United Nations Framework Convention on Climate Change

THE CONTRIBUTION

of the Clean Development Mechanism
under the Kyoto Protocol

TO TECHNOLOGY TRANSFER

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THE CONTRIBUTION OF THE CLEAN DEVELOPMENT MECHANISM UNDER THE KYOTO PROTOCOL TO TECHNOLOGY TRANSFER

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FOREWORD

Few who negotiated the Kyoto Protocol could have imagined what a ground-breaking success the clean development mechanism would prove to be. It has been embraced by governments and the private sector alike and provides a new channel for green investment.

It is estimated that as much as 1 billion tonnes of emission reductions will be generated by CDM projects in developing countries up to 2012. Such international collaboration on mitigation also brings important co-benefits for developing countries, by contributing to their sustainable development, which is an essential objective of the CDM.

This study takes an in-depth look at one of the more measurable co-benefits of the CDM – its contribution to the transfer of technology. In doing so it focuses on projects in all host countries and at all stages of development and implementation.

The study provides a deeper understanding of what drives technology transfer, and to what extent the CDM has played a catalytic role in the transfer of technology. For example, the study found that CDM projects create much-needed capacity in host countries, which enables other projects to make use of local skills and technological resources. This demonstrates that the CDM has been effective in delivering technology needed by developing countries.

The findings of this study are timely, Parties are currently discussing reform of the CDM and how the greater use of market instruments may form an integral component of a continuing, concerted international response to climate change. The lessons learned through this study are useful both in further enhancing the CDM and informing the design of any future instruments that aim to scale up and channel technology and financial support for mitigation in developing countries.

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United Nations Framework Convention on Climate Change
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EXECUTIVE SUMMARY

A TWO-FOLD OBJECTIVE

The clean development mechanism (CDM) under Article 12 of the Kyoto Protocol was designed from the beginning to meet multiple objectives. Under it, projects are registered that reduce emissions and enhance removals of greenhouse gases, leading to certified emission reductions (CERs) that are tradable on carbon markets and countable against emissions targets instituted at both company level under national legislation and country level under the Kyoto Protocol.

A key, complementary objective is that the CDM is to assist developing countries in achieving their sustainable development. There are many co-benefits of the investment in climate change mitigation projects channelled through the CDM towards developing countries, not least of which is the transfer of technology and know-how not already available in the host countries.

This study analyzes the technology transfer claims made by project participants in the project design documents (PDDs) of 4,984 projects that were in the CDM pipeline as of 30 June 2010. The projects registered by the CDM Executive Board at this time totalled 2,389, 170 were being considered for registration and a further 2,425 projects were undergoing validation by the third party verifiers engaged in the CDM.

These projects in the pipeline are associated with 81 countries and cover 25 project categories. This is a far richer information source than used for previous studies by the secretariat (UNFCCC 2007 and 2008), making this the most comprehensive analysis to date of the technology transfer that occurs through the CDM. The data used for this study were a combined and reconciled set from both the UNFCCC secretariat and the UNEP Risø Centre.
The technology transfer claims were further verified by confirming and elaborating information with a significant sample of project participants.

CDM AS A KEY DRIVER OF TECHNOLOGY TRANSFER

The findings of this study reveal both the extent of technology transfer that has occurred through the CDM and the changing shape of technology transfer as the use of the CDM by host Parties matures.

Overall, 30% of all projects in the pipeline, accounting for 48% of estimated emission reductions, involve technology transfer. The involvement may be as high as 44% of all projects, given that 24% of the PDDs do not specify whether technology transfer occurs and survey results suggest that 60% of these may in fact involve technology transfer.

Where the PDDs indicate whether technology transfer occurs, the rates of transfer vary considerably by project type, with for example only 13% of Hydro projects versus all N_2O projects showing technology transfer. Other notable examples of significant numbers of projects involving technology transfer include 34% for both Biomass Energy and Wind projects, 78% of Methane Avoidance projects, 39% of Energy Efficiency (Own Generation) projects and 82% of Landfill Gas projects.

Technology transfer is generally more strongly associated with larger projects of almost all project types. Although unilateral and small-scale projects are less likely to involve technology transfer, it is more common among the larger of these projects. 27% of unilateral projects were found to involve technology transfer, while the equivalent rate for small-scale projects was found to be 25%.

TECHNOLOGY TRANSFER EVOLVING WITH THE MATURITY OF THE CDM

The CDM has grown rapidly since the 2007 and 2008 technology transfer studies were completed, with a number of countries now hosting a considerable quantity of projects. Overall, this study indicates that technology transfer was more common during the early years of the CDM than it is today. The 2007 and 2008 studies, respectively, showed technology transfer to occur in 39% and 36% of projects, accounting for 64% and 59% of estimated emission reductions from the CDM.

This decline in technology transfer through the CDM is particularly evident for the three countries with the most CDM projects – China India and Brazil. Where Chinese projects have specified whether technology transfer is occurring, for example, the results show that over 90% of projects entering the pipeline in 2004 and 2005 made use of technology transfer while the same can be said in 2009 and 2010 for only 14% of projects.

Brazil and India show similar declines, albeit starting from lower starting points. In contrast, all other CDM host countries have a high rate of technology transfer that has declined only modestly over time. Such a decline in technology transfer is consistent with the increasing trend towards unilateralism in the CDM. The share of projects that had been approved only by the host Party at the time of their entry into the CDM pipeline rose from 70% in 2004 to almost 95% in 2010. Similarly, fewer subsequent approvals of participation in projects are now being given by developed countries, with the share of projects with developed country involvement falling from over 95% in 2004 to 60% in 2010.

Overall, these results suggest that the CDM has demonstrated its ability to contribute significantly to technology transfer towards developing countries, in particular in the early years of a host country's involvement.

Over time, the need for such international transfer eventually falls as local sources of knowledge and equipment become more established and awareness of the technologies available grows. This reflects increasing maturity in a host country's use of the CDM – the scope for the further inflow of technology is reduced and the need for technology diffusion within the country becomes more prominent.

Nevertheless, the vast majority of developing countries involved in the CDM currently remain at the stage in which substantial levels of technology transfer are being received and this can be expected to continue.

The statistical analysis undertaken for this study sheds further light on some of the factors driving the presence or otherwise of technology transfer in CDM projects. Such transfer is more likely to be present for host countries with smaller populations, lower rates of per capita overseas development aid (ODA), less developed business infrastructure, lower import tariffs, lower rankings on a democracy index, and less developed technical capacity. This suggests that developing countries, through their policies, can also greatly influence the rate at which technology is transferred.

Afforestation, Biomass Energy, Cement, Fugitive Gas, Hydro, PFCs and SF_6, and Reforestation projects are less likely than average to involve technology transfer, while Energy Efficiency (Industry), HFCs, N_2O, Transportation and Wind projects are more likely than average to involve technology transfer.

Preliminary results using information from the technology needs assessments (TNAs) undertaken by a number of developing countries suggest that revenue from CERs may help to overcome economic barriers, and technology licenses and other agreements associated with projects may help overcome barriers concerning intellectual property rights.

DIVERSITY IN SOURCES OF TECHNOLOGY TRANSFER

This study also considers the countries from which the transferred technology originates. 58% of the transferred technology originates in five countries – Germany, USA, Japan, Denmark and China. 84% of the transferred technology originates in developed countries. The leading suppliers of technology among developing countries are China, India, Chinese Taipei, Brazil and Malaysia.

Germany is the main supplier of technology for Energy Efficiency (Households), Wind, N_2O Destruction, and HFC projects. The USA is the largest supplier of technology for Energy Distribution, Fugitive Gases, Fuel Switch, Coal Mine/Bed Methane, Energy Efficiency (Supply Side), Solar, Geothermal, Methane Avoidance, and Landfill Gas projects. Japan is the largest supplier of technology for Energy Efficiency (Own Generation), Energy Efficiency (Industry), and HFC and PFC projects. Denmark is the largest supplier of technology to CO_2 Capture and Biomass Energy projects. China is the main supplier of technology for Hydro projects.

Project developers have a choice among a number of domestic and foreign suppliers of technology and no dominant supplier appears able to restrict the distribution of the technology or maintain technology prices unduly high. Most developed countries tend to receive CERs from projects for which they are technology suppliers.

I. INTRODUCTION

Technology development and transfer are included as priorities 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.[1] The Kyoto Protocol requires all Parties to cooperate in the development, application, diffusion and transfer of environmentally sound technologies that are in the public domain.[2]

Initiatives to help Parties fulfil these commitments include the creation of an Expert Group on Technology Transfer to provide advice to Parties, the establishment the Technology Information Clearing House (TTClear) by the Climate Change Secretariat, and the preparation of technology needs assessments (TNAs) by many developing country Parties.[3]

The CDM, as established by the Kyoto Protocol, does not have an explicit technology transfer mandate but it does have a more general objective of contributing to the sustainable development of developing countries. The contribution that the CDM makes to technology transfer – by financing emission reduction projects that use technologies currently not available in the host countries – may be seen in this light.

CDM project participants are not specifically required to report technology transfer but are required to provide details in PDDs on the technology used for their projects in the PDDs and, from these, information on technology transfer can be derived. This paper examines the technology transfer for all CDM projects under validation, registered or in the process of being registered (4984), making it the most comprehensive analysis to date. In doing so, this paper complements and builds upon a number of other similar studies that have analyzed the technology transfer reported for CDM projects.[4]

Section 2 provides background on what is meant by the term technology transfer. The CDM project data used in this study, in particular the information specifically relevant to technology transfer, are presented in Section 3.

Section 4 presents results of the analysis of technology transfer as it relates to which countries are receiving the technology, on what basis and through which project types. This section also assesses the factors that appear to determine the level of technology transfer that occurs and some specific trends in how the transfer of technology through the CDM is evolving as the mechanism matures.

Section 5 presents more analysis from the perspective of the suppliers of the technology being transferred. These results include the countries from which the technology originates, the diversity of the suppliers in relation to different project types and the relationship between the receipt of CERs and supply of the technologies.

Finally, section 6 discusses a number of opportunities for improvement in the analysis conducted for this study.

II. WHAT IS MEANT BY 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 procedures set for the CDM do not define 'technology transfer'.[6] The statements in the PDDs therefore reflect the implicit definitions of technology transfer made by the project participants. It is clear from the PDDs that project participants almost universally interpret technology transfer as meaning the use by the CDM project of equipment and/or knowledge not previously available in the host country.

Some CDM projects claim technology transfer for technology already available in the country. Since the analysis focuses on technology transfer between countries and all of the other projects appear to use that definition, the cases that claim technology transfer within the host country are classified as not involving technology transfer.

[1] UNFCCC, 1992, Article 4.1.

[2] UNFCCC, 1997, Article 10(c).

[3] UNFCCC, 2006a.

[4] See Seres, Haites and Murphy, 2009; Haites, Duan and Seres, 2006; UNFCCC, 2007; Dechezleprêtre, Glachant and Ménière, 2007; De Coninck, Haake and van der Linden, 2007; and UNFCCC, 2008.

[5] Metz *et al.*, 2000, p. 3.

[6] UNFCCC, 2006b, pp. 5–12.

III. CDM PROJECT DATA USED IN THE STUDY

As of 30 June 2010, 6,556 projects had entered the CDM pipeline. Of these, 1,572 were discontinued by 30 June 2010, either by not being successfully validated, being replaced by another project, being withdrawn by the project participants or having the request for registration being rejected by the Executive Board. This paper analyzes the statements relating to technology transfer in the PDDs of the remaining 4,984 CDM projects.

The CDM pipeline is taken to be all projects for which a PDD containing a description of the proposed CDM project has been completed and made available for public comment. This public availability of PDDs is required as part of the validation by independent 'designated operational entities' (DOEs) to ensure that proposed projects meet all requirements of CDM projects.

The UNFCCC secretariat maintains a list of projects and project information in this pipeline. The UNEP Risø Centre regularly adds additional information to these lists and assigns a project type to each project. For this study, both were combined, reconciled and used as the source of the CDM project data.

Figure III-1 shows the breakdown of the projects entering the pipeline each year, with the stacked bars indicating the status of these projects as of 30 June 2010. Up to this date, 2,389 had been registered by the CDM Executive Board with another 170 still undergoing the registration process. A further 2,425 projects were still undergoing validation as of 30 June 2010, showing that a significant body of projects was still being prepared for submission to the Executive Board (i.e. undergoing validation).

By including the projects still undergoing validation, a much larger dataset is presented for statistical analysis. While these projects may potentially differ from those finally submitted for registration, a statistical test indicates that the two groups are similar and so all projects in the pipeline, including those still under validation, have been used in the analysis contained in this paper.[7]

The 4,984 projects are associated with 81 countries and cover 25 of the 26 categories of greenhouse gas emission reduction actions, sectors and technologies contained in the classification of project types defined by the UNEP Risø Centre.[8] Since the previous study in 2008, the UNEP Risø Centre has revised its definitions of the project types and for this study the projects have been classified in line with these new definitions. This has lead to the reclassification of many projects. The changes affect mainly the Agriculture, Biogas, Methane Avoidance, Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6) project types. For this reason information relating to project types should not be compared with results presented in the previous studies (UNFCCC 2007, 2008).

