Preliminary Draft
Only for comments

ACQUISITION OF TECHNOLOGICAL CAPABILITIES THROUGH THE CLEAN DEVELOPMENT MECHANISM: SOME QUANTITATIVE EXPLORATIONS

Aradhna Aggarwal

Abstract

This study assesses the impact of the CDM on technological capabilities of implementing firms in India. Firm-level technological capability denotes a company's ability to utilise technological knowledge efficiently to assimilate, use, replicate and generate changes in existent technologies and enhance its competitiveness. It is measured by indigenous R&D expenditures and competitiveness indicators of firms, namely export intensity and total factor productivity. We use difference-in-difference technique in quasi experimental design of CDM-evaluation. The analysis draws on the balance sheet data of 612 firms over 2001 to 2011 from PROWESS database. Our empirical results show that CDM plays an important role in technological advancement of the implementing firms.

Key words: CDM, technology transfer, technological capabilities, fuel efficiency, domestic R&D efforts

Acknowledgement: I would like to thank the South Asian Network of Development Economics and Environment (SANDEE) for providing this study the funding and technical support. My sincere gratitude is due to Jeff Vincent for his guidance and comments on earlier drafts of the paper. I must also thank the participants of the workshops organized by SANDEE from time to time for their valuable suggestions to improve the study.

1. **Introduction**

It is widely recognised that innovations and technological solutions are critical in effective global response to the climate change challenge (Blackman, 1999; Yang, 1999; IPCC, 2000; Olsen, 2007). Achieving the global reduction of GHGs requires innovation to transform current technologies into cleaner and climate resilient technologies. But radical innovations are largely concentrated in a few highly industrialized countries (Pietrobelli, 2000). Developing countries which are at a greater risk of climate change impacts due to much of their population living in physically exposed locations and being largely dependent on climate sensitive sectors (agriculture, fisheries, tourism) and resources (such as water, biodiversity, mangroves, coastal zones, grasslands) for their subsistence and livelihoods, have low technological capability to shift to low carbon and climate resilient growth paths. They must either develop the technology by their own means or purchase it from developed countries both of which are costly options. Realising this, the UNFCCC (United Nations Framework Convention on Climate Change) which is the apex body formed in 1992 to provide solution to the growing problem on Climate Change under the guidance of IPCC (Intergovernmental Panel on Climate Change) mandates developed countries to take all practicable steps to promote, facilitate and finance the transfer of environmentally sound technologies and know-how to developing countries[1]. In order to implement this mandate, the negotiations under the UNFCCC have created a framework to promote the transfer of technologies[2]. This framework offers several alternative arrangements and organizational designs to implement technology transfer actions and plans. Other important technology transfer initiatives include, a special report on "Methodological and Technical Issues in Technology Transfer" by the Inter-governmental Panel on Climate Change (IPCC), a consultative process under the UNFCCC, workshops, and other fora supported by a variety of organizations, including the Climate Technology Initiative. However, there is evidence that the Clean Development Mechanism (CDM)- established in 1997 by the Kyoto Protocol (KP), is the largest market based mechanism that incentivises the private sector to finance low-carbon technology transfer to developing countries (Schneider et al., 2008)[3].

[1] See, Articles 4.1, 4.3 and 4.5 of the United Nations Framework Convention. The Kyoto Protocol, in Article 10(c), reiterates the requirement of all Parties to cooperate in the development, application, diffusion and transfer of environmentally sound technologies that are in the public domain (UN, 1997)

[2] This decision (FCCC/CP/2001/L.10) was forwarded to the 7th Conference of the Parties (COP-7) in November 2001, and was adopted there as FCCC/CP/2001/13/Add.1.

[3] As reported in Chatterjee (2011 p 9), "Until 2008, the CDM drove an investment flow of around 9 billion Euros into projects containing technology transfer and the level of investment has grown further (Schneider et al.,2008). This exceeds the investment generated by the Global Environment Facility (GEF), a fund specifically set up to promote technology transfer (Egenhofer et al., 2007)".

The CDM is a project-based mechanism, whereby eligible entities from developed countries are expected to finance emission reduction projects in developing countries and use carbon credits generated by these projects to meet a portion of their greenhouse gas (GHG) reduction commitments under the protocol. Although technology transfer is not an explicit mandate of the mechanism, it is expected to facilitate technology transfer by financing emission reduction projects that use technologies currently not available in host countries (OECD/ IEA, 2001; Kathuria, 2002; Ockwell et al., 2008, UNFCCC, 2010, p. 10). A fairly large body of literature has investigated the role of CDM in promoting transfers of clean technology and expertise from the technologically advanced North to South (Hansen 2011; Wang (2009) Chatterjee 2011; Das 2011; Dechezleprêtre et al. 2008, 2009; Doranova et al. 2009; Haites et al. 2006; Schneider et al 2008; Seres, 2007; Youngman et al,. 2007; Sepibu, 2009; De Coninck et al. 2007).

The present study is a contribution to this growing literature. It uses a novel methodology to examine the role of CDM in building technological capabilities of implementing firms in host developing countries with a particular focus on India. While most existing studies examine the claims of technology transfer made by project participants in their "Project Design Document" or in primary surveys; the present study goes a step ahead. It makes a distinction between technology transfer/import/acquisition on the one hand and its absorption and learning to build technological capability on the other, and focuses on the latter. It uses secondary database to investigate the role of CDM in building technological capability of implementing firms vis-à-vis that of non-implementing ones. While doing so it employs difference-in-difference technique in a quasi-experimental design framework. It is arguably the first study to attempt this kind of analysis based on the secondary database. Central in our approach is the argument that technology transfer/acquisition is only a necessary condition of building technological capabilities but not a sufficient one. The former needs to be absorbed and assimilated to build technological capability (Lall, 1992). We measure technological capability in terms of four indicators namely, indigenous R&D efforts, total factor productivity, export performance and fuel efficiency.

Currently, the CDM is imperilled. Carbon prices in the CDM market have declined sharply in the recent period and are projected to fall further signalling the potential death of this instrument. Policymakers and climate advocates alike increasingly question the continuing value of instruments like the CDM for various reasons. However, there is also a realisation that new solutions will take years to design and get operational. In the absence of new solutions, CDM is likely to remain the world's foremost – and possibly sole – means of gaining the benefits of a global carbon market" (CDM Policy Dialogue launched at the United Nations Climate Change Conference held in Durban, South Africa, p.2). Therefore, there is a strong need to analyse the impact of CDM on various stakeholders. Against that background the present study is expected to provide useful insights on CDM benefits in terms of upgrading technological capabilities of firms in developing countries.

The rest of the study is organised into five sections. It begins with the concept of CDM in Section 2. Section 3 reviews the theoretical relationship between CDM and technology transfers on the one hand, and technological capabilities of the implementing firms on the other.. Section 4 provides some preliminary observations on the role of CDM in technology transfers and its impact on technology acquisition by host country firms. It also reviews the existing literature in the Indian context. Section 5 describes the model and presents major hypotheses to be tested in the study. It also describes the methodology and database for the econometric analysis. Section 6 discusses the results. Section 7 concludes the study.

2. Understanding the Clean Development Mechanism

The CDM is one of the three Flexibility Mechanisms' introduced by the Kyoto Protocol. The Kyoto Protocol which was adopted in Kyoto, Japan, in 1997 and which established a legally binding obligation for 38 industrialized countries (including 11 emerging market economies) to reduce GHG emission by 5.2 percent below their 1990 level during the commitment period of 2008-12, introduced three 'Flexibility Mechanisms' to help these countries meet their targets. These are: emission trading, joint implementation (JI) and clean development mechanism (CDM). While emission trading is a system in which advanced (or Annex I) countries can buy and sell emission to achieve their targets, JI and CDM are project based mechanisms. Under "Joint Implementation" the developed countries' firms can jointly implement a project in their territory and can use the amount of emission reduced by the project to meet their targets. CDM, on the other hand, is designed to allow developed countries' firms to implement greenhouse gas emissions reducing projects in developing countries and receive credits which they can use in home countries to meet their carbon reduction targets. The carbon credits that are generated by a CDM project are termed Certified Emission Reductions (CERs). With costs of emission reduction typically much lower in developing countries than in industrialised countries, the latter can comply with their emission reduction targets at much lower cost by receiving credits for emissions reduced in developing countries. In this process developing countries also benefit. The mechanism permits them to acquire new clean technologies and assists them in achieving sustainable development. The basic principle of the CDM is simple: developed countries can invest in developing countries and receive credit for the resulting emissions reductions at low costs while developing countries benefit from the increased clean investment and technology flows. The range of possible projects under the CDM includes opportunities in conventional power generation, fuel switching, industrial applications, use of renewables, and forestry.

However, obtaining CDM status for a project involves a long bureaucratic process (UNFCCC) which consists of seven steps:

- **Project identification and design:** The project owner identifies an opportunity for a CDM project and develops a project design document (PDD) which includes a baseline estimate and an analysis of the net carbon.

- **Host country approval**: Project participant secures letter of approval from the Designated National Authority (DNA) of the host country.

- **Third party validation of project design and baseline:** Project design document (PDD) is validated by the ISO certified designated operational entity.

- **Registration**: Once a project is validated and approved by the host country, it is registered by the CDM Executive Board.

- **Monitoring-**Project participant is responsible for monitoring actual emissions according to approved methodology.

- **Verification**- An independent designated third party verifies project performance against the validated design and baseline in order to approve certification.

