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ABSORPTIVE CAPACITY IN TECHNOLOGICAL LEARNING IN CLEAN DEVELOPMENT MECHANISM PROJECTS

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Abstract: Technology transfer in Clean Development Mechanism (CDM) projects of the Kyoto Protocol has become one of the important issues addressed both in policy agenda and by academic scholars. In many CDM project host countries, technology transfer is among the key provisions of sustainable development objectives of the CDM projects. This study is an effort to investigate CDM projects' related technology transfer process from the organizational learning perspective. The prerequisite for successful technology transfer and organizational technological learning is to foster technological capabilities (TC) of an organization. In this study we used data from our survey of the CDM project host organizations in four largest CDM host countries India, Brazil, Mexico and China. We assessed TC building progress and studied various characteristics of the organizations. The present paper focuses on absorptive capacity related determinants of technological capability building in the CDM projects. Absorptive capacity is a multidimensional concept thus we investigated the effect of the dimensions such as prior knowledge, personnel qualification, and training efforts. A strong positive association was established between prior knowledge and TC building; and less for qualification variable. Besides we proved a curvilinear relationship between prior knowledge and TC building outcomes.

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1 Introduction

Technology transfer in Clean Development Mechanism (CDM) projects of the Kyoto Protocol has become one of the important issues addressed both in policy agenda and by academic scholars. In many CDM project host countries, technology transfer is among the key provisions of sustainable development objectives of the CDM projects. The foremost concern of a technology transfer initiative is building technological capabilities and a knowledge base which is crucial for sustainability of results of the project comprising this transfer. The success of a project and particularly of its technology transfer component depends to a large extent on various internal resources and capabilities of a company implementing the project. Knowledge resources being the major contributor to the organization's ability to assimilate new technology and knowledge are therefore a key aspect in successful technology transfer.

CDM projects are a relatively new phenomenon in traditional markets; they have rather unusual incentives for their initiation (carbon credits), involve only certain industrial sectors, and involve "green" technologies that are often nor widely diffused. While having certain specificities, CDM projects from the view of technical implementation, follow similar stages as many other new projects initiated by a company. Therefore the technology transfer and associated learning processes in these projects also are expected to follow common patterns of traditional processes. In addition, it is necessary to note that the focus of our analysis is the *organization* hosting CDM projects. In this regard in our attempt to explain the technological learning process under the CDM project experience we can benefit from organizational theory, particularly from the sub-area on organizational learning. Moreover, the combination of organizational learning literature with the literature on international technology transfer can give perspectives that would be interesting both for policy makers as well as for business managers (Cusumano and Elenkov, 1994). Nevertheless we have to bear in mind the specificities of the CDM project case in the interpretation of the study results and drawing theoretical and policy implication.

The technology transfer process is essentially considered as a knowledge accumulation process. Gupta and Govindarajan (2000) disaggregate this process into knowledge creation, acquisition, and retention, while Davenport and Prusak (2000) suggested that the knowledge transfer process consists of transmission and absorption, culminating in a behavioral change by the recipient. Many authors recognize the lack of absorptive capacity in the recipient as a friction, which slows or prevents transfer (Whangthomkum et al, 2006; Lin *et al*., 2002; Davenport and Prusak, 2000; Kim, 1997; Wong *et al*., 1999). Cohen and Levinthal (1989, 1990) in their seminal work highlighted the fact that organizations cannot benefit from external knowledge flows just by being exposed to them; instead, they must develop absorptive capacity, which authors define as the ability to recognize the value of new external knowledge, and then assimilate and utilise such knowledge for commercial ends. A firm's absorptive capacity builds on its existing stock of knowledge, much of which is embedded in its products, processes and people (Cohen and Levinthal, 1989), and it has become a key driver of a firm's competitive advantage because of the increased importance of external knowledge sourcing (Cockburn and Henderson, 1998; Zahra and George, 2002; Escribano *et al.* 2008).