A CDM project may be implemented by project participants from the host country alone or jointly with foreign participants. Projects that had been approved only by a non-Annex 1 host country (single participant) at the time they were posted for public comment are defined in this study as 'unilateral'projects'.[9] The share of unilateral projects fell from 70% in 2004 to 60% in 2006 but has since risen to almost 95% (see Figure III-2).

Some of these projects are subsequently approved by one or more Annex I Parties in order for the certified emission reductions (CERs) to be distributed to project participants from these countries directly. There has been a falling tendency for subsequent approvals to be given by Annex I countries, with the share of projects approved by one or more Annex I Party being over 95% for early projects but only 60% for more recent projects (see figure III-2). This trend is consistent with the overall shift towards unilateral projects that is evident from the numbers of projects being unilateral at the time of their being posted for public comment.

Information about technology transfer was collected from the individual PDDs. In Sections A.2 and A.4.3, project participants are requested to provide a description of the project and details on its technology, including a description of how environmentally safe and sound technology and know-how are to be used and transferred to the host Party(ies). In section B.5, they are required to demonstrate the additionality of the project and, if necessary, again make reference to the technology used in the project. These sections were reviewed to determine whether technology transfer was taking place as part of the project. In addition, to ensure that all statements relating to technology transfer had been identified, the remaining sections of each PDD were searched for keywords relating to technology transfer.[10]

Where technology transfer is mentioned, the project was coded to distinguish projects transferring both equipment and knowledge from those that transfer only one or the other. In many cases, the PDD explicitly states that the project involves no transfer of technology. For 1,206 other projects, the PDD makes no mention of technology transfer and it is unclear whether these involve technology transfer.

A survey of the projects covered by the 2008 study[11] (3296) was conducted to verify the use of technology transfer codes derived from the PDDs. Approximately 11% (370) of project developers responded. The results are presented in annex A. The results indicate that 'no technology transfer' was the correct classification for 88% of the 116 projects to which this code was assigned based on the PDD and 'technology transfer' was the correct classification for 89% of the 159 projects that claimed technology transfer in the PDD (see TABLE A-8 in ANNEX A).

However, the results also show that the projects claiming transfer of either knowledge or equipment in the PDD in practice usually involved both. Information on the nature of the technology transfer – knowledge only, equipment only or both knowledge and equipment – must be used with caution (see TABLE A-9 in ANNEX A).

Of the projects in the 2008 study for which technology transfer could not be determined, the current survey indicates that 58% involved technology transfer while 41% did not. Thus, the previous studies understated the rate of technology transfer. While the current study treats these projects as 'unknown' and excludes them from most analyses,[12] it is likely that a reasonable number of these projects in practice do involve technology transfer and the technology transfer rates stated in this study should be considered conservative estimates.

In addition to the nature of the technology transfer, the source countries for the technology are recorded. If the source was not identified in the PDD, the project's developers were contacted to determine the origins of the technology. Often the source is not known because the technology supplier for a proposed project has not yet been selected, so the source remains 'unknown' for about 20% of the projects that claim technology transfer.

[7] As discussed in ANNEX B, a dummy variable was added to the regression analysis to differentiate registered projects from those seeking approval. The regression is essentially unchanged by the addition of this variable which indicates that registered projects and projects seeking approval are similar in terms of technology transfer and can be grouped together for analysis.

[8] The UNEP Risø Centre CDM Pipeline includes agriculture projects in its classification of project types, but there are no 'agriculture' projects in the CDM pipeline.

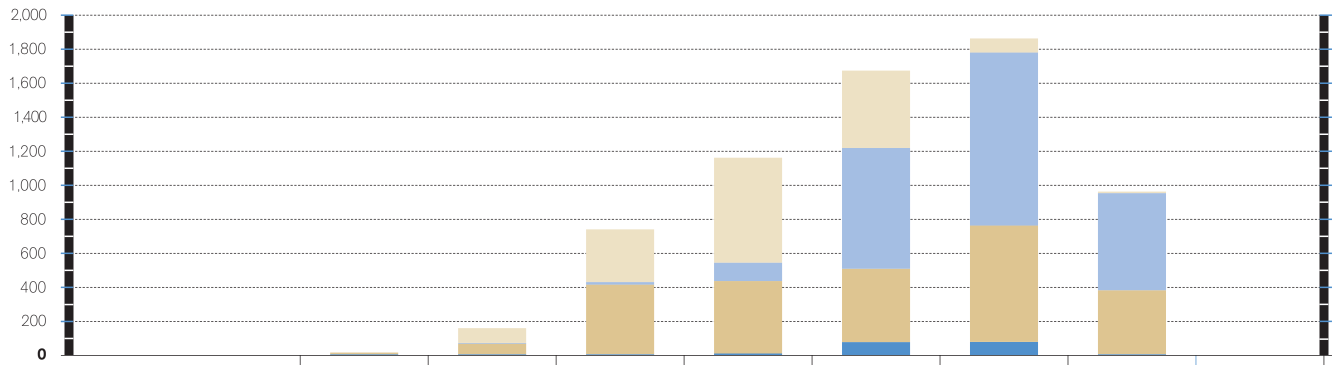
[9] In past analyses a project was defined as a unilateral project if it only had host country approval at the end of the period covered by the analysis. Since the number of countries that approve a project increases over time, that definition obscured the percentage of projects that were unilateral when they entered the pipeline. All projects have been reclassified to reflect the definition of a unilateral project as one with host country approval when it is posted for public comment.

[10] Keywords included: technology, transfer, import, foreign, abroad, overseas, domestic, indigenous, etc.

[11] UNFCCC, 2008.

[12] This study differs from the 2008 and 2009 studies in so far as the previous studies included projects that made no reference to technology transfer, but assumed these projects involved no technology transfer.

Figure III-1. **Number of projects entering the pipeline by year** (with project status as of 30 June 2010)



	2004	2005	2006	2007	2008	2009	2010	Total
Discontinued	10	87	310	617	455	83	9	1,572
Under validation	–	4	15	108	710	1,017	571	2,425
Registered	1	62	409	426	431	684	376	2,389
Registration requested	–	1	5	9	76	77	2	170
Total								**6,556**

Figure III-2. **Number of projects entering the pipeline by year and the extent of unilateral projects** (as of 30 June 2010)

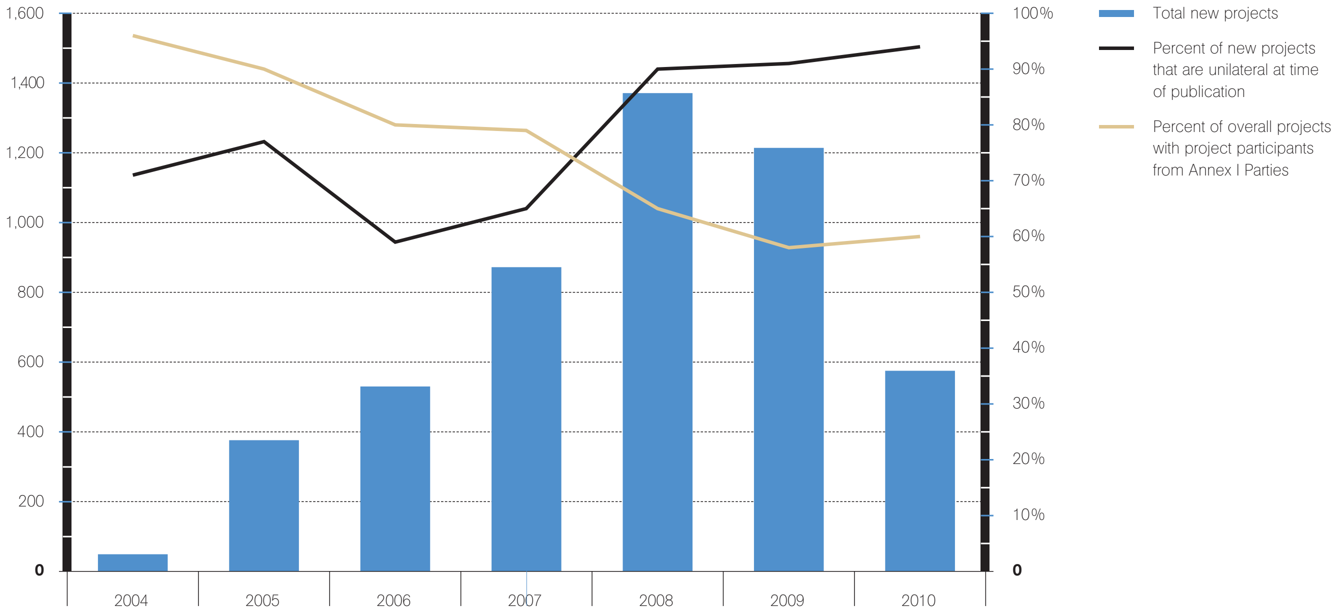


Table IV-1. **Frequency of technology transfer**

Nature of technology transfer	Number of projects	% of projects	% of annual emission reductions
All projects in the pipeline as of 30 June 2010			
Project specifically states no technology transfer – self reliant	2,262	45	33
No mention or indication of technology transfer in the PDD*	1,206	24	19
Project is expected to involve technology transfer	1,516	30	48
Total	4,984	100	100
Projects in the pipeline as of 30 June 2010 for which the PDD explicitly states the project is expected to or will not involve technology			
Project specifically renounces technology transfer – self reliant	2,262	60	41
Project is expected to involve technology transfer	1,516	40	59
Total	3,778	100	100
Projects in the pipeline as of 30 June 2010 expected to involve technology transfer			
Technology transfer of equipment only	515	34	34
Technology transfer of knowledge only	209	14	11
Technology transfer of equipment and knowledge	792	52	54
Total	1,516	100	100

* One PDD could not be found – it was added to this category

IV. RECIPIENTS OF TECHNOLOGY TRANSFER

4.1. OVERALL FREQUENCY OF TECHNOLOGY TRANSFER

Data on the frequency of overall technology transfer through the CDM is provided in TABLE IV-1.[13] As of 30 June 2010, 30% of projects in the pipeline and 48% of the estimated emission reductions claim to involve technology transfer. This reflects a falling trend over time, as the 2007 and 2008 studies, respectively showed the frequency of overall technology transfer to be 39% and 36% of projects and 64% and 59% of the annual emission reductions reported. However, using only those projects which explicitly state that they will, or will not, involve technology transfer, 40% of the projects accounting for 59% of the estimated emission reductions involve technology transfer.

As was discussed above, the survey results suggest that all these percentages underestimate the level of technology transfer by assuming that projects that do not mention technology transfer in the PDD do not involve technology transfer. Projects for which technology transfer could not be determined account for 24% of all projects in the pipeline. The follow-up survey indicates that about 60% of these projects involve technology transfer (see TABLE A-8 in ANNEX A). Applying this percentage to the projects for which technology transfer could not be determined would raise the rate of technology transfer to 44% of all projects.

Projects that expect to involve technology transfer are classified based on the nature of the technology transfer – imports of equipment only, transfer of knowledge through training and the engagement of foreign experts, and transfer of both equipment and knowledge. Based on the PDDs, 14% of projects that claim technology transfer involve transfer of knowledge only, 34% expect to import equipment only, and 52% expect to use both foreign knowledge and equipment. The follow-up survey suggests that the percentages for knowledge only and equipment only could be substantially lower and that almost 70% of the projects that involve transfer will import both knowledge and equipment (see TABLE A-8 in ANNEX A).

4.2. TECHNOLOGY TRANSFER BY PROJECT TYPE[14]

TABLE IV-2 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 of the estimated annual emission reductions for which technology transfer is claimed. The distribution of projects is not uniform: approximately one-third of the project types have 20 or fewer projects while another third have over 100 projects each, with Hydro, Wind, Biomass Energy and Methane Avoidance dominating the totals. The average project size varies widely across categories from less than 10 ktCO_2e per year for Afforestation and CO_2 Capture to 3,696 ktCO_2e per year for HFC reduction projects. The overall average is 140 ktCO_2e per year.

As shown in TABLE IV-1 the percentage of projects that claim technology transfer averages 40%. FIGURE IV-3 shows that the share of projects involving technology transfer ranges from 13% to 100% for different project types. This is not surprising for categories involving only a few projects, as in the case for example for Tidal and CO_2 Capture, but large differences are observed for project types with relatively large numbers of projects. Only 178 of the 1372 Hydro projects claim technology transfer, while 66 of the 70 N_2O destruction projects claim to involve technology transfer (the other four are 'unknown').

The technology transfer ratio is considerably higher in terms of share of estimated annual emission reductions than it is in terms of the share of projects. This indicates that projects claiming technology transfer are, on average, substantially larger than those that do not. This is true for most project types, although the Energy Distribution and Solar projects that involve technology transfer are much smaller than many similar projects that do not claim technology transfer.

[13] Eight PDDs claimed a technology transfer from one region to another within the host country. As discussed above, these projects were classified as not involving technology transfer.

[14] The definitions of the project types have changed since the previous study and all projects have been classified in accordance with the new definitions. Many projects have been reclassified into different project types, so results by project type cannot be compared with those in earlier studies.

Technology transfer claims for unilateral and small-scale projects by project type are summarized in TABLE IV-3. Over 80% of all projects are unilateral projects, but they account for approximately 75% of the annual emission reductions.[15] This means that the average size of unilateral projects, 128 ktCO_2e/yr, is about 10% smaller than that of all CDM projects. Approximately 27% of the unilateral projects claim technology transfer as compared to 40% of all projects. The unilateral projects that claim technology transfer are somewhat larger than the average for unilateral projects, accounting for 42% of the emission reductions.