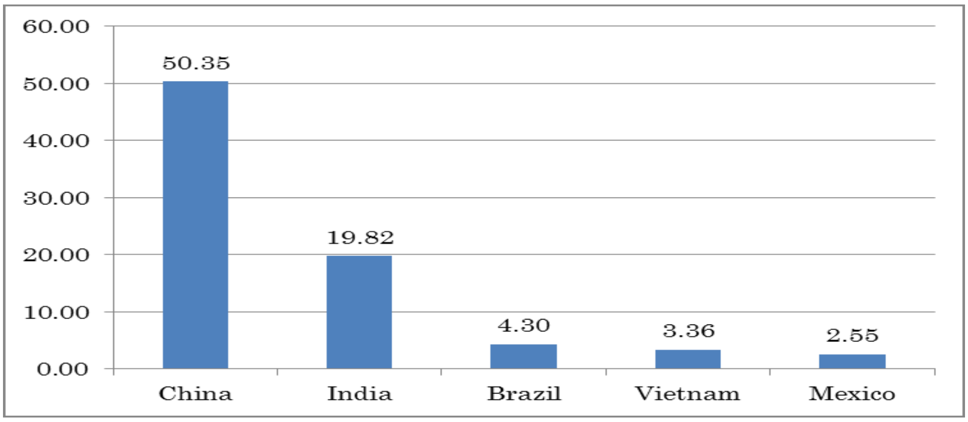
- **CER issuance**- Based on the host country approval, the validated projects design under baseline, and the verified project performance, CERs are certified and issued by the CDM Executive Board.

Each step of CDM registration involves cost. The transaction costs of CDM projects thus consist of the search costs, negotiation costs, PDD costs, approval costs, validation costs, registration costs, monitoring costs, verification and certification costs and costs accruing from the adaptation fee (Krey 2004). This in turn has implication for the implementing firm's resources and its financial performance.

According to the UNFCCC database, there were 7418 projects registered by the host party as of 31 December 2013 which helped nations mitigate approximately 1.4 billion tons of greenhouse gas emissions in a manner that realized US$3.6 billion in savings for developed countries.

India has been one of the largest CDM implementing countries. Our analysis of CDM projects by host country shows that India, China, Brazil, Vietnam and Mexico accounted for over 80 percent of these projects by December 31, 2013 (Figure 1). India and China alone accounted for over 70 percent of the total projects with India occupying the second place in terms of its share on registered CDM projects and investment undertaken therein.

Figure 1: Percentage share of registered project activities for 5 top host countries (As of December 31, 2013)



Sources: UNFCCC website

Figure 2 presents growth in India's total number of registered CDM projects between 2000 and 2013. Since the establishment of the Indian DNA (Designated National Authority) in 2003, it has approved a significant number of projects. As of 31 May 2012, 835 projects initiated by 698 firms had been registered by the CDM executive board, which accounted for about 20% of all the globally registered projects. This number increased to 1468 (initiated by 1283 firms) by 31 December 2013 (19.8% of the global projects). These projects have issued 0.19 billion tons of CERs as on 31 December 2013 (over 13% of worldwide CERs)[4].

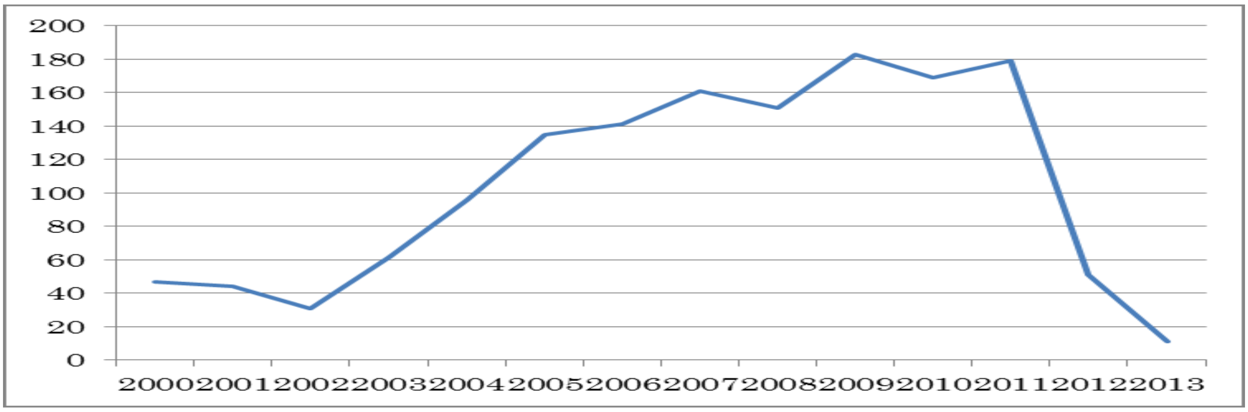
Since 2007 however there has been a continuous decline in the yearly number of such projects. There are at least three reasons for this slowdown:

- Global slow down

- Fall in the international prices of CERs
- EU focus of obtaining CERs from least developed countries instead of the major CDM countries

The steep fall notwithstanding India remains amongst the leading pack of the top 8 countries.

Figure 2: The total number of projects participants registered from 2000 to 2013 in India.



Source: IGES CDM Project Database

3. **CDM, Technology Transfer and Technological Capabilities: A Theoretical framework**

The IPCC (2000) 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."

In reality this flow is primarily from developed to developing countries' entities. Numerous channels exist through which technology can be transferred from developed country entities to their developing country counterparts. The available evidence shows that the bulk of technology is transferred via following channels (Maskus, 2004).

- Trade in goods and services is one. All imports bear some potential for transmitting technological information to developing countries. In particular, imported capital goods

4 **IGES CDM Project Database downloaded on 15 January 2014**.

and components/raw materials can directly improve productivity by being used in production processes.

- A second channel is foreign direct investment (FDI). Multinational enterprises (MNEs) generally transfer technological information to their subsidiaries. The vast literature on technology transfer indicates that the most advanced and frontline technologies are transferred through FDI (Dunning, 1993). This is because many of these special assets are a source of rents, and TNCs internalize their transfers to keep them tightly in-house. Since patent ownership of climate change technologies is concentrated in advanced countries, FDI can be the most important vehicle of transferring these technologies which can help developing countries to leapfrog to the most advanced technologies.
- A third major channel of ITT is technology licensing. This may occur within firms, among joint ventures, or between unrelated firms. Licensing typically involves the outright/ royalty based purchase of production and distribution rights for a product and the underlying technical information and know how necessary for its production. However, many advanced technologies are not available through licensing (Dunning, 1993; Markusen, 1995).

The CDM projects can facilitate technology transfer through any of these channels depending on the financing mechanism. The financial mechanism of CDM can take three major forms.

- **Direct investment by foreign investor in CDM projects:** It involves equity investment via joint venture companies/wholly owned subsidiaries or indirect (portfolio) investments via purchase of securities. Equity based investments provide equity for co-financing of projects that generate CER credits (investor receives profit/ROI[3] and CERs).

- **Purchase of yet-to-be-generated CERs:** This mode of financing involves forward contract (e.g., in the form of a carbon purchase agreement) or call option to purchase a specified amount of CERs generated by a CDM project upon delivery, normally with some up-front payment.

- **Purchase of CERs in the secondary market:** In this model of financing, Annex I country just buys Certified Emission Reductions (CERs) in the secondary market. This is the common form of financing in unilateral CDM where host countries entities develop and finance their own projects and sell or bank CERs generated by them (Seres and Heite, 2008; Lütken and Michaelowa, 2008). Developed country buyers purchase them in the secondary market.

Of the three financing arrangements, the first one results in the inflows of FDI to developing countries. It is expected that FDI towards environmentally supportive investments expands access to the technologies of multinational corporations and their marketing networks involving new markets for climate-friendly technologies or services in developing countries (Niederberger and Saner, 2005; UNCTAD, 2010). The second and third may involve technology acquisition by local firms through equipment purchases and/ or the technology licensing. In former (contractual agreements), the host country is benefited by the transfer of technology or equipment or the knowledge of the foreign partner or of any other source suggested by the partner. Further, the foreign partner also cooperates in identifying the low cost technologies, ensures funding and promotes capacity building to absorb technologies. It also provides technical support for adapting technology and maintaining it under local circumstances. In the third (secondary market purchase arrangements), there is a possibility for local project developer to buy foreign technology on a global market through technology licensing and capital goods imports. Public or private intermediaries can facilitate this type of transfer by providing information or access to capital.

The Project Design Document (PDD) which a CDM developer is required to submit to the UNFCCC for registration and approval of the projects under the CDM describes the technology which the developer perceives would be used and transferred in the project. It distinguishes between three forms of technology transfers:

- The transfer of knowledge, know-how, information or technical assistance from a foreign partner.
- An equipment transfer through equipment imports, such as wind turbines or gas burners, from a supplier located in a foreign country.
- Transfer of both equipment and a transfer of knowledge involve bundling of knowledge with equipment.

The PDD information has been the source of identifying the extent of technology transfer through CDM in most existing studies. However, potential transfer of technology is only a necessary condition for building technological capability of host country firms. It is expected the skills, knowledge, and resources acquired by local firms through technology transfers enable them to assimilate, change, and improve technology through such activities as capital stretching, adapting or modifying processes, improving efficiency, etc. As firms absorb new technologies, they may move up, and acquire design, engineering skills and resources. However, technological knowledge cannot easily be imitated by or absorbed across firms. To understand the tacit components and to exploit the commercial possibilities of the technologies, firms need upgrade their technological capability. The exploitation of external technology thus requires the creation of some absorptive capacity and ability to understand an externally sourced technology and apply it internally (Cohen and Levinthal, 1989; Patel and Pavitt, 1994). This may facilitate the understanding of the full productive potential of the technology by the buyers and, hence, may also lower the cost of such transfers (see also Robinson, 1988). But this in turn requires conscious allocation of funds on learning (Cooper, 1994; Teece 1977; Nelson and Winter 1982) and the extent of mastery achieved is uncertain and necessarily varies by firm according to these inputs. Thus if technological capability is defined narrowly as “scientific and engineering knowledge which is principally the outcome of own R&D efforts of a firm” then a technology transfer results into technological capabilities provided it is accompanied by **in-house technological efforts** by the host country project participant towards adapting or improving upon the imported ‘technology and/or equipment’.