An organization's technological knowledge can be represented by a bundle of technological capabilities indicating its competence in implementing certain functions and activities. Thus we interpret organizational technological learning as a technological capability building process and use these terms as synonyms in this study. The literature has offered a number of taxonomies of firm-level technological capabilities (e.g. Lall, 1992; Bell and Pavitt, 1993; Figueiredo, 2001) that were adopted by us in the survey of CDM project host organizations. In this survey we assessed technological learning outcomes of CDM project experiences and collected a range of data about these organizations. The present paper applies these data in addressing the following research question: how does the project host organization's absorptive capacity -represented by its prior knowledge, human resources, and training efforts- explain technological learning dynamics resulting from CDM projects? Furthermore we considered factors, such as characteristics of a technology acquirer organization, that may determine learning outcomes. We also investigated the exogenous effect of institutional factors working as an enabling environment for building organizational absorptive capacity and technological learning.

The academic contributions of this study are the following. The existing literature on technology transfer in CDM has a rather limited number of empirical studies[1] which have not managed to address technological learning issues deeply. Hence, the present study is a contribution in filling this gap, by applying unique and more comprehensive data collected through the survey of CDM project hosting companies. It is also necessary to note that in the family of studies focused on CDM, the present work is rather novel in its approach in studying the technology transfer issue by application of organizational theory and technological learning perspectives. By bringing concepts of technological capabilities and absorptive capacity, it enriches the CDM related literature conceptually and methodologically. On the other hand by bringing the example of CDM project implementation, it contributes to the empirical literature linking absorptive capacity phenomena with organizational learning and investigates in what manner this relationship works.

The paper is organized as follows. The next section presents a theoretical background in discussing the position of organizational learning literature towards technology and knowledge transfer, and elements of absorptive capacity as the determinants and develops a relevant hypothesis. The methodological part presents definitions of variables, data, and econometric methods. Further we present results of econometric analysis. The paper concludes with a discussion of results and implications for further research.

2 Theory and hypotheses

2.1 The role of absorptive capacity in technological learning

Ever since the introduction of the absorptive capacity concept by Cohen and Levinthal (1989; 1990) the literature stream on absorptive capacity has been growing. The concept has been used in studies of national innovation systems, economics growth, and international technology transfer (e.g. Mowery and Oxley, 1995; Keller, 1996; Liu and White 1997); though it found much wider application in the organizational learning literature, studying this phenomenon in firms, as well as in the interorganizational (dyadic and networks) contexts (e.g. Szulanski, 1996; Lane and Lubatkin, 1998; Kim, 1997).

The definition of absorptive capacity operationalized in the organizational theory was proposed by Cohen and Levinthal (1990) and further augmented by Lane *et al*., 2001; Zahra and George, 2002; Van Den Bosch *et al*., 2005. It refers to the firm's ability to recognize the value of external technology, knowledge, and information; to identify and acquire the new technology; to assimilate it, and to apply or exploit the new technology for commercial ends. There is a large number of studies showing the importance of absorptive capacity in improving firm's performance (e.g. Levinson and Asahi, 1995; Mowery et al., 1996). Many authors have proposed that absorptive capacity is the foundation for technological learning and eventually for innovation within an organization (Kedia and Bhagat, 1988; Fu and Shi, 1995; Veugelers and Cassiman, 1999) as well as in technological alliances (e.g. Lane and Lubatkin, 1998; Simonin, 1999; Ahuja and Katila, 2001). A quite commonly accepted assumption in many studies has been that learning and absorptive capacity co-evolve by influencing each other. This would appear applicable also for the case of technology transfer projects as learning is its crucial component.

Few authors who have done empirical studies on technology transfer projects in various industries, addressed the role of absorptive capacity in effectiveness of technology transfer (e.g. Lin *et al.*, 2002; Daghfous, 2004; Whangthhomkum *et al.*, 2006). Although these authors had diversified definitions of technology transfer outcomes, each definition largely captured elements of knowledge transfer and learning. This makes them comparable among each other, as well as makes relevant references for our study. The general agreement in these studies has been that successful technology transfer entails much more than the mere acquisition of physical assets, and

[1] To the best of our knowledge there is only one case-study that investigated knowledge transfer processes, technological capability building and spillover impacts in four CDM projects based in Malaysia (Hansen, 2008).