Small-scale projects represent 46% of all projects.[16] Small-scale projects, by definition, are much smaller than average (29 ktCO_2e/yr). Approximately 25% of the small-scale projects claim technology transfer as compared with 40% of all projects. The average size of small-scale projects claiming technology transfer is over 25% larger than the average size of small-scale projects that do not involve technology transfer.

It may be concluded that technology transfer varies widely across project types but is more common for larger projects. Small-scale and unilateral projects are less likely to involve technology transfer. Among small-scale and unilateral projects, technology transfer is more common for larger projects.

4.3. KEY FACTORS INFLUENCING TECHNOLOGY TRANSFER

A statistical analysis of the data was carried out to identify the key factors influencing technology transfer through the CDM. More detail on the statistical analysis is provided in annex B. Firstly, technology transfer was related to project characteristics, project type and host country to test which factors are most favourable to technology transfer.

The results are consistent with those reported by other studies, and the significant features are:

- Larger projects are more likely to involve technology transfer;
- Unilateral projects are less likely to involve technology transfer;
- Small-scale projects are less likely to involve technology transfer;
- Technology transfer frequency declines as the number of projects of the same type in a host country increases, suggesting that technology transfer often occurs beyond the CDM projects;
- Technology transfer was more common during the initial years of the CDM suggesting that the CDM helped by contributing to early awareness of the mitigation technology in the host country and that technological capacity was being developed in, or transferred to, developing countries through non-CDM channels;
- Afforestation, Biomass Energy, Cement, Fugitive Gas, Hydro, PFCs and SF_6 and Reforestation projects are less likely than average to involve technology transfer;
- Energy Efficiency (Industry), HFCs, N_2O, Transportation and Wind projects are more likely than average to involve technology transfer;
- The host country plays a very significant role in technology transfer;
- Technology transfer remains considerably higher for almost all host countries than it is for countries with relatively high numbers of CDM projects, in particular China, India and Brazil.

Secondly in order to understand the factors that make a host country more or less attractive for technology transfer, the likelihood of technology transfer from the above analysis were related to country characteristics, such as:

- Measures of the host country's attractiveness as a recipient of technology transfer, such as population, GDP per capita, gross capital formation, foreign direct investment (FDI), Official development assistance (ODA) per capita, and indicators of the ease of doing business and political freedom;
- Measures of the host country's overall technological capacity, such as the number of patents issued, and an index of technological capacity;
- Measures of the host country's technological capacity related to the technologies represented by the project type.

[15] All of the 25 project types that have at least one CDM project in the pipeline also have an unilateral project.

[16] Five of the 25 project types – Cement, Coal bed/mine Methane, N_2O, PFCs and SF_6, and Tidal – have no small-scale projects. All of the CO_2 Capture projects in the pipeline are small-scale projects.

Table IV-2. **Technology transfer by project type**

Project type	Number of projects	Average investment (USD/tCO_2e)	Average project Size (CO_2e/yr)	Technology transfer claims as percent of: Number of projects (%)	Technology transfer claims as percent of: Annual emission reductions (%)	% of projects where technology transfer could not be determined
Afforestation	10	–	26,839	33	47	40
Biomass Energy	643	234	67,974	34	45	33
Cement	32	74	152,152	21	19	41
CO_2 Capture	3	2,528	9,675	100	100	33
Coal bed/mine Methane	65	40	585,532	53	68	15
Energy Efficiency (Households)	32	167	40,852	38	58	50
Energy Efficiency (Industry)	126	1,356	29,481	65	64	46
Energy Efficiency (Own Generation)	421	221	132,383	39	63	24
Energy Efficiency (Service)	20	763	12,052	83	96	70
Energy Efficiency (Supply Side)	75	667	388,323	70	74	43
Energy Distribution	17	679	301,221	25	15	6
Fuel Switch	109	331	397,817	78	89	32
Fugitive	35	109	477,864	47	55	46
Geothermal	15	1,252	222,085	91	97	27
HFCs	22	169	3,696,440	91	97	0
Hydro	1372	372	109,965	13	11	17
Landfill Gas	297	93	154,841	82	87	25
Methane Avoidance	566	76	46,200	78	81	26
N_2O	70	49	711,373	100	100	6
PFCs and SF_6	17	389	291,838	75	91	53
Reforestation	42	362	101,433	25	23	43
Solar	47	5,921	22,402	60	43	26
Tidal	1	–	315,440	100	100	0
Transport	24	2,033	100,435	82	93	54
Wind	923	661	91,732	34	38	19
Grand Total	**4984**	**427**	**139,925**	**40**	**59**	**24**

Figure IV-3. **Technology transfer by project type as a % of projects**

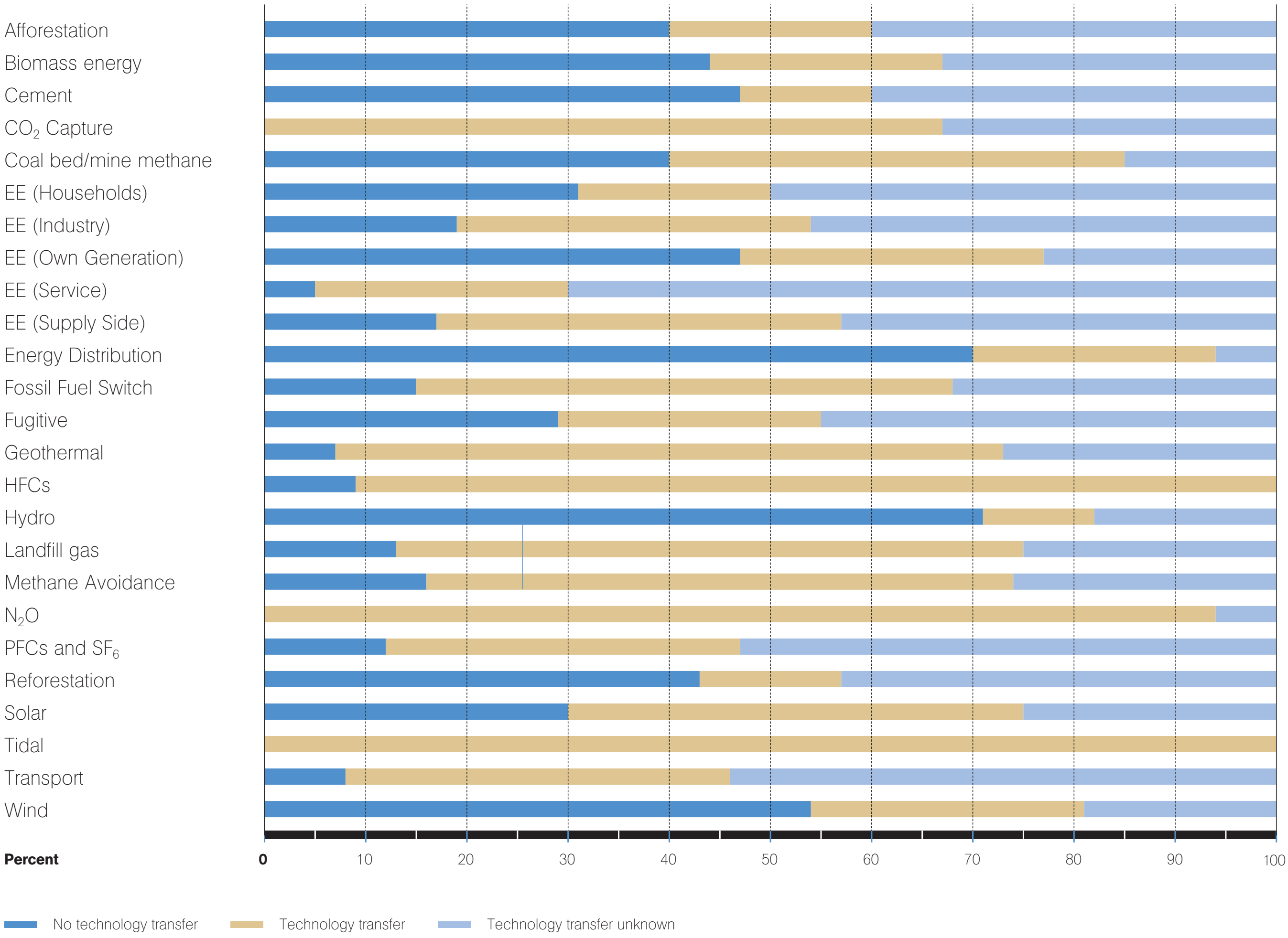


Table IV-3. **Technology transfer claims as a percentage of the total unilateral or small-scale projects**

Project type	Unilateral projects expressed in		Small-scale projects expressed in	
	Number of projects (%)	Annual emission reductions (%)	Number of projects (%)	Annual emission reductions (%)
Afforestation	20	24	25	36
Biomass Energy	21	32	24	42
Cement	11	14	–	–
CO_2 Capture	67	41	100	100
Coal bed/mine Methane	40	34	–	–
Energy Efficiency (Households)	24	24	20	38
Energy Efficiency (Industry)	36	39	34	31
Energy Efficiency (Own Generation)	25	38	21	23
Energy Efficiency (Service)	25	32	25	32
Energy Efficiency (Supply Side)	35	32	19	20
Energy Distribution	19	15	20	9
Fuel Switch	51	75	32	30
Fugitive	25	18	0	0
Geothermal	75	57	50	94
HFCs	93	100	67	62
Hydro	12	10	11	8
Landfill Gas	54	57	36	58
Methane Avoidance	50	55	52	43
N_2O	90	95	–	–
PFCs and SF_6	40	31	–	–
Reforestation	13	5	17	10
Solar	45	32	45	37
Tidal	100	100	–	–
Transport	36	41	50	42
Wind	25	30	16	21
Sub-Total	27	42	25	30
Total number	4,077	523,054 $ktCO_2e$	2,307	66,906 $ktCO_2e$
% of all projects	82	75	46	10

The results, which are preliminary, are generally consistent with the results of previous studies and other reports and indicate that technology transfer for CDM projects is more likely to occur for host countries with a smaller population, lower ODA per capita, with a less developed business infrastructure, where import tariffs are lower, with a lower ranking on the democracy indices, and with lower technical capacity.

Lastly, technology needs assessments (TNAs) have been completed by a number of CDM host countries.[17] The TNAs identify technologies needed by the country to reduce greenhouse gas emissions and barriers to the implementation of those technologies.[18] Some of the TNAs allow barriers to be identified by technology, which can be related to the CDM project types. This allowed an estimation of the types of barriers faced by CDM projects.

Preliminary results indicate that countries that have completed TNAs are more likely than other developing countries to have technology transfer, so the results may not apply to other countries. Countries and project types that face an information barrier[19] have a lower rate of technology transfer for CDM projects. Projects that face economic/market or intellectual property rights barriers have a higher rate of technology transfer. This suggests that revenue from the sale of CERs may help to overcome some technology transfer barriers and any intellectual property rights are overcome with licenses or other agreements on the imported knowledge and/or equipment, also as a result of the CDM project.

As stated above, these results are preliminary and await confirmation as more data become available. However, it is clear that developing countries can through their policies, influence the rate at which technology is transferred.

4.4. TRENDS IN TECHNOLOGY TRANSFER FOR SELECTED HOST COUNTRIES

Table IV-4 presents data on technology transfer claims made in PDDs for the 10 countries with the most CDM projects. Three countries – China, India and Brazil – dominate in terms of total numbers of the projects with 72%, and in terms of estimated annual emission reductions with over 77%.

Figure IV-4 shows trends in the rate of technology transfer claims for CDM projects for the three largest host countries – China, India and Brazil – as well as for other countries (Chile, Indonesia, Malaysia, Mexico, Republic of Korea, Thailand and Vietnam). Figure IV-4 also shows the average for all countries in terms of number of projects and estimated annual emission reductions. Projects for which technology transfer is not known are excluded.

The rate of technology transfer for all host countries has declined over time. The decline is much larger when measured in terms of estimated annual emission reductions than in terms of number of projects. The decline has been steeper than the overall average in China, India and Brazil. Initially, China had a rate of technology transfer higher than the average for all countries, but the rate is now

Table IV-4. **Technology transfer for projects in selected host countries**

Project type	Number of projects	Estimated emission reductions (tCO_2e/yr)	Average project size (CO_2e/yr)	Technology transfer claims as percent of: Number of projects (%)	Technology transfer claims as percent of: Annual emission reductions (%)	% of projects where technology transfer could not be determined
Brazil	338	34,269,995	101,391	25	54	32
Chile	69	7,182,105	104,088	52	72	43
China	1993	387,496,440	194,429	19	47	9
India	1254	117,940,808	94,052	13	23	40
Indonesia	100	11,207,814	112,078	59	43	38
Malaysia	127	7,009,300	55,191	60	65	35
Mexico	165	14,588,291	88,414	83	84	16
Republic of Korea	72	19,607,821	272,331	50	69	42
Thailand	115	6,369,257	55,385	80	79	16
Vietnam	106	6,772,217	63,889	73	60	24
All others	645	84,944,348	131,697	59	64	31
Grand Total	**4984**	**697,388,396**	**139,925**	**40**	**59**	**24**

substantially lower. India has consistently had a rate of technology transfer lower than the average for all countries. In Brazil the frequency has been approximately equal to the average for all countries.