Some experts adopt a wider notion of technological capability. According to them it is tacit knowledge that is embedded in firms’ procedures and personnel, organisational structures, knowledge management, external interactions and integrations, which is finally manifested in their performance (see for instance Zahra and George 2002, Zawislak et al 2012; Kwanghui and Falk 2013; among many others). There are several measures of firms’ technological competitiveness. For the purpose of this paper, we select three such indicators, namely, fuel efficiency, export performance and total factor productivity. In what follows, we specify our hypotheses for empirical testing.

Main hypotheses

As suggested above, technological capability is defined in two ways: narrow and wider. While the narrow conceptualization leads to an analytic focus on the domestic R&D efforts (as discussed above), the wider conceptualization leads to a focus on dynamic capabilities of firms which influence their performance. We consider both of them while formulating our main hypotheses.

Narrow conceptualisation of technological capability: Based on this definition, our first hypothesis is,

H1: The adoption of CDM influences local R&D efforts of implementing host firms.

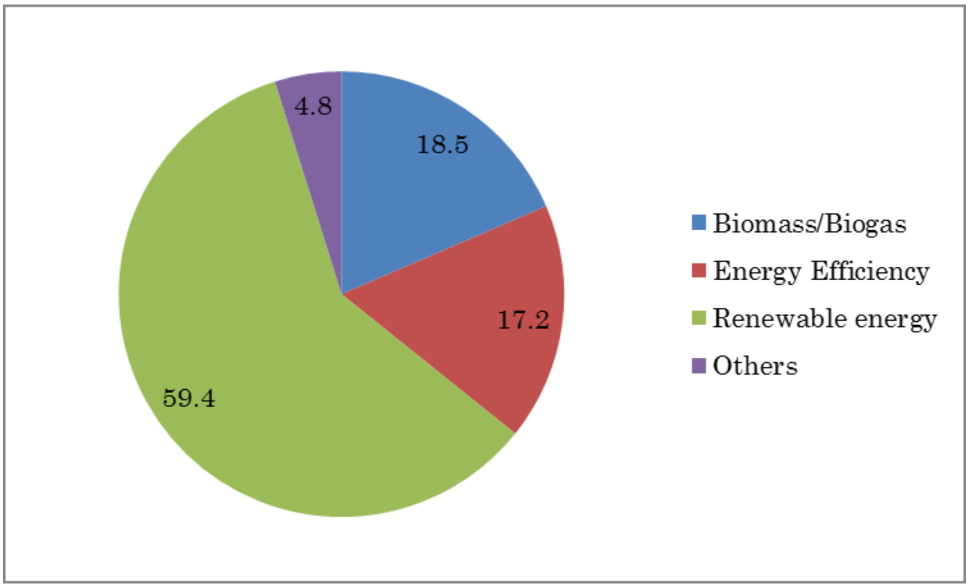
The nature of this relationship has been subject to a considerable debate in the literature, with some studies arguing for substitution effect (Blumenthal, 1979; see also, Kumar and Siddharthan, 1997). This means that technology imports (via CDM) may substitute internal R&D efforts and hence adversely affect the technological capabilities of local firms. The literature for India by and large supports the complementarity hypothesis, that is, technology imports are followed up by further technological effort to adapt and absorb the imported knowledge (see Lall, 1983; Katrak, 1997; Kumar, 1987; Deolalikar and Evenson, 1989; Siddharthan, 1988, 1992; Aggarwal, 2000, among others). However, Fikkert (1993) reported an inverse relationship between technology imports and R&D in a framework that treated them as jointly determined. Kumar and Saqib (1996), and Kumar and Siddharthan (1997, p. 133) emphasized the complex nature of the relationship, which depends upon interactions with a number of other variables. Embodied knowledge also offers valuable opportunities for absorption and adaptation through reverse engineering. Evidence suggests that there is a positive relationship between capital imports and R&D activities of Indian enterprises (see, for instance, Basant, 1997; Kumar and Aggarwal 2005). Overall, we hypothesise that the CDM implementation affects local R&D efforts positively. The high transaction cost of implementing CDM projects (as discussed above) may however affect the firms' financial capacity to invest in local R&D and the hypothesis may turn out to be weakly established.

Wider definition of technological capability: Our next three hypotheses are based on the wider definition of acquisition of technological capability.

H2: CDM implementation enhances fuel efficiency of the host firms.

From the perspective of CDM projects, fuel efficiency may be an important indicator of performance. This is because energy related projects dominate the portfolio of CDM projects worldwide. In India, too, over 95% of the CDM projects pertain to renewable energy and energy efficiency (Figure 3). While biomass/biogas projects accounted for 18.5% of the total projects as of 31 December 2013, the share of other renewable energy projects had been 59.4%. Energy efficiency/fuel switch comprised of another 17.2% projects.

Figure 3: Distribution of CDM projects by sector (as of 27 December, 2013)



Source: Author's calculations based on **IGES CDM Project Database**.

H3: CDM implementation improves total factor productivity (TFP) of the host firms.

In general, we may expect a positive relationship between TFP and CDM implementation due not only to improved fuel efficiency or cleaner technology but also to improved organizational capacity, knowledge management, social capital, and greater external and internal interactions affecting dynamic capabilities of the implementing firm. But as discussed above, a CDM firm is also likely to face increased implementing costs pulling down its productivity. Further, a CDM project may be a small part of its overall operations having little impact on its overall efficiency.

H4: CDM implementation promotes export performance of the host firms.

A technologically and dynamically capable firm is likely to export more. Further, the implementing firms are expected to generate substantial goodwill in international markets by adopting cleaner technologies and may be able to export more. However, the CDM implementation costs may affect their cost competitiveness and hence the export performance. The impact of CDM implementation on exports may thus turn out to be weak.

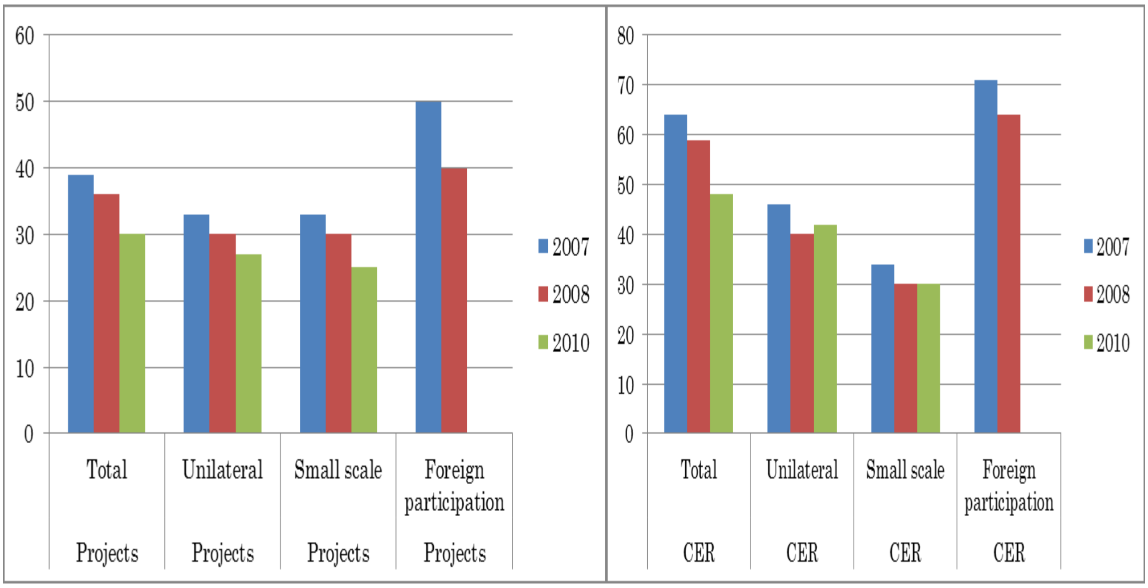
Other hypotheses

The core assumption of the above theoretical framework is that there is technology transfer associated with CDM implementation. Existing studies indicate that technology transfer through CDM is dependent on various project and firm specific factors in a given host country. Some of important factors are as follows.

Project specific factors

Foreign participation: As discussed above, the CDM was essentially designed to ensure the participation of Annex I country entities in CDM projects hosted in the developing countries. Therefore these projects should either be bilateral or multilateral. However, in 2005, the CDM Executive Board approved the idea of unilateral CDM also. Evidence suggests that technology transfer is more common for projects that involve foreign participants than for unilateral projects. Figure 4, for instance, shows that just under half of the projects that have foreign participants, representing 71% of the estimated emission reductions for those projects claim technology transfer. On the other hand, a mere 30% of the unilateral projects indicate technology transfer. We therefore hypothesise that the projects involving foreign participation affect firms' technological capabilities significantly more than the unilateral projects.

Figure 4: Technology transfer claims by scale and foreign participation



Source: Seres (2007), Seres and Haites (2008) and UNFCCC(2010)

Project size: The rulebook of CDM distinguishes between two categories of projects:

small scale and large scale projects. In order to be identified as small scale project, a project activity must meet the eligibility requirements clearly laid down in the rules. Projects registered as small-scale CDM projects are entitled to use simplified modalities and procedures. There is a general consensus that small scale projects involve less technology transfer (Seres, 2007; UNFCCC, 2010; see also Figure 4). Another important observation that can be made (Figure 4) is that technology transfer claims have been declining across all categories of projects irrespective of their scale and foreign participation. But, this decline is less modest in terms of CER that these projects accounted for. Cleary, technology transfer is increasingly contained in relatively larger of the projects across all categories. It is therefore expected that the large projects affect firms' technological capabilities significantly more than the small projects.

