 Tidal	1				100.0%	
					100.0%	
21 Transport	1	100.0%				
		100.0%				
22 Wind	99	58.6%	17.2%	3.0%	21.2%	
		38.2%	30.9%	5.1%	25.9%	
23 Others	0					
Total	854	66.5%	11.4%	7.0%	13.8%	1.3%
		34.5%	41.2%	6.6%	16.1%	1.5%
Note: the top row for each project type shows the distribution based on number of projects while the bottom row shows the distribution based on estimated annual emission reductions.						

Equipment transfer is more common for larger projects while smaller projects involve transfers of both equipment and knowledge or knowledge alone. About one-third of the projects that claim technology transfer involve only equipment, but those projects account for almost two-thirds of the emission reductions. Almost half of the projects that involve technology transfer claim both equipment and knowledge transfers, but they account for only about one-quarter of the emission reductions. Transfers of knowledge alone involve 16% of the projects accounting for 8% of the emission reductions.

A host country can influence the extent of technology transfer involved in its CDM projects through the criteria it establishes for approval of CDM projects. Other factors, such as tariffs on imported equipment, also affect the extent of technology transfer involved in CDM projects. As a result, the rate of technology transfer is significantly higher than average for several host countries, including China, Ecuador, Guatemala, Honduras, Malaysia, Mexico, Peru, South Africa, Thailand and Viet Nam and significantly lower than average for a few host countries, including Chile and India. Technology transfer does not appear to be closely related to country size or per capita GDP.

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Notes

[1] Philibert, 2004.

[2] United Nations, 1992, Article 4.1.

[3] United Nations, 1997, Article 10(c).

[4] See FCCC, 2006a.

[5] IPCC, 2000, p. 3.

[6] IPCC, 2000, p. 3.

[7] FCCC, 2006b, p. 16.

[8] FCCC, 2006b, pp. 5-12.

[9] A small-scale CDM project is:
(i) a renewable energy project with a maximum output capacity equivalent of up to 15 megawatts (or an appropriate equivalent);
(ii) an energy efficiency improvement project that reduces energy consumption, on the supply and/or demand side, by up to the equivalent of 15 gigawatt/hours per year; or
(iii) an other project that both reduces anthropogenic emissions by sources and directly emits less than 15 kilotonnes of carbon dioxide equivalent annually.

[10] Ellis and Karousakis, 2006, reports almost 1000 projects as of May 2006. The document does not contain a list of the projects. While a list might be available from the authors, it might not include all of the information available for each project in Fenhann 2006. There is no definitive list because the number of projects increases by an average of about 2.5 per day (Fenhann, 2006 reports 860 on 20 June 2006, an increase from 744 on 3 May 2006).

[11] Ellis and Karousakis, 2006 reports 14 project types – renewable electricity, electricity generation, energy efficiency, (avoided) fuel switch, F-gas reduction, N_2O reduction, landfill gas capture, other CH_4 reduction, manure and wastewater, transport, cement, sinks, carbon capture and storage, and other. The UNFCCC reports registered projects by 8 project types – agriculture, chemical industries, energy demand, energy industries (renewable / non-renewable sources), fugitive emissions from fuels (solid, oil and gas), fugitive emissions from production and consumption of halocarbons and sulphur hexafluoride, manufacturing industries, and waste handling and disposal. See http://cdm.unfccc.int/Statistics/Registration/RegisteredProjByScopePieChart.html

[12] A few projects use both a small-scale methodology and a methodology for a regular project. Those projects are classified as regular projects.

[13] The duplicated project is a wind project in China reported as CDM 194 (row 260) and CDM 710 (row 275). The former is an earlier version of the project design document and so is excluded. Project design documents could not be found for a landfill gas project in China reported as CDM 781 (row 257) and an industrial energy efficiency project in India reported as CDM 721 (row 556). Whether technology transfer was or was not being claimed could not be determined for three N2O destruction projects reported as CDM 692 (row 833), CDM 734 (row 304), and CDM 758 (row 822).

[14] A project's PDD is available on the website of the designated operational entity retained to validate

the project. PDDs for registered projects are available on the website of the FCCC secretariat.

[15] A total of 568 projects were classified as claiming no technology transfer (including the 5 projects that claimed technology transfer within the host country). Of these 164 explicitly stated that the project involves no technology transfer.

[16] A total of 286 projects make technology transfer claims; 257 were assigned a single technology transfer code, 10 were assigned two codes and 19 were assigned three codes.

[17] The population and GDP data are from the "Data-Population2000" and "Data-GDP-PPP" sheets respectively.

[18] When total emission reductions to 31 December 2012 are used as the measure of project size the results are similar (63.3% rather than 65.5%). It also yields similar results for unilateral and small-scale projects. Since total reductions to 31 December 2012 combines the effect of annual emission reductions and the project start date, annual emission reductions is judged to be a better measure of project size and only those results are reported.

[19] Brazil, 2005, p. 2.

[20] China, 2005, Article 10, p. 2.

[21] India, undated, p. 1.

[22] Lee, 2006, slide 7.

[23] When such "dummy" variables are created they can not collectively cover all observations or they lead to multicollinearity, which biases the test statistics. A dummy variable was not created for coal mine/bed methane projects, but this project type was subsequently found to be not significant.

[24] None of the cement projects and all of the N_2O projects included a technology transfer claim, so all of the observations for each of those project types would have only one value – 0 for cement and 1 for N_2O – and the estimated equation would predict for those project types perfectly. The dataset includes only one tidal and one transport project, so the variable for those project types would predict them perfectly whether they involve technology transfer or not.

[25] Diagnostic tests on the influence of individual observations while comparing both the Pearson $\chi 2$ and the deviance to the predicted probabilities indicates that there are no outlier observations exerting undue influence on the model.

[26] Dropping the additional project type variables has virtually no impact on the explanatory power of the equation because the pseudo R^2 and percentage of observations classified are virtually identical to those for equation 1. The fact that the variables for biogas and HFC projects are statistically significant for equation 1 and are not included in equation 2 because they have very little significance indicates that collinearity distorts the test statistics in equation 1.

[27] Although not statistically significant, the sign for biomass energy projects is also negative.

[28] As indicated by the increase in the pseudo R^2 and percentage of observations classified correctly, the explanatory power of the model is increased by adding the country variables.

[29] Population is significant at the 0.01 level with a negative sign indicating less technology transfer for

larger countries. GDP, another measure of country size, is not statistically significant, but does have a negative sign. GDP per capita is also statistically significant at the 0.01 level with a positive sign, indicating more technology transfer for higher income countries.