The rate of technology transfer for other host countries has been much higher than the overall average and has declined only modestly, which is consistent with the results of the statistical analysis above.

Several factors contribute to these results. First, as more projects of a given type are implemented in a country the rate of new technology transfer declines. As well as recognizing that the technology used by these projects is now available in the host country, this also indicates that a transfer of technology to a CDM project creates capacity in the country that allows later projects to rely more on local knowledge and equipment. These results suggest that the CDM has been effective in delivering the technology needed by the developing countries that are already host to many projects. The technology involved in these project is also established in those host countries.

Second, the development and/or transfer of the technologies used by CDM projects appear to have been happening through other channels as well. This is confirmed by the statistical analysis, which shows a positive correlation with time variables but a decline in the magnitude and statistical significance over time (see ANNEX B).

[17] <http://unfccc.int/ttclear/jsp/CountryReports.jsp>.

[18] The TNAs also cover adaptation technologies, but only the mitigation technologies are relevant for this analysis.

[19] Examples of information barriers in TNA's include in rank order: shortage of information on energy efficiency and ecological safety of technology equipment, shortage of information about governmental structures, difficulties in obtaining information on organizations and companies that deal with energy efficient and modern climate change mitigation technologies, lack of information among investors on the potential technology market and lack of information about financing.

Figure IV-4. **Trend in technology transfer**

This weakening of the correlation suggests that similar technologies were being developed in host countries or being transferred to them through other channels. For example, Haščič and Johnstone (2009) find that the CDM explains only part of the transfer of wind technologies to developing countries.

Finally, the composition of the CDM pipeline has changed over time. Initially, the pipeline featured a small number of large HFC, N_2O and Landfill Gas projects. Since then the mix of projects has become more diverse, with Hydro and Wind now being the most common project types. Each project type has a different frequency of technology transfer, so changes to the composition of the pipeline affect the average rate of technology transfer. Similarly, the number of host countries has grown over time. New host countries typically have a higher rate of technology transfer, so the average has not fallen as rapidly as the rates for China, India and Brazil.

Technology transfer induced by CDM projects, then, spreads beyond these projects as the number of projects of a given type in a host country increases.[20] That enables later projects of those project types in the host countries to rely more on local knowledge and equipment. And similar technologies are being developed in host countries or being transferred to them through other channels. The declining rates of technology transfer in such categories are being offset by high rates of technology transfer for CDM projects in smaller countries with fewer projects.

4.5. KEY FACTORS INFLUENCING TECHNOLOGY TRANSFER

Each CDM project must be approved by the host country government. As part of the approval process the host country government may choose to impose technology transfer requirements. This section illustrates some aspects of the policies put in place by three key countries in the CDM – China, India and Brazil.

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."[21] This is a general provision for the country's use of the CDM rather than a mandatory requirement for each project. The rate of technology transfer for projects in China is about half the average for all CDM projects measured in share of projects (19% versus 40%) and about 80% of the average for annual emission reductions (47% versus 59%).

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."[22]

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. However, technology transfer within a country, claimed by eight Indian projects, is excluded from this analysis. India has the lowest rate of international technology transfer of all host countries whether measured in terms of number of projects (13% versus 40%) or estimated annual emission reductions (23% versus 59%).

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 "contribution to technological development and capacity-building."[23] Technology transfer is not mentioned directly; instead the project's contribution to technology development is assessed as part of its contribution to sustainable development. Technology transfer for Brazilian projects is below the average for all CDM projects measured in share of projects (25% versus 40%) and annual emission reductions (54% versus 59%).

Clearly, a host country is a key factor determining the extent to technology transfer is involved in its CDM projects. It can do this explicitly through 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[24] also can affect the extent of technology transfer involved in CDM projects as illustrated by the statistical analysis.

[20] This supports the assessment that the CDM contributes to technology transfer by lowering several technology-transfer barriers and by raising the transfer quality (Schneider *et al.*, 2008).

[21] Government of China, 2005, Article 10, p. 2. <http://www.ccchina.gov.cn/en/>.

[22] Government of India, undated, p. 1. <http://cdmindia.nic.in/host_approval_criteria.htm>.

[23] Government of Brazil, 2005, p. 2. <http://www.mct.gov.br/index.php/content/view/14666.html>.

[24] Wang, 2010.

V. SUPPLIERS OF TECHNOLOGY TRANSFER

5.1. ORIGINS OF THE TECHNOLOGY

Where the source of the technology is specified, the country of origin was tabulated in the analysis for this study. If more than one country supplied technology to a project, each country was credited with a fraction of the project. For example, for a project that involved a transfer of equipment from one country and both knowledge and equipment from another country, each supplier country would be credited with one-half of the technology transfer associated with the project.

Many PDDs identify technology transfer, but do not specify the source of the technology. If the source was not identified, the project's developers were contacted to determine the origins of the technology. The source of the technology remains 'unknown' for about 20% of the projects that claim technology transfer (see TABLE V-5).

This is, at least partly, due to projects for which the technology has not yet been sourced because the project has not yet been implemented. The main sources of the technology transferred through CDM projects are shown in FIGURE V-5.

When projects for which the source of the technology is 'unknown' are excluded, the top five technology suppliers are Germany, the USA, Japan, Denmark and China. Together they supply 58% of the projects. About 84% of the projects get their technology from Annex I countries. China, India, Chinese Taipei, Brazil and Malaysia are the leading non-Annex I technology suppliers.

FIGURE V-6 below and TABLE V-5 show the sources of the technology by project type, the largest supplier and its share overall. Most project types draw on technology from several countries. Although Germany supplies the largest number of projects, it is the main supplier only for Energy Efficiency (Households), Wind, N_2O destruction, and HFC (tied with Japan). The USA is the largest technology supplier for nine project types – Energy Distribution, Fugitive Gas, Fuel Switch, Coal Mine/Bed Methane, Energy Efficiency (Supply Side), Solar, Geothermal, Methane Avoidance, and Landfill Gas projects. Japan is the largest technology supplier for Energy Efficiency (Own Generation), Energy Efficiency (Industry), and HFC and PFC projects. Denmark is the largest technology supplier to CO_2 Capture and Biomass Energy projects. China is the main supplier of technology for Hydro projects.

Figure V-5. **Leading sources of technology transfer** (as a percentage of projects)

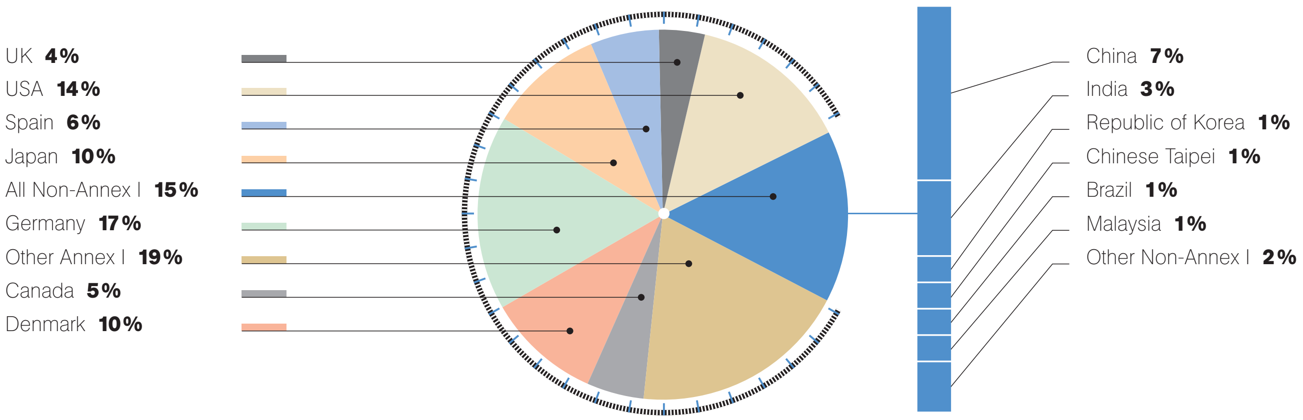


Figure V-6. **Origins of technology transfer by project type** (as a percentage of projects)

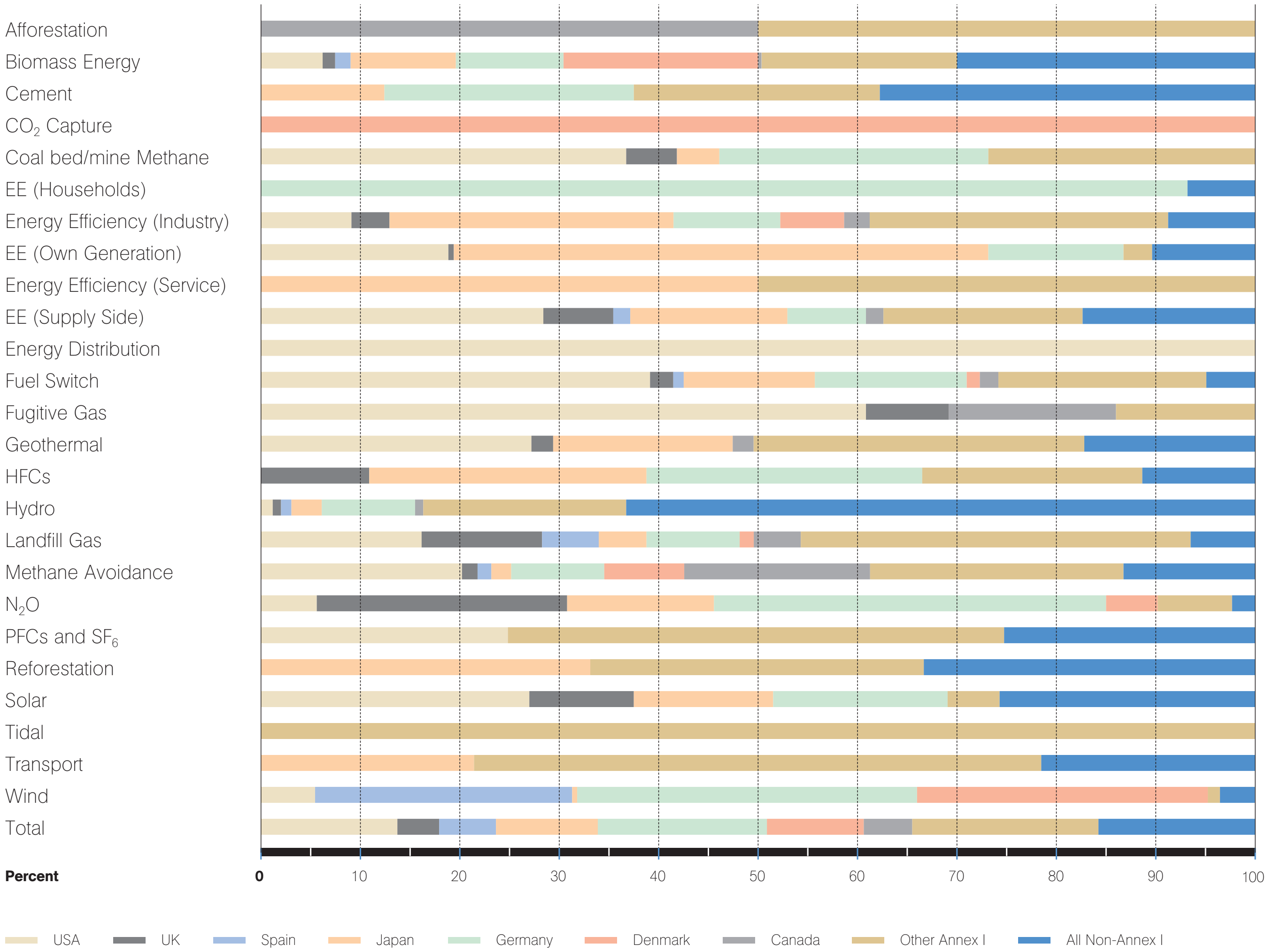


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Table V-5. **Originating countries of technology transfers by project type** (number of projects) (continued)