Type of economic activity: Further, it has been observed that agriculture, hydro fluorocarbons (HFC), landfill gas, waste management, and nitrogen dioxide (NO2) tended to have more frequent recourse to foreign technology. Amongst energy related projects, Tidal, Geothermal projects, fuel switch and energy efficiency projects have high technology transfer potential followed by wind and solar energy. On the other hand, biomass, bio gas, cement, hydro, energy distribution, and afforestation/reforestation have relatively less potential for technology (Seres 2007, 2008; Dechezleprêtre et al 2009). Thus technology transfer opportunities differ across sectors and need be captured in the analysis.

Firm specific factors

There has been a vast literature on inter-firm differences in behavior and performance. Some of them are observables while others are not. The effect of these variables needs to be captured to analyse the relationship between CDM and the indicators of technological relationship**.**

Thus, the basic model adopted for the analysis is as follows

Technological_Capability = f(CDM_adoption, Project Specific, Firm Specific)…………..…(1)

Technological capability of a firm is indicated by domestic R&D expenditures, efficiency in fuel consumption, total factor productivity and export performance of firms.

Project specific factors include: foreign involvement, project scale, technology transfer opportunities.

Firm specific factors are captured by observables such as the scale of firm operations, and non-observables.

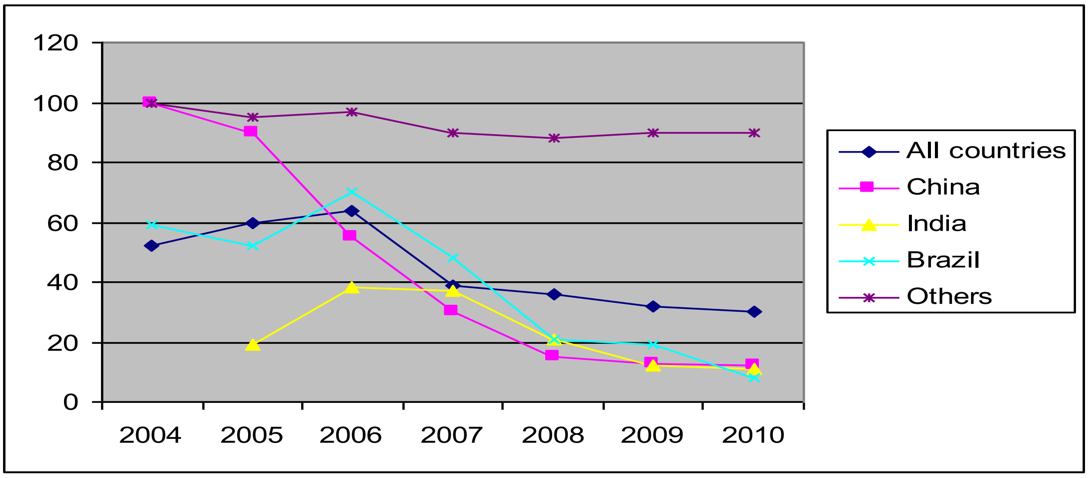
Before the empirical analysis however, we sumamrise some preliminary observations based on the PDD based data on technology transfers.

4. CDM and Technology transfer: Some preliminary observation in India and review of the existing studies

The patterns of technology transfers based on the analysis of explicit claims on technology transfer made in the CDM Project Design Documents in India and other major CDM implementing countries are presented in Figure 6. It shows that the projects claiming technology transfers are highly concentrated in China, India, Brazil and Mexico. In 2010, these countries accounted for 75% of the total projects claiming technology transfers and these projects accounted for 79% of CER. What is however more important to note is that the rate of international transfer in India has always been lower than the world average whether measured in terms of number of projects or annual emission reductions but it declined further. In 2005, 40% (vs. the world average of over 60%) of the projects reported technology transfers which declined further to around 12 percent in 2010.

Apparently, in India the CDM implementing firms are likely to use domestic technology in most cases affecting the technological capability-enhancing effects of CDM implementation.

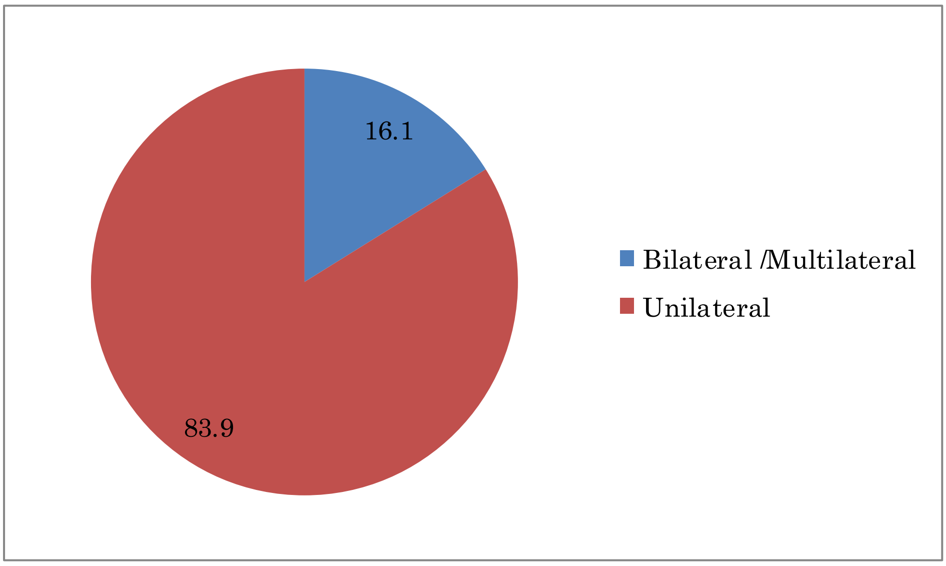
Figure 5: Proportion of registered projects that have claimed technology transfer



Source: UNFCCC (2010)

Further, since 2006, the share of unilateral projects in new projects has been increasing in India (Aggarwal, 2011). As of December 27, 2013, nearly 84% projects registered were unilateral (Figure 6).

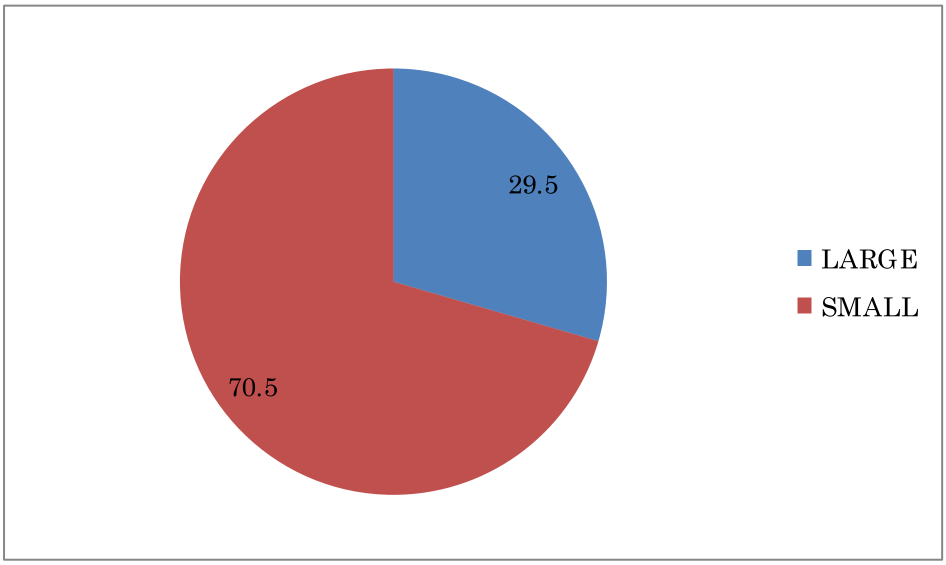
Figure 6: Distribution of CDM projects by foreign participation in India



Source: Author's calculations based on **IGES CDM Project Database**.

Figure 7 indicates that, of the 1468 projects as on December 31, 2013, 1055 (70.5%) projects were small (Figure 7). In contrast, China hosts mostly large-scale projects with only 26% of total projects categorized as small projects. The world average share of small projects is 46 percent which constitute almost 10 percent of CERs. The share of small projects in Brazil and Mexico is close to the world average (Aggarwal 2011).