	Geothermal	HFCs	Hydro	Landfill Gas	Methane Avoidance	N_2O	PFCs and SF_6	Reforestation	Solar	Tidal	Transport	Wind	Total
Argentina	–	–	–	0	–	–	–	–	–	–	–	–	**1**
Australia	0	–	1	1	3	0	–	–	–	–	–	–	**9**
Austria	–	–	8	4	7	0	1	–	–	1	–	–	**26**
Belgium	–	–	–	3	13	–	–	–	–	–	–	–	**23**
Brazil	0	–	4	0	1	–	–	1	–	–	–	–	**15**
Colombia	–	–	–	–	–	–	–	–	–	–	–	–	**0**
Canada	0	–	1	7	49	–	–	–	–	–	–	–	**61**
China	1	–	54	2	2	–	1	–	4	–	2	2	**88**
Costa Rica	–	–	0	–	–	–	–	–	–	–	–	–	**0**
Czech Republic	–	–	1	–	–	–	–	–	–	–	–	1	**3**
Denmark	–	–	–	2	21	3	–	–	–	–	–	64	**118**
Egypt	–	–	–	1	–	–	–	–	–	–	–	–	**1**
EU	0	–	2	11	6	–	–	–	1	–	–	–	**27**
Finland	–	–	2	–	2	–	–	–	–	–	–	–	**11**
France	–	4	4	7	–	1	–	1	–	–	1	–	**25**
Germany	–	5	10	13	24	25	–	–	3	–	–	76	**208**
Guatemala	–	–	–	–	–	–	–	–	–	–	–	–	**0**
Iceland	2	–	–	–	–	–	–	–	–	–	–	–	**2**
India	–	–	12	–	1	–	–	–	–	–	–	6	**33**
Israel	0	–	0	0	2	–	–	–	–	–	–	–	**3**
Italy	–	–	2	8	1	0	–	1	–	–	–	–	**13**
Liechtenstein	–	–	–	–	–	–	–	–	–	–	1	–	**1**
Luxembourg	–	–	–	–	–	0	–	–	–	–	–	–	**0**
Japan	2	5	3	7	5	9	–	1	3	–	2	1	**125**
Malaysia	–	–	–	–	6	–	–	–	–	–	–	–	**10**
Mexico	–	–	0	–	2	–	–	–	–	–	–	–	**4**
Netherlands	–	–	–	9	7	–	–	–	1	–	–	2	**20**
New Zealand	0	–	0	1	6	–	–	–	–	–	–	–	**7**
Norway	–	–	1	–	–	3	–	–	–	–	–	–	**5**
Poland	–	–	–	–	–	–	–	–	–	–	–	–	**1**
Russia	–	–	3	–	–	–	–	–	–	–	–	–	**4**
Singapore	–	–	–	3	–	–	–	–	–	–	–	–	**3**
South Africa	–	–	–	0	–	–	–	–	1	–	–	–	**2**
Korea, Republic of	–	2	–	1	2	1	–	–	–	–	–	–	**6**
Spain	–	–	1	8	4	–	–	–	–	–	–	57	**72**
Sweden	–	–	–	–	19	–	–	–	–	–	2	–	**30**
Switzerland	–	–	0	10	3	0	1	–	–	–	–	–	**22**
Chinese Taipei	–	–	0	1	13	0	–	–	0	–	–	–	**16**
Tunisia	–	–	–	0	–	–	–	–	–	–	–	–	**0**
Thailand	–	–	–	–	4	–	–	–	–	–	–	–	**7**
UK	0	2	1	16	4	16	–	–	2	–	–	–	**49**
Unknown	1	2	38	45	65	4	2	3	2	–	2	32	**239**
Uruguay	–	–	–	–	–	–	–	–	–	–	–	–	**0**
Ukraine	–	–	–	–	–	–	–	–	–	–	–	–	**0**
USA	2	–	2	22	53	4	1	–	5	–	–	12	**171**
Total	**10**	**20**	**149**	**181**	**327**	**66**	**6**	**6**	**21**	**1**	**9**	**251**	**1.516**

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Table V-5. **Originating countries of technology transfers by project type** (number of projects)

	Afforestation	Biomass Energy	Cement	CO_2 Capture	Coal bed/ mine Methane	Energy Efficiency (Households)	Energy Efficiency (Industry)	Energy Efficiency (Own Generation)	Energy Efficiency (Service)	Energy Efficiency (Supply Side)	Energy Distribution	Fuel Switch	Fugitive Gas
Argentina	–	0	–	–	–	–	–	–	–	0	–	–	–
Australia	1	2	–	–	1	–	1	0	–	–	–	–	–
Austria	–	1	–	–	1	–	1	–	–	1	–	1	–
Belgium	–	7	–	–	–	–	–	–	–	–	–	1	–
Brazil	–	8	–	–	–	–	–	0	–	1	–	–	–
Colombia	–	–	–	–	–	–	–	–	–	0	–	–	–
Canada	1	0	–	–	–	–	1	–	–	0	–	1	1
China	–	8	1	–	–	–	3	9	–	1	–	2	–
Costa Rica	–	–	–	–	–	–	–	–	–	–	–	–	–
Czech Republic	–	1	–	–	–	–	–	–	–	–	–	0	–
Denmark	–	24	–	2	–	–	3	–	–	–	–	1	–
Egypt	–	–	–	–	–	–	–	–	–	–	–	–	–
EU	–	4	1	–	–	–	–	–	1	–	–	2	–
Finland	–	2	–	–	–	–	1	–	–	1	–	3	–
France	–	2	–	–	0	–	2	2	–	–	–	2	–
Germany	–	13	1	–	6	5	4	13	–	2	–	8	–
Guatemala	–	0	–	–	–	–	–	–	–	–	–	–	–
Iceland	–	–	–	–	–	–	–	–	–	–	–	–	–
India	–	13	–	–	–	–	–	1	–	–	–	–	–
Israel	–	0	–	–	–	0	–	–	–	–	–	–	–
Italy	–	–	–	–	–	–	1	–	–	–	–	0	–
Liechtenstein	–	–	–	–	–	–	–	–	–	–	–	–	–
Luxembourg	–	–	–	–	–	–	–	–	–	–	–	–	–
Japan	–	13	1	–	1	–	11	51	1	3	–	7	–
Malaysia	–	4	–	–	–	–	–	–	–	–	–	–	–
Mexico	–	–	1	–	–	–	0	–	–	–	–	–	–
Netherlands	–	1	–	–	–	–	1	–	–	–	–	–	–
New Zealand	–	–	–	–	–	–	–	–	–	–	–	–	–
Norway	–	–	–	–	–	–	1	–	–	–	–	–	–
Poland	–	–	–	–	–	–	–	–	–	–	–	1	–
Russia	–	–	–	–	–	–	1	–	–	–	–	–	0
Singapore	–	–	–	–	–	–	–	–	–	–	–	–	–
South Africa	–	0	–	–	–	–	–	–	–	–	–	–	–
Korea, Republic of	–	–	–	–	–	–	–	–	–	–	–	1	–
Spain	–	2	–	–	–	–	–	–	–	–	–	–	–
Sweden	–	3	–	–	4	–	1	–	–	1	–	–	–
Switzerland	–	2	–	–	–	–	3	1	–	1	–	1	1
Chinese Taipei	–	1	–	–	–	–	–	–	–	–	–	–	–
Tunisia	–	–	–	–	–	–	–	–	–	–	–	–	–
Thailand	–	2	–	–	–	–	–	–	–	1	–	–	–
UK	–	1	–	–	1	–	2	1	–	1	–	1	1
Unknown	–	28	–	–	6	1	7	32	3	11	3	5	3
Uruguay	–	0	–	–	–	–	–	–	–	–	–	–	–
Ukraine	–	–	–	–	–	–	–	–	–	–	–	0	–
USA	–	8	–	–	9	–	4	18	–	5	1	21	4
Total	2	148	5	2	29	6	46	128	5	30	4	58	9

5.2. DIVERSITY OF TECHNOLOGY SUPPLIERS

A large market share for a few technology suppliers may indicate that the technology is controlled by a few sources, an oligopoly, which may have implications for restricting the distribution of the technology or keeping the technology prices relatively high.

Table V-6 builds on the levels of technology transfer, by project type, contained in figure IV-3 by showing the concentration of countries that supply the technology. The table presents the number of supplier countries and the shares of the largest supplier country, and four largest supplier countries as percentages of the annual emission reductions for projects that claim technology transfer and for which the technology supplier is known.

Fourteen project types have at least 10 projects that claim technology transfer. In only one such case – Energy Efficiency (Own Generation) – does the share of the largest foreign supplier country exceed 50% of the projects that involve technology transfer. For the thirteen other project types in this category, the share of the largest supplier country ranges from 16% to 48% of the projects that involve technology transfer. The combined share of the four largest supplier countries across these 14 project types ranges from 45% to 95%. The number of supplier countries is nine or more except for HFCs and PFCs, for which it is five.[25]

The market shares of the firms supplying the specific technology are typically lower than the percentages indicated by the figures shown for countries in table V-6. The principal supplier countries often have several firms that export a given technology. In addition, for almost all of these project types, there is at least one domestic supplier in most host countries. Thus, the project types for which sufficient data are available suggest that project developers have a choice among a number of domestic and/or foreign suppliers with no dominant supplier able to restrict the distribution of the technology and/or keep the price high.

5.3. RELATIONSHIP OF TECHNOLOGY SUPPLY AND CER RECEIPTS

Table V-7 maps the receipt of CERs from projects to the supplier of the technology used in those projects. The data has been assembled for a sample of 231 projects for which CERs have been transferred within the system of registries under the Kyoto Protocol and for which the supplier of the technology is known.[26] The ‘total technology’ row shows the percentages of the sample projects that use technology provided by each supplier country. The rows above this indicate which countries have received CERs from these projects.[27]

For example, Japan supplies technologies to 10% of the sample of projects, with Austria receiving 4% of the CERs and Germany receiving 8% of the CERs generated from these projects. The “receipt” of CERs refers to CERs transferred from the CDM registry to the national registry of Japan, which may in practice be held by either private sector or government actors.

The highlighted diagonal cells indicate the percentage of the CERs purchased by an actor in a country that are generated from projects for which the country is a technology supplier. This information suggests that countries tend to receive CERs from projects for which they are technology suppliers. In some instances this relationship is very strong – 91% of the CERs received by Denmark in this sample come from projects for which it is a technology supplier. The corresponding percentages for Spain, Germany and Japan are 50%, 40% and 37%, respectively. Whether the CERs purchases are contractually linked with the technology supply is, however, not known.

In summary, most Annex I countries tend to receive CERs from projects for which they are a technology supplier, although the nature of this relationship is not known.

[25] Barton (2007) found that developing countries have good access to solar photovoltaic and wind technologies at competitive prices. This is consistent with the data in Table V-6.

[26] Where a project has more than one technology supplier or CER buyer each supplier/buyer is credited with a fraction of the project.

[27] In the previous study (UNFCCC, 2008) the analysis used annex I Parties that had approved the project as a proxy for buyers. However, such approval is simply a prerequisite for the distribution of CERs directly to project particiants and does not indicate that CERs will necessarily be received by the entity approved for the project.

Table V-6. **Diversity of technology supply by project type**

Project type	Number of projects	Projects with no technology transfer	Number of projects that claim technology transfer	Number of known technology suppliers	Share of four largest suppliers* (%)	Share of largest suppliers* (%)	Largest supplier
Afforestation	10	4	2	2		50	
Biomass Energy	643	284	147	28	52	20	Denmark
Cement	32	15	4	5	88	25	
CO_2 Capture	3	–	2	1		100	Denmark
Coal bed/mine Methane	65	26	29	8	88	37	USA
EE (Households)	32	10	6	2		93	Germany
EE (Industry)	126	24	44	18	56	29	Japan
EE (Own Generation)	421	196	126	10	95	54	Japan
EE (Service)	20	1	5	2		50	
EE (Supply Side)	75	13	30	15	59	29	USA
Energy Distribution	17	12	4	1		100	USA
Fuel Switch	109	16	58	19	74	39	USA
Fugitive Gas	35	10	9	5	94	61	USA
Geothermal	15	1	10	11	79	27	USA
HFCs	22	2	20	5	89	28	Japan/Germany (Tie)
Hydro	1372	986	148	24	75	48	China
Landfill Gas	297	40	182	26	45	16	USA
Methane Avoidance	566	91	328	26	56	20	USA
N_2O	70	–	66	14	85	40	Germany
PFCs and SF_6	17	2	6	4		25	
Reforestation	42	18	6	4		33	
Solar	47	14	21	9	77	27	USA
Tidal	1	–	1	1		100	Austria
Transport	24	2	9	5	86	29	Sweden
Wind	923	495	253	9	95	34	Germany
Total	4984	2262	1516	44	51	17	Germany

* as a share of total projects

VI. OPPORTUNITIES FOR IMPROVEMENT

Much has been done to harmonize the various sources of CDM data and improve its quality leading to a significant enhancement in the reliability of the results and statistical analysis in this study.

Despite these efforts, a number of areas remain where the data could be improved. First, there are 1,206 projects where the technology could not be determined to be either domestic or foreign and which were excluded from the analysis. Indications are that many of these projects will involve technology transfer. Determining whether they involve technology transfer would provide a more robust dataset for future analyses.

Second, the origin of the technology is unknown in 20% of the projects that involve technology transfer. For those projects where the origins of the technology are known, responses from the survey of the 2008 project (UNFCCC, 2008) indicated that considerable improvements in precision could be made to the technology provider data.

Third, this study establishes a compelling case that technology is being transferred but is somewhat less compelling in determining its nature, that is, whether the transfer is in the form of knowledge, equipment, or both. The follow-up survey indicates that the nature of the technology transfer often differs from that anticipated when the PDD is prepared, so more insight into the nature of the technology transfer would require a larger and more systematic follow-up survey.

In addition to the variables analysed in this study, an area that may warrant more attention is the level of 'CER taxation' and other direct impositions on CDM projects. Some host countries withhold a percentage of the CERs generated by a CDM project that depends on the project type. This, in turn, may have consequences for technology transfer by making different project types more or less financially viable. Currently, there are no studies that analyse the impact of 'CER taxation'.

The data clearly reveal a general trend toward lower rates of technology transfer for CDM projects as host country capacity increases, but the strength of this trend differs by country and project type. At present the ability to analyse these trends is limited by the short period of time for which data are available. Data relating to CDM projects cover the period from 2004 to mid-2010; however data on variables that help explain these trends, such as GDP, are currently only available through 2008. Furthermore, the limited number of countries for which TNA information is available and the resolution of these data allowed only preliminary statements on the nature of possible barriers to technology transfer in this study.

Follow-up work on these elements would be beneficial to further improve and include new data to provide a more complete picture of technology transfer in CDM projects. This could also be accomplished in the form of surveys specifically focused on areas where the data is limited. For example, the survey conducted for this study on the 2008 data effectively demonstrated where the data was limited and was crucial in shaping the present statistical analysis, but the response rate was limited. This was expected as the survey was designed to complement the data collection from PDDs and no follow-up was made on initial communications. However, a new survey could be designed to complement data collection from all PDDs and to maximise the response rate. In addition gathering technology transfer data could be part of information on project specific co-benefits requested at various points of submission during the CDM project cycle.[28]

[28] Paragraph 106 of the 56th CDM Executive Board meeting report, 17 September 2010.

Table V-7. **Relationship between technology suppliers and CER purchases**

Percentage of CERs purchased	Overall technology suppliers (%)															Total CERs (%)	Overall share of CERs (%)
	Austria	Denmark	France	Germany	Italy	Japan	Netherlands	Spain	Sweden	Switzerland	United Kingdom	Other	Canada	EU	USA		
Austria	0	24	0	10	0	4	0	47	0	0	0	0	4	12	0	100	4
Denmark	0	91	9	0	0	0	0	0	0	0	0	0	0	0	0	100	0
France	0	1	9	18	2	0	0	20	0	10	2	4	0	20	15	100	2
Germany	9	18	0	40	0	8	12	0	0	0	0	10	0	2	2	100	6
Italy	0	0	40	20	19	0	0	19	0	0	1	0	0	0	0	100	2
Japan	2	7	2	10	0	37	0	6	1	0	5	18	2	0	9	100	11
Netherlands	6	28	10	10	6	0	13	3	1	1	5	7	2	0	9	100	7
Spain	2	0	17	26	0	0	0	50	0	0	0	0	0	0	5	100	2
Sweden	0	35	1	2	0	33	0	17	11	0	0	1	0	0	0	100	1
Switzerland	1	8	3	10	4	9	1	1	9	0	4	4	18	3	25	100	30
UK	1	8	2	19	0	7	0	9	4	3	7	7	10	1	19	100	33
Other	56	13	12	13	0	0	0	0	0	0	0	6	0	0	0	100	1
Total technology	2	11	4	15	2	10	2	8	4	1	5	7	9	2	16		
Overall share of technology	2	8	2	14	1	8	1	5	2	1	3	28	4	2	19		

Notes:
1. "Total technology" is the technology supplier's share of technology supplied to projects with CERs transfered only.
2. "Overall share of technology" is the technology supplier's share of the technology supplied to all projects. For example Denmark supplied 11% of the projects for which CERs have been transferred, but only 8% of all projects for which the source of the imported technology is known.

ANNEX A

The survey indicates that the no transfer classification (code -1) was correct for 88% of the 116 projects. A technology transfer claim (codes 1, 2 and 3) was correct for 89% of the 159 projects, although the projects that claimed transfer of knowledge or equipment only usually involved both (relatively high percentages of projects originally coded 1 or 2 are coded based on the survey information). Of the projects that did not report technology transfer (code 0) in the PDD, 58% involved technology transfer while 41% did not. Since there are 1206 projects in the current study with a code 0 it is likely that a fair number of those actually involve technology transfer and that the actual technology transfer rates stated in this study are conservative estimates.

The similarity of the percentages in the first two columns indicates that the survey responses are representative of all projects covered by the 2008 study. The last two columns indicate that the statements in the PDD relating to the nature of the technology transfer must be used with caution. Transfer of both knowledge and equipment is much more common than indicated by the PDDs, while transfers of knowledge only and equipment only is less common.

Note that while the nature of the technology transfer (code 1, 2 or 3) was not very accurate, a technology transfer claim (codes 1, 2 and 3) was correct for 89% of the 159 projects. Thus most of the analyses in this study aggregate projects with codes 1, 2 and 3 in order to get projects that involve technology transfer.

Codes based on information in the PDDs may be incorrect because the information may be incomplete and/or the choice of technology changes during project implementation.

PDDs are designed to report detailed information on the proposed project, but not on possible technology transfer. Technology transfer data has to be sifted out of the information contained in the PDD and then be interpreted. Very often the PDD will report that some key components of the technology expected to be applied in the project will come from outside the country, but will not provide much detail about the associated technology transfer. Thus the information in the PDD may be incomplete and is sometimes difficult to code.

The original PDD review was carried out in 2008, but many of the projects predate that by several years. The survey was carried in 2010, allowing a lot more time for those project developers to change their minds as to the specific technology to use for the project. Moreover, most of the projects in the 2008 study had not yet been implemented. Project developers may have changed the planned technology as they implemented their projects. Project developers may report their ‘best guess’ in the PDD prior to implementation, but may make changes during implementation.

Table A-8. **Comparison of original and revised technology transfer codes for survey respondents (%)**

	Survey code					
Original code	**-1**	**0**	**1**	**2**	**3**	**Number of observations**
-1	88		9		3	116
0	41	2	8	2	48	85
1	14		31		53	49
2	7		7	21	66	29
3	11		11	4	74	81
Not coded	63		38		100	9
Total	43		12	3	41	370

Table A-9. **Comparison of the distribution of technology transfer across projects that claim technology transfer (%)***

		Survey responses		
Code	**Original codes all projects 2008 study***	**Original codes**	**Revised codes**	**Original codes all projects this study**
1	32	31	25	34
2	15	18	6	14
3	53	51	69	52

The codes are:

-1 = Project specifically states no technology transfer
0 = No mention or indication of technology transfer in the PDD
1 = Technology transfer of equipment only
2 = Technology transfer of knowledge only
3 = Technology transfer of equipment and knowledge

* *Sources:* UNFCCC, 2008, Table A-8, table IV-4

ANNEX B

STATISTICAL ANALYSIS

Regression analysis is a statistical technique used to examine the relationship between a dependent variable, such as technology transfer, and a series of independent variables, such as the project characteristics and the host country.

The regression analysis conducted for this study has two stages. First, an equation that relates technology transfer to project characteristics, project type and host country is estimated. That equation is used to predict the probability of technology transfer for different combinations of project type, host country and year. In the second stage an equation that relates those predicted probabilities to country characteristics is estimated. Each stage is described in turn below.

STAGE 1: THE TECHNOLOGY TRANSFER EQUATION

This equation is similar to that estimated in previous reports (UNFCCC, 2007, 2008) and other studies.[29] Technology transfer is related to project characteristics, project type and host country. Previous reports and other studies also include some country characteristics in the equation, such as population and gross domestic product (GDP) per capita. In this study those characteristics are included in the stage two analysis.

In this stage, two equations are estimated, the first one is very similar to past studies where all 4,984 observations are used. It (Equation 1 in TABLE B-11) includes 4,984 observations – 2,262 self-reliant projects that specifically renounce technology transfer, 1,516 projects that specifically state they expect to involve technology transfer, and 1206 projects that do not mention technology transfer. This last group is assumed not to involve technology transfer. In practice many of the 1206 projects in this last group will actually involve a technology transfer. Assuming that the projects do not involve technology transfer, when many will involve technology transfer creates statistical 'noise'. To eliminate this 'noise' the second equation (Equation 1 in TABLE B-11) is estimated using only the 3,778 projects that specifically state they will (1,516) or will not (2,262) involve technology transfer.

Technology transfer, the dependent variable, takes a value of 1 when a project includes a technology transfer claim, regardless of the nature – knowledge or equipment only or both knowledge and equipment – of the transfer, and a value of 0 otherwise.[30] With a dependent variable that has a value of either 0 or 1, the appropriate form of regression analysis is 'logit analysis'.

The independent variables are:

- The project size (estimated ktCO_2e reduced per year);[30]
- A variable that identifies unilateral projects;
- A variable that identifies small-scale projects;
- A variable that identifies the number of previous projects of the same type in the host country (1 for the first project, 2 for the second project of the same type in the country, 3 for the third, etc.);
- The year in which the project was posted for public comment
- The project type
- The host country

Statistical tests indicate that there is a significant time trend. Using the year as the value of the time variable does not yield good statistical results because of the small differences in the values – 2004 is only slightly larger than 2003. A time variable is created with 2008 – the year with the largest number of projects – as the base (0) and values that range from -5 for 2003 through +2 for 2010.

A set of 'dummy variables'[32] is created for the project type. With the exception of the reference project type, there is one variable for each project type.[33]; thus, a total of 24 variables. A Cement project, for example, has a value of 1 for the Cement variable and a value of 0 for all of the other project type variables. Energy Efficiency (Own Generation) was chosen as the reference project type because it has a technology transfer frequency similar to the average for all projects. After dropping projects for which technology transfer is not known, there are 322 Energy Efficiency (Own Generation) projects of which 39% accounting for 63% of the emission reductions, involve technology transfer, compared with 40% of projects representing 59% of the emission reductions for all projects for which technology transfer is known.[34]

Another set of 'dummy variables' is created for the host country. A project located in China, for example, has a value of 1 for the China variable and a value of 0 for all of the other host country variables. Brazil was chosen as the reference country because it has a technology transfer frequency similar to the average for all projects. After dropping projects for which technology transfer is not known, there are 229 projects in Brazil of which 38%, accounting for 68% of the emission reductions involve technology transfer, compared with 40% of projects representing 59% of the emission reductions for all projects for which technology transfer is known.

As part of the estimation procedure, the statistical tool drops any variable for which prediction is perfect and this necessarily results in the loss of a few observations from each model. This will happen if there is only one project in a category – project type or host country – or all projects in a category claim (or do not claim) technology transfer. When all projects are used for the estimation (Equation 1) only the one Tidal project and four projects in 2003 are dropped together with the 27 host countries identified in TABLE B-10. When the 1,206 projects for which technology transfer is not known are excluded (Equation 2), the two CO_2 projects, 66 N_2O projects and an additional 26 host countries are dropped. The 27 countries that remain in Equation 2 host 88% of all projects.

The equation was first estimated including a dummy variable to identify projects that have not yet been registered. This variable tests whether the registered projects differ from those still pending approval. The coefficient for that variable is far from being significant and there is very little change in the pseudo R2 for the equation. This indicates that registered projects and projects pending approval are similar so all are used for the regression analysis.

As in previous studies (UNFCCC, 2008), the equation was estimated assuming that the projects for which technology transfer is not known (code 0) do not involve technology transfer. The results are reported as Equation 1 in TABLE B-11. The statistical properties of the equation are very similar to those for the equation in the previous study (UNFCCC, 2008), the pseudo R2 is 0.367 and the estimated equation classifies 82% of the observations correctly. Equation 1 mimics the assumptions made in previous studies and is included simply to allow comparison with the results presented in those studies.

Then the equation was estimated excluding the 1,206 projects for which technology transfer is not known because the follow-up survey (see TABLE A-8 IN ANNEX A) indicated that almost 60% of those projects involve technology transfer. The results are reported as Equation 2 in TABLE B-11. This improves the statistical properties of the equation; the pseudo R2 rises to 0.512, the estimated equation classifies 87% of the observations correctly, and more of the coefficients are statistically significant. This clearly indicates that Equation 2 is a better predictor of technology transfer.

The results are consistent with our expectations and with the results of previous studies and others.

- The coefficient for project size is positive and statistically significant indicating that larger projects are more likely to involve technology transfer;
- The coefficient for unilateral projects is negative suggesting that they are less likely to involve technology transfer;[35]
- The coefficient for small-scale projects is negative indicating that they are less likely to involve technology transfer;
- The coefficient for the number of projects of the same type is negative and statistically significant indicating that rate of technology transfer falls as the number of projects of the same type in a host country increases suggesting that technology transfer extends beyond the CDM projects;
- The coefficients for the time variables are positive and statistically significant (with the exception of 2004) prior to 2008 suggesting that the CDM contributed to early awareness of the mitigation technology in the host country and that similar technologies are being developed in, or transferred to, host countries through other channels as well.

[29] See Seres, Haites and Murphy, 2009; Haites, Duan and Seres, 2006; UNFCCC, 2007; Dechezleprêtre, Glachant and Ménière, 2007; De Coninck, Haake and van der Linden, 2007; and UNFCCC, 2008.

[30] In principle the relationship could be different for projects that involve knowledge only, equipment only, or both knowledge and equipment. Then it would be appropriate to estimate a separate equation for each type of transfer. However, the survey results reported in TABLE A-8 and TABLE A-9 indicate that the codes for the nature of the transfer are not very accurate; PDDs that suggest a transfer of knowledge or equipment only often have both. But the codes for technology transfer or no transfer are quite accurate. Thus the equation considers all types of technology transfer as a single category.

[31] Actual emission reductions can differ significantly from the estimated reductions. The UNEP Risø Centre CDM reports the 'issuance success' the credits issued relative to the estimated emission reductions by project type. The overall rate is 96.5%, but this ranges from a low of 18% for one solar project to a high of 123% for 21 N_2O projects and one CO_2 Capture project. The use of project type variables in the regression analysis should capture differences between estimated and actual reductions by project type.