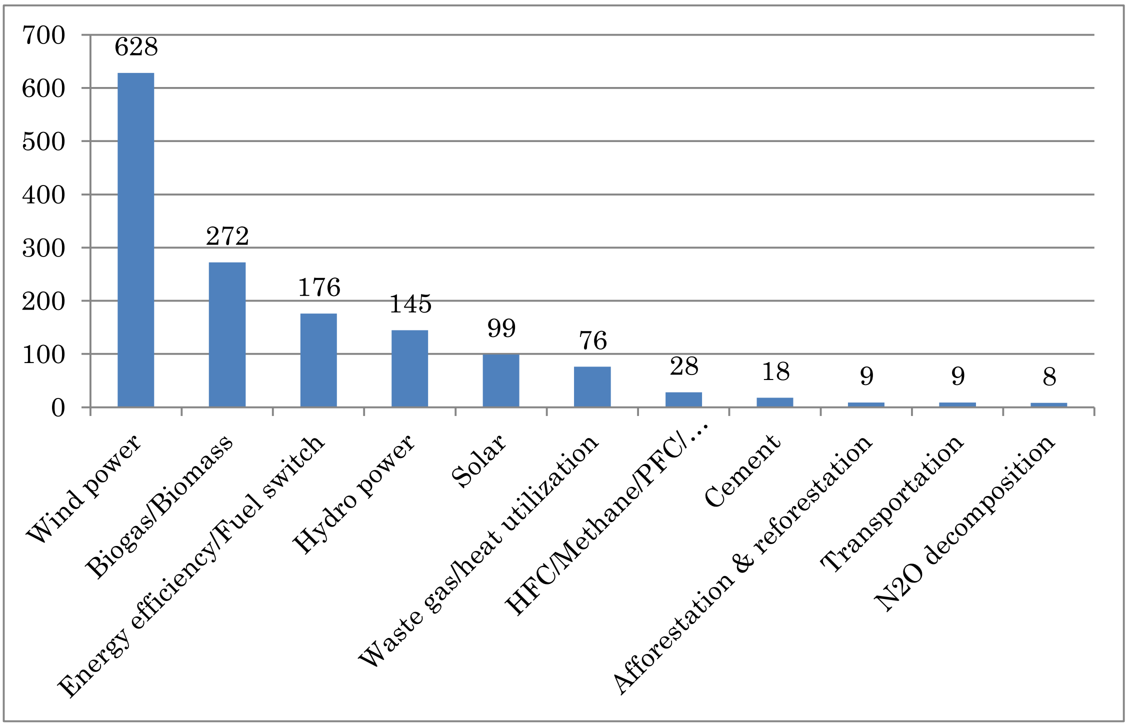
Figure 7: Registered CDM projects by scale of project in India



Source: Author's calculations based on **IGES CDM Project Database**.

Finally, evidence suggests that CDM projects hosted in India are concentrated in renewable energy including biomass energy. The high end industrial gas projects account for a small share of total projects. This is clearly borne out by Figure 8 below.

Figure 8: Registered CDM projects by type of economic activity in India



Source: Author's calculations based on **IGES CDM Project Database**.

In a nutshell, the analysis of growth and patterns of CDM projects in India reveals that

- The number of CDM projects has been declining since 2007 even though the country continues to occupy the second position.
- Further, much of the abatement actions are concentrated in a few categories of activities.
- Finally, there has been a steady increase in the share of small and unilateral projects in total CDM projects.

These patterns indicate that the role of CDM as a means of upgrading technological capabilities of firms is expected to be limited. The existing studies also bring out the limitations of CDM in supporting large scale technology transfers. In a study of 380 CDM projects across Brazil., China, India, and Mexico, Doranova (2009) finds evidence of learning through CDM implementation in India. She defines technological learning at three levels:

- **Basic level:** At the most basic level firms get equipped with the skills, knowledge, and resources to deal with day-to-day activities (and problems) more efficiently. These are termed 'the process operation capabilities'.
- **Intermediary level:** firms acquire the skills, knowledge, and resources which enable them to assimilate, change, and improve technology through such activities as capital stretching, adapting or modifying processes, improving efficiency, etc.
- **Advanced level:** firms acquire design and engineering skills and resources.

Her primary survey based study reveals that the progress in technological capability of host country firms as a result of CDM experience is typically associated with the medium levels of technological learning. However, learning generated in energy efficiency, HFC gases destruction, fugitive emissions and landfill gas capture projects have made substantial contribution to technological capabilities at all levels. The studies showed technology transfer also depend on countries specific factors.

Das (2011) focuses on the database of 1000 globally registered projects from the original CDM Project Design Documents and builds on that by collating information and the relevant web pages of the UNFCCC web portal. Only when such import is found to be associated with evidence of technology learning in the host country, in some form or the other, is it regarded as a case of technology transfer[5]: Overall, of the total 1000 projects, a mere 265 involved technology transfer. Her analysis further shows that in most projects technological learning and capability building is confined only to the basic or operational level. The percentage share of projects with technology transfer varies widely across countries. Among the top 14 host countries, Mexico has the highest share of projects involving technology transfer whereas India has the lowest share. In India, 16 out of 326 projects are found to have involved technology transfers. However, it is not very clear from the study as to what type of complementary information she gathers to reach her conclusions.

In a recent study based on interviews with industry, FICCI (2012) finds that CDM has not contributed to technology transfer. Project developers state that technology transfer has taken place neither in unilateral projects nor in several bilateral and multilateral projects. One of the probable reasons for this is the lack of financial assistance. Majority of the survey respondents (62%) are of the opinion that technology transfer did not take place. There are however anecdotal cases of technology transfers. A majority (62%) responded that there was

[5] However, the aforementioned classification of technology transfer need not be mutually exclusive in the sense that more than one classification may hold simultaneously for a particular CDM project.

no technology transfer. Of the remaining 38% of the survey respondents, over 29% reported imports of equipments and over 8% have indicated a bundle of equipment imports and licensing.

Lema and Lema (2013) focus on wind power to analyse the role of CDM in technology transfer. They do not find evidence that CDM plays the spearheading role for enhanced technology transfer. They find that India and China have built significant firm capabilities in the wind power field, which has been the result of ambitious host country policies (particularly in China) and firm level strategies and investments more than of CDM. They conclude that the domestic technological capabilities influence the flow and mechanisms of technology transfer. Most advanced skills and capabilities have been developed independent of CDM and have later been replicated in CDM projects. They opine that the nature of technology transfer in CDM may be an effect rather than a primary cause of domestic capabilities.

In summary, the existing literature which essentially focuses on the PDD based technology transfer data reveals a weak relationship between CDM implementation and technology absorption or learning. But it must be noted that the PDD claims which have been the source of information on technology transfers provide only *ex ante* assessment of technology transfers and not the actual one. Chatterjee (2011) reports that the post CDM implementation interviews with developers indicate that many of these projects involve technology transfers, which is not anticipated when the PDD is prepared. Thus, any analysis based on the ex-ante information (or even the perception of the developers) cannot be considered completely reliable. To improve the understanding of the CDM's real contribution to technology transfer, it is important that there is a rigorous analysis based on the secondary data on the effects of CDM implementation.

In a study on CDM induced- technology transfers, Aggarwal (2011) finds that technology transfers have been declining over time, in particular in major CDM-active countries. Not only that, it has also been observed that these countries have actually become a source of technology transfers through CDM. In 2007, technology transfer from these countries was less than 10% of all technology transfer. Five countries namely, Brazil, China, India, South Korea and Chinese Taipei were the source of 94% of equipment transfers and 74% of knowledge transfers from these sources. By 2010, 15 percent of the projects get their technology from developing countries. She concludes that it may be due to the fact that the CDM experience has contributed significantly to building up their technological capabilities.

The present study is based on the secondary data to test the hypothesis if firms investing in CDM projects get technologically more competitive than the non-implementing firms.

5. **The Model, Methodology and data base**

5.1 The Methodology

We use panel data based Difference-in-Differences (DID) techniques to measure the effect of a CDM project on technological capabilities of firms. The DID estimator represents difference between the pre and post treatment in treatment vs control groups.

$$Yij = \alpha_1 + \alpha_2 \mathrm{T}.d + \alpha_3 T + \Sigma \alpha_{kContr} ds + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where i= both control and treatment firms

Y is the outcome variable

α_1= constant term

T: Dummy for the treatment group

T.d= Post treatment effect on the treatment vs control group

α_2 = Difference-in-Difference effect

α_3= treatment group specific effect (to account for average permanent differences between treatment and control)

From 1 and 2, our models for the analysis are

$$Yij = \alpha_1 + \alpha_2 \sum \mathrm{CDM}.dj + \alpha_3 CDM + \Sigma \alpha_{kContr} ds + \varepsilon_{it}$$

Since the CDM implementation year differs across firms, the dummy "d" does not represent a fixed year of treatment.

5.2 Database

The study uses two sources of data for the empirical analysis: the CDM database of the Institute for Global Environment Strategies (IGES); and the Centre for Monitoring Indian Economy's PROWESS database of large and medium Indian companies. Building the database required a long and complicated exercise involving several steps.

- As a first step, we gathered information on all 864 projects registered in India as on May 31, 2012 from the IGES database. IGES entered into the memorandum of understanding (MOU) with the UNFCCC secretariat on the exchange of CDM data, signed in May 2008. The information of relevant items is extracted from the publicly available sources on the UNFCCC web-site. The database provides comprehensive information on the status of CDM projects, their category and scale, location, year of implementation, collaborators involved, implementing host country and its companies, and the issue of carbon.

- In the second step, we created a list of the host firms and mapped them with the firms covered in the PROWESS database. Prowess is a database of large and medium Indian firms. It contains detailed information on over 27,000 firms. These comprise of all companies traded on India's major stock exchanges and several others including the central public sector enterprises. Collectively, the companies covered in Prowess account for 75 per cent of all corporate taxes and over 95 per cent of excise duty collected by the Government of India. Prowess provides balance sheet data of each company. This includes quantitative information on production, sales, consumption of raw material and energy. Totally, the number of indicators per company is close to two thousand. We extracted from this database information for two groups of companies: CDM and Non CDM firms.

  - **CDM firms:** Of the 864 implementing companies, we could match 292 firms in PROWESS. We identified NIC codes of all 292 CDM firms.
  - **Non-CDM firms:** We then selected non-CDM firms in those NIC categories. While sampling non-CDM firms in each NIC code, we generated random number from the computer after ranking the firms in order of size. However, we found that many firms had very little data with respect to the variables of our interest. We therefore discarded those firms and generated new random numbers. The process was thus repeated to extract the sample of non-CDM firms.

- As a next step, we extracted selected financial data of these firms for the years from 2001 to 2012. In all, 20 variables were selected that included, R&D, gross Assets, licensing of technologies, sales, salaries and wages.