[32] Also known as indicator variable or just dummy it is a variable that takes the values 0 or 1 to indicate the absence or presence a categorical effect that may be expected to shift the outcome.

[33] For the logit regression model, one of the project type dummy variables and country dummy variables had to be left out to avoid 'multicollinearity'

[34] The choice of the reference category is arbitrary, although it is desirable that it include a substantial number of observations. The choice of the reference category affects the values of the estimated coefficients but not whether the coefficient is statistically significant. The coefficient for a project type reflects its frequency of technology transfer relative to that of the reference project type. Selecting a project type with a low frequency of technology transfer, such as Hydro, would lead to positive coefficients for most of the other project types since they have a higher frequency of technology transfer. Energy Efficiency (Own Generation) was chosen because its rate of technology transfer is similar to the average for all projects.

[35] The coefficient is statistically significant at the 5% level for Equation 1 (when all projects are included) but not for Equation 2 (when projects for which technology transfer is not known are excluded).

Table B-10. **Countries dropped from the regression analysis due to perfect prediction**

All countries listed are dropped from Equation 2	
	Countries included in Equation 1
Albania	Azerbaijan
Bahamas	Bhutan
Bangladesh	Bolivia
Cape Verde	Cambodia
Cuba	Cameroon
Congo (Democratic Republic)	Congo
Côte d'Ivoire	Costa Rica
Ethiopia	Argentina
Georgia	Cyprus
Ghana	Dominican Republic
Guyana	Egypt
Jamaica	Fiji
Korea (Democratic Republic)ublic)	Honduras
Lebanon	Israel
Liberia	Jordan
Madagascar	Moldova
Mali	Morocco
Malta	Nepal
Mauritius	Nicaragua
Papua New Guinea	Panama
Rwanda	Paraguay
Senegal	Qatar
Singapore	Syria
Sudan	Tunisia
Swaziland	Tanzania
Former Yugoslav Republic	Uzbekistan
Zambia	

Table B-11. **Coefficients for the technology transfer equations**

(All variables that are significant at the 0.05 level or more are highlighted in blue type in the table)

	Equation 1	Equation 2
Constant	-0,141	0,355
tCO2yr	4,61E-07	1,00E-06
Unilateral	-0,219	-0,097
projects of same type	-0,007	-0,006
Small scale	-0,426	-0,836
Year 2004	-0,85	0,644
Year 2005	0,05	0,688
Year 2006	0,837	1,14
Year 2007	0,474	0,545
Year 2009	0,166	0,022
Year 2010	0,365	-0,003
Argentina	1,33	2,2
Armenia	0,942	
Azerbaijan	1,61	
Bhutan	2,68	
Bolivia	2,09	
Cambodia	2,72	
Cameroon	1,23	
Chile	1,1	3,35
China	-0,107	-0,55
Colombia	0,144	2,42
Costa Rica	1,68	
Cyprus	2,5	
DPR of Korea		
DR of Congo	4,34	
Dominican Republic	1,71	
Ecuador	1,52	3,74
Egypt	1,06	
El Salvador	1,11	1,2
Fiji	1,19	
Guatemala	1,46	2,91
Honduras	2,96	
India	-0,97	-0,829
Indonesia	1,33	3,95
Iran	2,25	1,69
Israel	1,47	
Jordan	1,48	
Kenya	1,99	3,54
Lao PDR	2,61	2,73
Malaysia	1,49	3,33
Mexico	2,11	3,89
Republic of Moldova	2,79	
Morocco	1,242	
Nepal	1,39	
Nicaragua	2,82	
Nigeria	1,37	1,37

Notes:

1. Equation 1 is estimated using 4,974 projects – 4,984 projects less 10 excluded due to perfect prediction. Projects which do not mention technology transfer are assumed not to involve technology transfer. Equation 2 is estimated using 3,530 observations – 3,778 projects that specifically state they do (1,516) or do not (2,262) involve technology transfer less 248 excluded due to perfect prediction.
2. Each cell shows the estimated coefficient for each variable. All variables that are significant at the 0.05 level or more are highlighted in the table.
3. The coefficients describe the effects of the independent variables on the predicted logarithmic odds of technology transfers. For example, in equation 1, a unilateral project decreases the log odds of a technology transfer by -0.219. In other words, each occurrence of a unilateral project multiplies the odds of a technology transfer by $e^{-0.219}$ = 0.8033, where e = 2.71828 is the base for natural logarithms. More simply, each occurrence of a unilateral project reduces the odds of a technology transfer by 20% (1 – 0.8033).

Table B-11. **Coefficients for the technology transfer equations** (continued)

(All variables that are significant at the 0.05 level or more are highlighted in blue type in the table)

	Equation 1	Equation 2
Pakistan	1,73	2,74
Panama	0,957	
Paraguay	3,02	
Peru	1,45	3,22
Philippines	0,83	1,03
Qatar	0,948	
Republic of Korea	0,351	2,61
South Africa	1,51	2,31
Sri Lanka	2,3	3,85
Syrian Arab Republic	-1,656	
Thailand	2,42	4,01
Tunisia	-1,59	
Uganda	-0,116	0,962
United Arab Emirates	0,218	2,34
Tanzania	1,395	
Uruguay	1,82	3,83
Uzbekistan	2,54	
Vietnam	3,21	5,74
Other	2,78	
Afforestation	-3,57	-3,87
Biomass Energy	-0,89	-1,29
Cement	-1,61	-1,67
CO_2 Capture	0,51	
Coal bed/mine Methane	-0,158	-0,124
Energy Efficiency (Households)	-0,92	0,06
Energy Efficiency (Industry)	0,462	1,38
Energy Efficiency (Service)	-0,663	1,15
Energy Efficiency (Supply Side)	-0,477	-0,02
Fuel Switch	0,06	0,625
Fugitive	-2,61	-3,18
Geothermal	-0,485	0,143
HFCs	2,09	1,22
Hydro	-1,78	-2,42
Landfill Gas	0,083	0,662
Methane Avoidance	-0,268	-0,19
N_2O	2,62	
PFCs and SF_6	-1,14	-0,271
Reforestation	-3,17	-3,75
Solar	0,212	-0,77
Transport	-0,361	1,84
Wind	0,7	0,357
Number of observations	4974	3530
Pearson's chi2	2242	2366,67
Probability > chi2	0,00	0,00
Pseudo R2	0,36	0,51
Correctly classified (%)	82,23	86,63

4. The value of the Pearson x^2 is used to test the null hypothesis that the coefficients of all of the variables are equal to zero. The probability of a x^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 coefficients using the 'z' values (not included in TABLE B-11).
5. The pseudo R^2 and percentage 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.

Previous analyses have covered relatively short time periods and so have not included time explicitly in their regression equations. Our results find time to be a statistically significant variable for the early years of the CDM. The positive coefficients suggest relatively high rates of technology transfer during the early years of the CDM. The declining values of the time coefficients suggest that similar technologies were being developed in host countries or being transferred to them outside the CDM.

The project types that involve more or less technology transfer than average (taken as Energy Efficiency Own Generation) are listed in TABLE B-12. Afforestation, Biomass Energy, Cement, Fugitive Gas, Hydro, PFCs and SF_6 and Reforestation projects are less likely than average to involve technology transfer while Energy Efficiency (Industry), HFCs, N_2O, Transportation and Wind projects are more likely than average to involve technology transfer. Bear in mind that Equation 2 is preferred since it excludes the statistical 'noise' created by projects that do not mention technology transfer and hence has better statistical properties.

The host countries that involve more or less technology transfer than average are listed in TABLE B-13. The results indicate that the host country plays a very significant role in technology transfer. Many of the host country variables are statistically significant – 27 of 52 in Equation 1 and 20 of 27 in Equation 2. Comparing this to a random distribution, there would be two or three significant host country variables in Equation 1 and 1 or 2 in Equation 2.

Recall that Brazil is used as the reference country since its rate of technology transfer is roughly equal to the average. Almost all host countries have a higher than average rate of technology transfer, probably because China and India, which together account for over half of the projects, have lower than average rates of technology transfer.

Table B-12. **Project types that involve technology transfer more or less often than average**

Project type	Equation 1	Equation 2
Afforestation	less	less
Biomass Energy	less	less
Cement	less	less
Energy Efficiency (Industry)		more
Fugitive Gas	less	less
HFCs	more	
Hydro	less	less
Landfill Gas		more
N_2O	more	n/a
PFCs and SF_6	less	
Reforestation	less	less
Transportation		more
Wind	more	more

Notes:
1. Project types for which the frequency of technology transfer is more or less than that for Energy Efficiency (Own Generation) (roughly the average for all projects) at a 5% level of statistical significance.
2. N_2O is dropped from equation 2 due to perfect prediction so that coefficient is not available.
3. With the sole exception of Transportation, where the coefficient is not statistically significant for one equation it has the same sign as indicated for the other equation; for example, the coefficient for HFCs in equation 2 is positive.

Table B-13. **Host countries that involve technology transfer more or less often than average**

Host country	Equation 1	Equation 2
Argentina	more	more
Cambodia	more	
Chile	more	more
China		less
Colombia		more
Congo	more	
Costa Rica	more	
Cyprus	more	
Ecuador	more	more
Guatemala	more	more
Honduras	more	
India	less	less
Indonesia	more	more
Israel	more	
Kenya	more	more
Malaysia	more	more
Mexico	more	more
Moldova	more	
Nicaragua	more	
Pakistan	more	more
Paraguay	more	
Peru	more	more
Philippines	more	more
South Africa	more	more
South Korea		more
Sri Lanka	more	more
Thailand	more	more
Uruguay	more	more
Uzbekistan	more	
Vietnam	more	more

Notes:
1. Host countries for which the frequency of technology transfer is more or less than that for Brazil (roughly the average for all projects) at a 5% level of statistical significance.
2. Where the coefficient is statistically significant in equation 2 but not Equation 1, it has the same sign in equation 1. For example, China has a negative sign and Colombia a positive sign in equation 1.
3. The host countries for which the cell for Equation 2 is blank are not included in that equation.

STAGE 2: THE PREDICTED PROBABILITY OF TECHNOLOGY TRANSFER EQUATION

The technology transfer equation in stage 1 indicates that the host country plays a very significant role in technology transfer. This stage of the analysis attempts to better understand the factors that make a host country more or less attractive for technology transfer.[36]

The technology transfer equation is used to calculate the predicted probability of technology transfer for various combinations of host country, project type and year; for example, equation 2 in stage 1 predicts that wind projects in India that entered the pipeline in 2005 have a probability of 0.2836 (28.36%) of involving technology transfer. The probability of technology transfer is predicted using Equation 2 from stage 1 because it has better statistical properties.

The predicted probability is calculated for every combination covered by the projects used to estimate the equation; a total of 502 combinations. For many combinations there is only one project and the data for that project – project size, unilateral or not, small-scale or not, number of previous projects of the same type – are used to calculate the predicted probability. Where there are multiple projects for a combination, the average values for those projects are used to calculate the predicted probability. Hydro projects in China in 2008 is the combination with the largest number of projects – 280.

The predicted probability of technology transfer has a value between 0 and 1 inclusive. In addition to the 502 combinations for which the probability is predicted, 33 combinations corresponding to projects eliminated from the estimation of Equation 2 due to perfect prediction are included with a probability of 1 or 0 as appropriate.[37] Thus the statistical analysis for this stage starts with a total of 535 observations.

The predicted probability of technology transfer is the dependent variable. The independent variables considered are:

- A measures of the host country's attractiveness as a recipient of technology transfer, such as:
  - Population;
  - GDP;
  - GDP per capita;
  - Gross capital formation as a share of GDP;
  - Foreign direct investment (FDI) as a share of GDP;
  - Imports as a share of GDP;
  - Exports as a share of GDP;
  - Official development assistance (ODA) per capita;
  - Tariff rate;
  - Indicators of the ease of doing business;
  - Indicators of political freedom.
- Measures of the host country's overall technological capacity, such as:
  - Gross expenditure on research and development (GERD) as a share of GDP;
  - Scientific and technical journal articles;
  - Number of researchers;
  - Number of patents issued;
  - Archibugi and Coco (ArCo) index of technological capability.
- Measures of the host country's technological capacity related to the technologies represented by the project type, such as:
  - Number of patents issued for relevant technologies;
  - Scientific and technical journal articles related to the relevant technologies;
  - Share of renewable electricity generation (for renewable energy project types).
- Barriers to technology transfer for the project type reported by the host country in its Technology Needs Assessment (TNA). TNAs are not available for all CDM host countries, so this variable is not available for all project types/host countries.

[36] Flues (2010) examines the factors that determine the probability that a country will host a CDM project.

[37] These projects are dropped from the estimation because all of the projects in a particular category involve, or do not involve, technology transfer. Thus the 'predicted' probability for such a category is that the projects all involve (probability = 1) or do not involve (probability = 0) technology transfer.

The data are from the World Development Indicators (World Bank, 2010). The GDP is divided by the population to calculate the GDP per capita for each host country. Data on Tariffs were collected from the World Trade Organization's World Tariff Profiles 2009. Data on indicators of political freedom and share of renewable electricity generation originated from Hadenius and Teorell 2005 and Energy Information Administration 2009 respectively, consolidated and supplied by Florens Flues 2010. The ArCo index is from Archibugi and Coco (2004). Finally, the data on number of patents by country were supplied by the OECD, 2010.