- Finally, we merged the CDM database obtained from the IGES with the companies' financial database to create a panel dataset for the years 2001 to 2012 and constructed our variables as follows *a. Variable construction*

Outcome variables

R&D Intensity: R&D expenditure to sales ratio
Fuel intensity: Fuel expenditure to sales ratio
TFP: Total factor productivity calculated using the Solow method.
Export intensity: Exports to sales ratio

Main variables:

Dj: j takes the value from 1 to 10. D1 means the year of implementation of the project, d2 means the first year after the project is implemented. And so on.
D_CDM: A dummy that takes value 1 for firms implementing CDM projects and 0 for those firms not implementing CDM project.

Project specific:

- **Unilateral**: A dummy that takes value 1 for unilateral projects and 0 for bilateral.
- **Size** (Large/ Small): A dummy that takes value 1 for large or multiple projects and 0 of small projects
- **Proj_Category:** A dummy variable takes value 1 for economic activity where technology transfers are likely to be significant and is 0, otherwise.

Firm specific:

- **Sale**: log of sales
- **Sale2**: Square of Sale
- Firm specific dummies

Time specific

- **Year dummies** (to control for the time-varying unobservable effects)

To examine whether the sample of firms used in the study is representative of the population, we undertook a comparative analysis of the sample and census firms in terms of the scale, foreign participation, and category. It is presented in Table 1.

Table 1: A comparative analysis of sample vs census database

	Sector	Sample	Census
Sector	Afforestation	0.72	0.61
	Biogas	2.17	2.11
	Biomass	22.74	16.41
	Cement	5.05	1.16
	Energy efficiency	6.14	9.33
	Fuel Switch	5.05	2.65
	HFC reduction	1.81	0.48
	Hydro power	5.05	9.87
	Methane avoidance	1.81	1.3
	N2O decomposition	1.08	0.54
	PFC reduction and substitution	0.36	0.14
	Transportation	0.36	0.61
	Waste gas/heat utilisation	13.72	5.17
	Wind power	33.94	42.75
	Solar	-	6.74
Foreign participation	Unilateral	81.5	83.9
Size	Small	58	70.5

Source: Author's calculations

5.4 Descriptive Statistics

The descriptive statistics presented in Table 2 is based on our sample. It shows that a CDM firm is typically larger than the non CDM firm. However, the size variation is also large in the case of CDM firms. Further, R&D intensity of CDM firms remain almost the same in the pre- and post- CDM implementation period. It must also be observed that the R&D intensity of non CDM firms has been greater than that of the CDM firms. It may however be observed that the CDM firms are more fuel efficient as compared with non-CDM firms. It could be due to the scale factor. More interesting is the fact that fuel efficiency of CDM firms has improved over time. Export intensity and productivity appear to have declined for the CDM firms after they initiated CDM projects. This could be due to complex interactions between different market factors which need to be controlled. In both the cases, non-cdm firms lag far behind the CDM implementing firms.

Table 2: Descriptive statistics of the major variables

	Firm	Year	Observations	Average	Standard deviation
SALES	CDM	First year of initiation	224	31495.730	200691.900
	CDM	2010	243	55022.580	247779.000
	Non CDM	2010	212	15424.990	89095.300
Fuel-intensity	CDM	First year of initiation	214	7.575	8.016
	CDM	2010	223	6.413	6.990
	Non CDM	2010	196	17.608	108.679
R&D intensity	CDM	First year of initiation	245	0.131	1.109
	CDM	2010	282	0.138	0.571
	Non CDM	2010	297	0.188	1.756
Export-intensity	CDM	First year of initiation	245	11.19	.346
	CDM	2010	282	9.47	.181
	Non CDM	2010	297	7.08	.186
TFP	CDM	First year of initiation	151	.182	1.063
	CDM	2010	204	-.125	1.19
	Non CDM	2010	148	-.559	2.95

Source: Author's calculations

6. Empirical results

The models are estimated using fixed effect cluster-robust-VCE estimates. Our estimates are corrected not only for panel heteroskedastic data but are robust to the within panel (or cluster) correlation of errors. These estimates have more conservative standard errors and smaller t-statistics than the Huber-White-sandwich estimators. The latter assumes that errors are distributed independently within panels. We estimated the models for all the outcome variables. The variable "project-category" turned out to be insignificant in all equations and is dropped in final estimations.

6.1 R&D intensity: Narrow conceptualization of technological capability

The results are presented in Tables 3 and 4. It shows that CDM implementing firms increase their R&D efforts significantly but the results are not so robust. We therefore made a distinction between two categories of firms: one, firms with "sales turnover" less than 100 million and two, firms with "sales turnover" of 100 million. It is found that the implementation of CDM model significantly affect the domestic R&D efforts of large firms. The coefficients of d1 to d8 emerge positive and significant indicating that the implementation of CDM has an immediate impact on the R&D activities of these firms. In the long run the effect tends to dissipate. On the other hand, small firm do not seem to be benefitted by the CDM implementation. As a matter of fact, the sign of domestic R&D efforts for these firms turn even negative in the long run. Interestingly, the coefficient of CDM turns out to be positive and significant for d-CDM which indicates that the small firms that have some threshold technological capability are more likely to implement the project than others. In general, small firms have not been reporting R&D expenditures. Only 3-4% of these firms have reported undertaking R&D with the R&D-intensity to be about 0.1%. On the other hand, 25% of the large firms have reported R&D expenditures and their R&D intensity is around 0.4%. They are thus in a position to upgrade their learnings. Thus a threshold level of technological capabilities is required for the benefitting from the market based mechanism of CDM.

Table 3: Fixed effect cluster-robust-VCE estimates of R&D intensity

	All firms		Firms with sales< = Rs. 1000 million		Firms with sales> Rs. 1000 million	
	Coef.	t	Coef.	t	Coef.	t
d_cdm	-0.00062	-1.14	0.0016	-0.84	0.0001	0.2
Sales	6.13E-05	0.17	-0.0003	0.19	-0.0005	-0.24
Sale2	2.63E-05	0.69	0.0000	0.68	0.0000	0.25
d_size	-0.00151	-1.47	0.0011	-1.2	-0.0012	-0.93
d_unilateral	-0.00195	-2.86	-0.0001	-1.16	**-0.0022**	**-2.53**
d_rd	0.001554	1.11	0.0006	1.34	**0.0032**	**1.7**
d0	**0.001639**	**1.77**	0.0004	0.52	**0.0022**	**2.34**
d1	0.001398	1.44	0.0002	1.93	**0.0020**	**2.07**
d2	**0.002301**	**2.56**	0.0006	0.24	**0.0024**	**2.24**
d3	0.001362	1.12	0.0003	1.26	**0.0020**	**1.9**
d4	**0.004735**	**1.86**	-0.0001	0.15	**0.0023**	**1.99**
d5	0.001325	0.91	-0.0003	1.15	**0.0022**	**1.85**
d6	**0.002306**	**1.87**	-0.0005	1.51	**0.0023**	**1.76**
d7	0.002854	2.02	-0.0005	0.35	**0.0031**	**2.13**
d8	0.001668	1.07	-0.0016	0.73	0.0015	0.93
d9	0.002108	1.46	-0.0001	-0.84	0.0018	1.21
Firm specific	Yes		Yes		Yes	
Year specific	Yes		Yes		Yes	
Observations	4649		1725		2924	
No of firms	552		327		374	
F-statistics	F(26,551)	1.11	F(23,326)	.	F(26,373)	1.25

Source: Author's estimates

It must also be observed that the coefficients of d-size and d-unilateral emerge significant, both with a negative sign. This means that small and unilateral projects are associated with significantly less local R&D efforts than their counterpart large and bilateral/multilateral projects, in particular in large companies. Most variables for small firms turn out to be insignificant but with correct signs.

6.2 Other performance variables

Fuel efficiency: It turned out that the CDM effects on fuel intensity are negative. The coefficient of fuel intensity is negative in all specifications. However, it becomes significant in the third year of CDM implementation (Table 5) and is sustained in the long run. A disaggregated analysis by firm size however indicates that the small firms are benefitted in the short run but it is a one-time effect which is not sustained in the long run. On the other hand, large firms are able to reduce their fuel intensity after certain gestation period and then continue to improve it for some time.

Table 4: Fixed effect cluster-robust-VCE estimates of fuel intensity

	All firms		Firms with sales< = Rs. 1000 million		Firms with sales> Rs. 1000 million	
	Coef.	t	Coef.	t	Coef.	t
d_cdm	0.048	0.42	-0.30	-1.17	0.017	0.66
sales	-3.575	-2.02	-3.69	-2.02	-0.011	-2.96
sale2	0.437	2.18	0.32	2.23		
sale3	-0.017	-2.29				
d_size	-0.004	-0.08	0.62	1.28	-0.005	-0.97
d_unilateral	-0.013	-0.14	-0.08	-0.19	-0.006	-1.18
d0	0.001	0.04	-0.02	-0.12	0.001	0.26
d1	-0.020	-0.78	-0.11	-0.74	-0.003	-0.81
d2	-0.065	**-1.77**	-0.34	**-1.41**	-0.003	-0.8
d3	-0.101	**-1.59**	-0.09	-0.45	-0.004	-0.77
d4	-0.125	**-1.69**	-0.14	-0.65	-0.006	-1.21
d5	-0.139	**-1.58**	-0.28	-1.04	-0.004	-0.74
d6	-0.151	**-1.51**	-0.26	-0.83	-0.012	**-1.56**
d7	-0.139	-1.2	-0.26	-0.79	-0.018	**-1.55**
d8	-0.176	-1.43	0.04	0.15	0.009	0.79
Firm specific	Yes		Yes		Yes	
Year specific	Yes		Yes		Yes	
Observations	4339		1524		2815	
No of firms	525		301		363	
F-statistics	F(24,524)	0.51	F(21,300)	.	F(22,362)	3.13

Source: Author's estimates

Interestingly, there is no significant relationship between the size and financing type of the CDM projects on the one hand and fuel intensity on the other. However there is a cubic relationship between the firm size and fuel intensity. This suggests that the fuel intensity declines with firm-size up to a threshold level, beyond which it rises to another threshold before falling again with size. Within small firms (sales less than Rs 1000 million) the relationship turns out to be U-shaped with very small firm's upto a threshold level of sales having negative relationship with fuel intensity. Large firms (above the sales of Rs 1000 million) have a linear inverse relationship with fuel intensity.