Data were collected for the period from 2000 through the most recent year available, usually 2008 or earlier. Some of the variables, the Archibugi and Coco (ArCo) index of technological capability for example, are available only for a single year. Data for some variables are not available for many of the CDM countries for one or more years; for example, the number of full-time equivalent research staff is missing for 58 of 81 CDM countries in 2005.

Linear relationships among the independent variables (multicollinearity) cause problems in the regression analysis. Two types of collinearity checks were performed. First, correlation matrices were calculated.[38] They identify pairs of variables that are closely related. Where two variables had a correlation coefficient greater than 0.85, one was dropped or transformed as discussed below. Second, each independent variable was regressed against all of the other potential independent variables to identify possible linear relationships. If the regression for an independent variable has an R2 greater than 0.9, it was dropped because it would not contribute much to the analysis.

The collinearity checks found that population, GDP, foreign direct investment (FDI), fossil fuel generation and renewable generation are strongly correlated. There is also strong correlation between full-time equivalent researchers, researcher head count, and scientific/technical journal publications. The 'ease of doing business' rank is a combination of the component indexes, but the component indexes are not closely related. None of these relationships is surprising.

To address these collinearity issues we use the log of population and per capita GDP, express FDI as a percent of GDP, and calculate the renewable share of electricity generation while dropping GDP, conventional electricity generation, and renewable electricity generation. Full-time equivalent researchers, researcher head count, and scientific/technical journal publications are dropped due to collinearity and the large number of missing observations. Research and development expenditure is also dropped due to the large number of missing observations. Thus, the measures of technological capacity used are the ArCo index, the discounted stock of patents issued and the renewable share of electricity generation.

The estimated coefficients for the predicted probability of technology transfer equation are shown in TABLE B-14.[39] Data availability forces the use of time lags on the variables for which annual data are available. Predicted probabilities cover the period 2004 through 2010 (six months). But the most recent GDP data are for 2008, so a two year lag is used for population, which implicitly matches 2010 projects in a country with its 2008 population. To detect whether the time lags imposed by the data and the absence of country data differentiated by project type affect the results, time and project type, dummy variables are included in the equation. Those results are also shown in TABLE B-14. If the independent variables fully explained the predicted probabilities, the dummy variables would not be statistically significant.

[38] In principle only a single correlation matrix with all of the potential independent variables is needed. However, due to missing data for several of the variables it was necessary to calculate several correlation matrices for different subsets of the variables.

[39] Since the dependent variable is continuous – it can take any value between 0 and 1 inclusive – the equation is estimated using the ordinary least squares method.

Table B-14. **Coefficients for the predicted probability of technology transfer equation**

(All variables that are significant at the 0.05 level or more are highlighted in blue type in the table)

	Without dummies	With time and project type dummies		
Variable	Coefficient	Coefficient	Variable	Coefficient
Two year lag of Population (logarithm)	-0,123	-0,14	Year 2004	0,103
Two year lag of Per capita GDP	-1,2E-05	-1,1E-05	Year 2005	0,073
Two year lag of FDI as a % of GDP	-0,021	-0,01	Year 2006	0,095
Two year lag of Gross Fixed Capital formation as percent of GDP	-0,001	0,00	Year 2007	0,025
Two year lag of imports as percent of GDP	0,003	0,00	Year 2009	0,001
Two year lag of exports as percent of GDP	-0,006	0,00	Year 2010	-0,007
Two year lag of net ODA per capita	-0,010	-0,01	Afforestation	-0,499
Percent of energy generation from renewable sources, 2004	-0,002	0,00	Biomass Energy	-0,167
Ease of doing business	-0,002	0,00	CO_2 Capture	0,128
Tariff rate 2007/2008	-0,016	-0,02	Cement	-0,154
Democracy index (0 = least, 10 = most democratic)	-0,069	-0,06	Coal bed/mine Methane	0,108
Arco Index; index of technological capabilities, 2004	1,108	0,54	Energy Efficiency (Households)	-0,173
Knowledge stock – discounted stock of patents issued	-1,6E-06	-1,6E-06	Energy Efficiency (Industry)	0,100
			Energy Efficiency (Service)	0,066
			Energy Efficiency (Supply Side)	0,029
			Energy Distribution	-0,058
			Fuel Switch	0,155
			Fugitive	-0,363
			Geothermal	0,128
			HFCs	0,328
			Hydro	-0,317
			Landfill Gas	0,089
			Methane Avoidance	-0,033
Constant	2,185	2,134	N_2O	0,241
Number of observations	494	494	PFCs and SF_6	0,063
F (23, 470)	31,28	34,35	Reforestation	-0,463
Probability > F	0,00	0,00	Solar	-0,200
R2 (%)	45,86	76,19	Transport	0,206
Adjusted R2 (%)	44,40	73,97	Wind	0,022

The overall statistical results are quite good. The R2 is 0.44 without the time and project type dummy variables and it jumps to 0.74 when those variables are included. The statistical significance of many of the time and project type dummy variables, indicates that more time-specific and project type specific variables are needed. Patent data by country, project type, and year are being compiled but were not available for this analysis. This data may help since patent data by country are highly significant in the current results.

The results are generally consistent with expectations and with the results of previous studies and other reports.[40] Technology transfer for CDM projects is more likely in host countries with a smaller population,[41] with lower ODA per capita, where it is harder to operate a business, lower import tariffs, with a lower ranking on the democracy index,[42] and with lower technical capacity as measured by the knowledge stock.[43]

These results are preliminary. Additional data and analyses are needed. More current and more complete time series are needed to test different lags. And more project type data by country are needed to understand different rates of technology transfer by project type for a given country. These could include patents issued by project type by year, emissions reduction potential by project type and country and cost per tonne of CO_2e reduced by project type and country drawn from marginal abatement cost curves.

The estimation of the predicted probability of technology transfer is repeated for the countries that have TNAs where barriers could be identified by project type. This allows barriers to the implementation of mitigation technologies to be included in the analysis for the first time. However, the number of country, project type and year combinations is significantly reduced because of the limited number of countries for which this TNA information is available; the number of combinations drops from 494 to 177. In addition, the TNA countries are not representative of the larger sample of CDM host countries; the TNA countries are more likely to have technology transfer. The results are shown in TABLE B-15.

The statistical properties of the estimated equation are quite good with an adjusted R2 of 0.86. However, the sign and statistical significance of several of the variables change from those estimated for the larger sample (TABLE B-14). This may reflect the fact that the TNA countries have a higher rate of technology transfer than the countries in the larger sample.

Only three of the ten categories of barriers – economic/market, information, and intellectual property rights – are statistically significant at the 5% level. Countries and project types that face an information barrier have a lower rate of technology transfer for CDM projects while those that face economic/market or intellectual property rights[44] barriers have higher rates of technology transfer.

At first glance these results may appear counter intuitive; how can barriers to technology transfer lead to higher rates of technology transfer? It is possible to interpret the results as indicating that it may be possible to overcome some barriers to technology transfer for specific CDM projects. CDM projects, for example, earn revenue from the sale of credits thus helping to overcome some economic/market barriers. Concerns about a host country's intellectual property rights regime that inhibit technology transfer could be addressed for specific CDM projects through licenses or other agreements covering the imported knowledge and/or equipment.

In summary, the statistical analysis performed for this study presents improved results for the technology transfer equation (Equation 2 of stage 1). The importance of the host country and project type is confirmed. In addition, a significant time trend has been detected.

Stage 2 of the analysis attempts to better understand the factors that make a host country more or less attractive for technology transfer. Preliminary results indicate that the size of the country and greater technological capacity reduce the rate of technology transfer for CDM projects. But additional data – more current and more complete time series, and more project type data by country – are needed for a more thorough analysis.

A preliminary analysis has also been conducted for 43 countries where barriers could be identified by technology (project type) from TNAs. This allows barriers to be included in the analysis for the first time. Countries and project types that face an information barrier have a lower rate of technology transfer for CDM projects while those facing an economic/market or intellectual property rights barrier have a higher rate of technology transfer. These results need to be verified by further research.

Table B-15. **Coefficients for the predicted probability of technology transfer equation for host countries where barriers by technology have been identified by technology** (All variables that are significant at the 0.05 level or more are highlighted in blue type in the table)

Variable	Coefficient	Variable	Coefficient
Two year lag of Population (logarithm)	0,140	Year 2004	0,391
Two year lag of Per capita GDP	-5,8E-05	Year 2005	0,124
Two year lag of FDI as a % of GDP	-0,008	Year 2006	0,146
Two year lag of Gross Fixed Capital formation as percent of GDP	0,005	Year 2007	0,023
Two year lag of imports as percent of GDP	0,004	Year 2009	0,034
Two year lag of exports as percent of GDP	0,006	Year 2010	0,002
Two year lag of net ODA per capita	0,000	Afforestation	-0,452
Percent of energy generation from renewable sources, 2004	0,009	Biomass Energy	-0,147
Ease of doing business	0,003	CO_2 Capture	
Tariff rate 2007/2008	-0,004	Cement	-0,234
Democracy index (0 = least, 10 = most democratic)	0,034	Coal bed/mine Methane	0,116
Arco Index; index of technological capabilities, 2004	4,257	Energy Efficiency (Households)	-0,101
Knowledge stock – discounted stock of patents issued	-1,9E-06	Energy Efficiency (Industry)	0,092
Economic/market barrier	0,203	Energy Efficiency (Service)	
Human barrier	-0,002	Energy Efficiency (Supply Side)	0,054
Information barrier	-0,287	Energy Distribution	0,128
Institutional barrier	0,042	Fuel Switch	0,243
Infrastructure barrier	0,177	Fugitive	-0,203
Intellectual property barrier	0,117	Geothermal	0,014
Others barrier	-0,071	HFCs	0,485
Policy barrier	-0,186	Hydro	-0,261
Technical barrier	-0,080	Landfill Gas	
Regulatory barrier	0,222	Methane Avoidance	-0,060
Constant	-1,980	N_2O	0,308
Number of observations	177	PFCs and SF_6	
F (23, 470)	23	Reforestation	-0,463
Probability > F	0,00	Solar	-0,170
R2 (%)	89,61	Transport	0,139
Adjusted R2 (%)	85,71	Wind	-0,028

[40] The coefficient for per capita GDP is negative and not significant. Dechezleprêtre, Glachant and Meniere, 2007 find it has an insignificant negative coefficient. Doranova, Costa and Duysters, 2010 find an insignificant positive coefficient for per capita GDP.

The coefficient for FDI inflows as a percent of GDP is negative and not significant. Dechezleprêtre, Glachant and Meniere, 2007 find it has a negative coefficient significant at the 10% level. Doranova, Costa and Duysters, 2010 excluded FDI inflows due to multicollinearity concerns. For the transfer of mitigation technologies not limited to the CDM, Dechezleprêtre, Glachant and Meniere, 2010 find that FDI barriers can promote technology transfer; a positive coefficient in this context.

This analysis separates imports and exports (as a percentage of GDP) and finds that they have opposite effects, but neither is statistically significant. Dechezleprêtre, Glachant and Meniere, 2007 use total trade – imports plus exports as a percent of GDP – and find that it has a significant positive coefficient. Doranova, Costa and Duysters, 2010 also use imports plus exports and find that it has a positive, but not significant, coefficient.

The coefficient for the renewables share of electricity generated is negative but not significant. Doranova, Costa and Duysters, 2010 find it has an insignificant positive coefficient.

The coefficient for the tariff rate is negative and statistically significant. Dechezleprêtre, Glachant and Meniere, 2010 find that a high tariff rate has a negative impact on the transfer of mitigation technologies, suggesting a negative coefficient.

The coefficient for the ArCo index is positive but not statistically significant. Dechezleprêtre, Glachant and Meniere, 2007 find a significant positive coefficient for the ArCo index, but the sign and its statistical significance differs by sector.

Dechezleprêtre, Glachant and Meniere, 2007 find that GDP growth for 2000–2004 has a significant positive coefficient. Doranova, Costa and Duysters, 2010 excluded GDP growth due to multicollinearity concerns. Flues, 2010 finds economic growth to be a significant positive influence on the number of CDM projects a country is likely to host.

[41] Dechezleprêtre, Glachant and Meniere, 2007 find a negative coefficient for the log of population that is not statistically significant. Doranova, Costa and Duysters, 2010 find a significant positive coefficient for the log of population. Flues, 2010 finds population to be a significant positive influence on the number of CDM projects a country is likely to host.

[42] The coefficient is positive and statistically significant. Flues, 2010 finds political freedom to be a significant positive influence on the number of CDM projects a country is likely to host.

[43] Haščič and Johnstone, 2009 create a discounted stock of patented inventions by recipient country's inventors using the perpetual inventory method with a 10% discount rate as a measure of the absorptive capacity of the recipient country. The expected sign is positive since increased absorptive capacity should increase transfers. The coefficient here is negative and statistically significant. However, the sign on the total (not discounted) number of patents issued during 2000–2006 is positive and statistically significant.

[44] Dechezleprêtre, Glachant and Meniere, 2010 find that a lax IPR regime has a negative effect on transfer of mitigation technologies generally.

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