Table 5: Fixed effect cluster-robust-VCE estimates of total factor productivity

	All firms		Firms with sales< = Rs. 1000 million		Firms with sales> Rs. 1000 million	
	Coef.	t	Coef.	t	Coef.	t
D_cdm	78.6	0.93	-413.6	-0.97	10.66	0.89
Sales	-705.3	-0.99	-119.0	-0.32	2.78	0.78
Sale2	37.2	1	-36.7	-0.77	-0.05	-0.4
d_size	143.4	1.06	359.4	0.76	3.45	1.01
d_unilateral	-119.9	-0.9	-870.9	-0.99	11.52	1.06
d0	-91.2	-1.23	-884.1	-1.01	-22.37	-1.01
d1	-97.9	-1.21	-898.3	-1.01	-22.39	-0.97
d2	-88.8	-1.19	172.2	0.8	-15.19	-1.04
d3	-6.4	-0.25	262.6	0.86	-13.62	-1.01
d4	-0.8	-0.03	267.2	0.85	-13.58	-1.03
d5	-1.4	-0.04	355.2	0.9	-13.51	-1.04
d6	8.6	0.21	442.9	0.91	-11.29	-1.04
d7	-0.3	-0.01	676.4	0.98	-10.87	-1
d8	52.0	0.66	0.0		-13.70	-1.02
Firm specific	Yes		Yes		Yes	
Year specific	Yes		Yes		Yes	
Observations	2924		803		2121	
No of firms	463		216		333	
F-statistics	F(23,462)	.	F(21,215)	.	F(23,232)	

Source: Author's estimates

Productivity effects: Productivity effects are negative in the initial years of CDM implementation perhaps due to high transactional costs and investment involved in the process. It turns positive in the later years in particular for the small firms. Interestingly, the productivity effects of CDM implementation on large firms remain negative for most years. However, the relationship remains insignificant statistically in all the cases. It could be because CDM projects constitute a small part of the overall operations of a company and hence are not likely to have significant impact on their overall productivity. The effect appears to be relatively more prominent for smaller firms where CDM projects may constitute a relatively larger component of the total business.

Table 6: Fixed effect cluster-robust-VCE estimates of export intensity

	All firms		Firms with sales< = Rs. 1000 million		Firms with sales> Rs. 1000 million	
ex_int	Coef.	t	Coef.	t	Coef.	t
d_cdm	**-0.015**	**-1.61**	-0.002	-0.10	**-0.023**	**-2.880**
Sales	0.002	0.25	0.003	0.39	**-0.065**	**-1.550**
Sale2	0.001	0.77	0.001	0.89	**0.004**	**1.800**
d_size	0.000	-0.01	-0.015	-0.75	0.005	0.440
d_unilateral	-0.009	-0.95	-0.001	-0.09	-0.012	-1.130
d0	0.004	0.57	0.021	1.12	0.003	0.400
d1	0.007	0.85	0.014	0.82	0.006	0.690
d2	0.012	1.28	0.012	0.72	0.013	1.250
d3	0.016	1.39	0.015	0.60	0.019	1.530
d4	**0.029**	**1.99**	0.028	0.74	**0.037**	**2.370**
d5	0.022	1.32	-0.010	-0.39	**0.032**	**1.770**
d6	0.028	1.46	0.017	0.58	**0.038**	**1.820**
d7	**0.033**	**1.62**	**0.051**	**2.42**	**0.041**	**1.850**
d8	0.078	1.54	0.022	1.00	0.087	1.490
Firm specific	Yes		Yes		Yes	
Year specific	Yes		Yes		Yes	
Observations	4506		1659		2847	
No of firms	544		320		367	
F-statistics	F(24,543)	3.23	F(22,319)	.	F(24,366)	2.59

Source: Author's estimates

Export intensity: Exports suffer in the initial years due to the gestation period involved. However in the long run exports of the implementing firms, in particular the large firms, are improved. Since productivity-enhancement effects are insignificant, it could be due to

- the goodwill that they generate for the adoption of the green processes
- better external integration, and
- improved organizational capabilities

Small firms are not found to have benefitted significantly in terms of their export performance. This is despite the fact that export intensity of smaller firms is not found to be significantly smaller than that of the large firms. This could be due to differential composition of the target markets. The large firms may be targeting the advanced countries' markets which are likely to have greater consciousness of the environment related issues. This may not be the case with the small firms.

Other project specific factors are found to be insignificant in determining the export enhancing effects of CDM implementation. However, d_unilateral turns negative in all the equations indicating that bilateral and multilateral projects are more effective in export enhancing effects.

7. Conclusions

It is normally believed that the contribution of the CDM to building technological capabilities in developing countries can at best be regarded as minimal. There are several concerns with technology transfer through the CDM expressed in the literature. These are listed below.

- The rate of technology transfer through the CDM has fallen over time.
- Technology transfer through the CDM prevails in a few sectors, and bypasses others.
- The CDM, while contributing to individual project level technology transfer, has been incapable of encouraging more widespread policy support for technology transfer.
- Technology transfer through the CDM often means import of foreign equipment which does not improve technological understanding and capacity to innovate in developing countries
- Technology transfer in the CDM cannot be consistently monitored because there is no common definition of what is considered technology transfer.
- Given that the core objective of a project participant in a CDM project is to generate carbon credits in a cost-effective manner the project participants may, in general, be expected to look for knowledge elements in any technology import deal only to the extent necessary for successful operation of the project concerned.

Overall, most studies conclude that the role of CDM in building absorptive and technological capabilities has remained limited. They rely primarily on the data collected from Project Design Document (PDD) claims. The analysis based on the ex-ante information cannot be considered completely reliable. Some studies are based on the data collected through primary surveys. This information is based on the perception of the respondents and may not be accurate. Further technology transfers are in general equated with technology absorption and building up of technological capabilities. But the former may not always result into the latter. To improve the understanding of the CDM’s real contribution to technology transfer therefore it is important that there is a rigorous analysis of pre- and post- performance of the firms in terms of the indicators of technological capability. This study has identified these indicators on the basis of the existing literature and used the balance sheet data of CDM and Non-CDM firms to analyse the differential performance of the CDM and Non CDM firms in the pre- and post- CDM implementation periods.

Our results are as follows.

- The CDM involvement does benefit the implementing firms in terms of technological capability. It results in greater R&D, lower fuel intensity and improved export performance. The total factor productivity does not significant enhancement.
- The benefits are not necessarily equitably distributed. Large firms are expected to benefit more than the smaller ones.
- Further, while the impact on domestic R&D efforts is almost immediate, performance indicators respond with a time lag.
- In general, bilateral/multilateral and large CDM projects are more likely to benefit the implementing firms. However, the difference is found to be significant only for large firms and in terms of local R&D efforts after controlling the effects of the main variables.

Overall, there is evidence that CDM implementation has an immediate influence on the local R&D efforts in particular by large CDM implementing firms. In the long run, firms' performance in terms of fuel efficiency and integration with the world market is also improved. This demonstrates the dynamic capability enhancing effects of CDM implementation. However, the results are weak and do not indicate sustained improvement in the performance of firms. Therefore, there is a need to give the CDM a more explicit agenda of technology transfers. But this alone may not address the issues involved in technological up-dation of the host firms. There is a need for more attractive environment for investors through climate friendly policies, target setting and removed barriers to technology transfer. In sum, this paper supports the conclusion reached by the CDM Policy Dialogue (p.25): "The CDM is a valuable tool that – with appropriate reforms that are the subject of the remaining recommendations in this report – should be retained and scaled up to enhance the cost-effectiveness of, and to promote, global mitigation activities".

REFERNCES

Aggarwal, A., 2000. Deregulation, technology imports and in-house R&D efforts: an analysis of the Indian experience. Research Policy, vol. 29 (9). Elsevier Science, North Holland, pp. 1081–1093.

Aggarwal A. (2011) South-South Cooperation in Technology Transfers and the Clean Development Mechanism: Some explorations Tech Monitor, May-June, 2011, pp: 37-47

Basant, R., 1997. Technology strategies of large enterprises in Indian industry: some explorations. World Development 25 (10), 1683–1700.

Blackman A., 1999. The Economics of technology diffusion: implications for climate policy in developing countries, Discussion Paper 99-42, Resources For the Future, Washington DC.

Blumenthal, T., 1979. A note on the relationship between domestic research and development and imports of technology. Economic Development and Cultural Change 27 (2), 303–306.

CDM Policy Dialogue (2011) Climate change,carbon markets and the cdm: a call to action Report of the High-Level Panel on the CDM Policy Dialogue, accessed from http://www.cdmpolicydialogue.org/report/rpt110912.pdf on 5 may 2014.

Chatterjee B. (2011) Briefing paper "Technology Transfer through the Clean Development Mechanism (CDM)" AEA Technology Study on the Integrity of the Clean Development Mechanism ED56638 Issue Number 1 December 2011 Centre for European Policy Studies and Stockholm Environment Institute

Cohen and Levinthal (1989), "Innovation and learning: The two faces of R&D", *The Economic Journal*, Volume 99, September pg. 569-596

Cooper, 1994. Relevance of innovation studies to developing countries. In: Cooper, C._Ed.., Technology and Innovation in International Economy. Edward Elgar, UN Univ. Press, pp. 1–37.

Das, K. (2011); Technology Transfer under the Clean Development Mechanism: An Empirical Study of 1000 CDM Projects; The Governance of Clean Development Working Paper Series 014 – July 2011; Economic and Social Council Research and University of East Anglia; UK.

De Coninck, H.C., F. Haake and N. van der Linden. 2007. Technology Transfer in the Clean Development Mechanism. Climate Policy. 7(5): pp.444-456.

Dechezleprêtre et al., (2008); "The Clean Development Mechanism and the International Diffusion of Technologies: An Empirical Study", *Energy Policy;* Vol. 36; pp. (1273–1283).

Dechezleprêtre, A., Glachant, M., Ménière, Y., (2007). The North-South Transfer of Climate-Friendly Technologies through the Clean Development Mechanism, Cerna, École des Mines de Paris, available at http://www.cerna.ensmp.fr/Documents/AD-MG-YM-ReportMDM.pdf

Deolalikar, A.B., Evenson, R.E., 1989. Technology production and technology purchase in Indian industry: an econometric analysis. The Review of Economics and Statistics 71 (4), 687–692.

Doranova Asel (2009) Technology transfer and learning under the Kyoto regime : Exploring the technological impact of CDM projects, PhD dissertation, UNU-Merit Maastricht University

Doranova Asel, Costa Ignara, Duysters Geert (2009). Knowledge Base Determinants of Technology sourcing in the Clean Development Mechanism Projects, Working paper series 29, United Nations University, Maastricht.

Dunning, J.H., 1993. Multinational Enterprises and the Global Economy. Addison-Wesley, Reading.

Egenhofer, C., L. Milford, N. Fujiwara, T. Brewer and M. Alessi (2007), *Low carbon Technologies in the Post-Bali Period: Accelerating their Development and Deployment*, ECP Report No. 4, presented at COP/MOP, Bali, Indonesia on 7 December 2007, European Climate Platform (ECP). Brussels.

FICCI (2012) Impacts, Governance and Future of CDM (Indian Industry perspective), Federation of Indian Chambers of Commerce and Industry (FICCI), New Delhi, India

Fikkert, B., 1993. An open or closed technology policy? The effects of technology licensing, foreign direct investment, and technology spillovers on R&D in Indian industrial sector firms. Unpublished Ph.D. Dissertation, Yale University, New Haven, CT.

Haites, E., Duan, M., Seres, S. (2006). Technology Transfer by CDM Projects. Climate Policy 6(3): pp.327–344.

Hansen, U.E. (2011) An empirical case study of the transfer of GHG mitigation technologies from Annex 1 countries to Malaysia under the Kyoto Protocol's clean development mechanism (CDM), International Journal of Technology Transfer and Commercialisation, 10 (1), 1-20

IGES CDM Project Database provided by Institute for Global Environment Strategies (IGES)

IPCC (2000): *Methodological and Technological Issues in Technology Transfer*, Cambridge, UK and New York, Cambridge University Press.

IPCC, 2007: Intergovernmental Panel on Climate Change Fourth Assessment Report: Climate Change (2007)

Krey, M (2004). Transaction Costs of CDM Projects in India: An Empirical Survey. HWWA-Report No. 238, Hamburgisches Welt-Wirtschafts-Archiv (HWWA), Hamburg Institute of International Economics.

Katrak, H., 1997. Developing countries' imports of technology, in house technological capabilities and efforts: an analysis of the Indian experience. Journal of Development Economics 53, 67–83

Kumar N. and Aggarwal A. (2005) Liberalization, outward orientation and in-house R&D activity of multinational and local firms: A quantitative exploration for Indian manufacturing, Research Policy 34 (2005) 441–460

Kumar, N., Saqib, M., 1996. Firm size, opportunities for adaptation, and in-house R&D activity in developing countries: the case of Indian manufacturing. Research Policy 25 (5), 712–722.

Kumar, N., Siddharthan, N.S., 1997. Technology, Market Structure and Internationalization: Issues and Policies for Developing Countries. Routledge and UNU Press, London and New York.

Kumar, N., 1987. Technology imports and local research and development in Indian manufacturing. The Developing Economies 25, 220–233.

Kwanghui L. and M. R. Falk (2013). Absorptive Capacity. In Mie Augier and David J. Teece (Eds.), The Palgrave Encyclopedia of Strategic Management. Palgrave Macmillan Publishers Ltd,

Lall, S., (1983). Determinants of R&D in a LDC: the Indian engineering industry. Economics Letters 13 (4), 379–383.

Lall, S. (1992) Technological Capabilities and Industrialization, 20 World Development. 165, 166 (1992)

Lema A. and R. Lema (2013) Technology transfer in the clean development mechanism: Insights from wind power Global Environmental Change 23 (1), 301-313

Lütken and Michaelowa, (2008). Corporate strategies and the clean development mechanism: Developing County financing for developed count commitments; Edward Elgar, UK

Markusen, J. 1995. "The Boundaries of Multinational Enterprises and the Theory of International Trade." Journal of Economic Perspectives 9: 169-89.

Maskus, K. E., (2004). Encouraging international technology transfer, UNCTAD/ICTSD Issue Paper, Geneva.

Mowery, D.C. and Rosenberg, N. (1989). Technology and the Pursuit of Economic Growth. Cambridge University Press, Cambridge, UK.

Nelson, R. R. and winter, S. J. (1982). An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge, Mass.

Niederberger, A.A., Saner, R., (2005). Exploring the relationship between FDI flows and CDM potential. Transnational Corporations 14, 1–41.

Ockwell D. G., Watson J., MacKerron G., Pal P., Yamin F., (2008). "Key policy considerations for facilitating low carbon technology transfer to developing countries," Climate Policy, in press.

OECD/IEA, (2001). Technology without Border: Case studies in successful technology transfer, OECD/IEA, Paris hal-00437547

Olsen, K. H. (2007). The Clean Development Mechanism's Contribution to Sustainable Development: A Review of the Literature. Climatic Change, 84, 59–73.

Patel, P., Pavitt, K., (1994) Patterns of technological activity: their measurement and interpretation. In: Stoneman, P._Ed.., Handbook of the Economics of Innovation and Technical Change. Blackwell, Oxford.

Pietrobelli, C. 2000. Technology transfer for developing countries. In: Schroeer, D., Elena M. (Eds.), Technology Transfer. Ashgate, Aldershot.

Robinson, R.D., 1988. International transfer of technology: theory.In: Issues and Practices. Cambridge Ballinger

Saner, R. (2005), "Hype or Reality: Can the CDM trigger FDI?" ECP Background Paper # 2 (downloadable at: http://www.ceps.be/Article.php?article_id=485).

Schneider, M., A. Holzer and V. Hoffmann (2008). Understanding the CDM's Contribution to Technology Transfer. Energy Policy. 36: pp.2930– 2938.

Sepibu, J.D. (2009) Reforming the clean development mechanism for technology transfer, Swiss national centre for competency in research. Working Paper No 2009/42

Seres S., Haites. E., (2008), Analysis of technology transfer in CDM Projects, Prepared for UNFCCC Registration & Issuance Unit CDM/SDM.

Seres, S., (2008). Analysis of Technology Transfer in CDM Projects, Prepared for the UNFCCC Registration & Issuance Unit CDM/SDM, Bonn. http://cdm.unfccc.int/Reference/Reports/TTreport/TTrep08.pdf

Seres, S. (2007). Analysis of Technology Transfer in CDM Projects. Bonn: UNFCCC Secretariat.

Siddharthan, N.S., 1988. In-house R&D, imported technology and firm size: lessons from Indian experience. Developing Economies 26, 212–221.

Siddharthan, N.S., 1992. Transaction costs, technology transfer, and in-house R&D: a study of the Indian private corporate sector.Journal of Economic Behaviour and Organization 18, 265–271.

Teece, D.J., 1977. Technology transfer by multinational firms — the resource cost of transferring technological know how. Economic Journal 87, 242–261.

UN, 1997: Ranking procedures for environment, especially the ISO's series 14000: its effects for trade and investments in developing countries. Board for Trade and Development. TD/b/COM.1/EM.42.

UNCTAD (2010) Investing in low carbon economy, World Investment Report, United Nations, New York and Geneva

UNFCCC (1992). United Nations Framework Convention on Climate Change. FCCC/INFORMAL/84.

UNFCCC (2010); The contribution of the Clean Development Mechanism under the Kyoto Protocol to technology transfer; Available at: http://cdm.unfccc.int/about/CDM_TT/index.html

Wang B, (2009) Can the CDM bring technology transfer to developing countries? An empirical study of technology transfer in China's CDM projects. The Governance of Clean Development Working Paper 002 – August 2009

Yang, Z., (1999). Should the north make unilateral technology transfers to the south? North–South cooperation and conflicts in responses to global climate change, Resource and Energy Economics 21, 67–87.

Youngman, R., Schmidt, J., Lee, J. and De Coninck, H. (2007) Evaluating technology transfer in the Clean Development Mechanism and Joint Implementation, Climate **Climate Policy , 7(6) 2007 Special Issue: Technology transfer and investment risk in international emissions trading**

Zahra, S.A. and G. George. (2002), "Absorptive Capacity: A Review,Reconceptualization,and Extension", *Academy of Management Review*,Volume 27, Issue 2,pg.185-203

Zawislak, P.; Alves, A.; Tello-Gamarra, J.; Barbieux, D.; Reichert, F. (2012) Innovation capability: from technology development to transaction capability. Journal of Technology Management and Innovation, v. 7, n. 2, p. 14-27, 2012.