the recipient's lack of absorptive capacity can result in a poor transfer. Lin *et al* (2002) established that such factors as the type of technology, the transfer channels and the R&D processes will not be able to successfully support a firm without strong absorptive capacity, in its technology transfer performance. The study by Whangthhomkum *et al.* (2006) was focused on investigating relationships between dimensions of technology transfer performance and elements of absorptive capacity, thus excluding other internal and external factors from their analytical model. The finding was that effectiveness of technology transfer is related to all elements of absorptive capacity positively, but not all to the same degree. For example Daghfous (2004) studied the influence of prior knowledge and learning efforts (which are important components of absorptive capacity) on effectiveness of technology transfer projects and found a positive effect in both cases, however the effect of prior knowledge was weaker in comparison with factors associated with learning efforts.

Furthermore, few conceptual papers from the technology transfer stream have discussed the absorptive capacity as one of the determinants of successful technology and knowledge transfer (e.g. Cusumano and Elenkov, 1994; Dunning, 1994). Among the critical remarks from these papers is that absorptive capacity is a necessary condition to a successful technology transfer but not an alternative to it.

Thus in the literature the positive influence of absorptive capacity on technological learning outcomes has been well established. However, the singled out impacts of its dimensions has been rather under-investigated. Absorptive capacity, being a complex factor, represents company's knowledge accumulated through its experience and training, and residing in its employees (Cohen and Levinthal, 1990; Zahra and George, 2002; Van Den Bosch, 2005). In our study we acknowledge this multidimensional feature of absorptive capacity. We consider its dimensions such as prior knowledge, human capital, and training efforts, and investigated their individual influence on technological learning results of CDM projects. Previously, the independent impact of each of these components has not been investigated. Often authors use just one of the above mentioned components as a proxy of absorptive capacity, although in survey based studies the measurement of it was done through multiple indicators which were further put into one factor (e.g. Daghfous, 2004; Whangthomkum *et al.*, 2006; Bohn, 1993).

In this paper we also follow the insights from the studies discussing the role of knowledge resources heterogeneity in knowledge transfer between two units or organizations (Szulanski, 1996; Lane and Lubatkin, 1998; Ahuja and Katila, 2001), as well as technological distance (Noteboom, 1992, 1999) and technological overlap (Mowery et al. 1996; Kim and Inkpen, 2005). These studies address learning and innovations in dyads of technological partners and argue that the relationship between technological distance/overlap and learning outcomes is non-linear, or of inverted U-shape character. Following these studies one can expect that the highest learning results, and the best appropriation of the technology is achieved in cases where the technology recipient companies already have some prior knowledge about the technology, rather than having no knowledge or being completely familiar with the technology. Furthermore we also distinguish between prior knowledge related to earlier experience with technology application and/or development, and those related to prior experience with CDM projects. The last aspect is conditioned by the fact that it is a study based on a CDM project case.

2.2 Hypotheses

Prior knowledge and technological distance

Innovation and technological change literature frequently has noted that the technological process can not be improved if it is not well understood (Yeung and Ulrich, 1994) and that it is crucial that the company possesses relevant and knowable information before starting to address uncertainty in production and innovation activities (Daghfous, 2004; Daghfous and White, 1994). A similar argument holds for technology transfer projects. The technology can not be successfully transferred if the recipient is not able to understand the processes it is based on. Having the knowledge based on training or acquisition of codified knowledge is usually not enough, therefore experience with a similar technology leads to a faster and more efficient transfer and appropriation of it.

In this regard, Cohen and Levinthal (1990) referred to memory development, in which accumulated prior knowledge enables the ability to store new knowledge into one's memory and to recall and use it. This process grounds the key notioa n of absorptive capacity which stipulates that prior related knowledge facilitates the learning or absorption of new related knowledge. Correspondingly, Cohen and Levinthal (1990) argued that the ability to evaluate and utilise outside knowledge is largely a function of the level of prior related knowledge.

Inkpen (2002) summarised that the acquisition of knowledge is a cumulative process, meaning knowledge builds only on the knowledge that is already there. Similarly Powell et al (1996) argued that knowledge facilitates the use of other knowledge and what can be learned is crucially affected by what is already known. Grant (1996) and Dyer and Singh (1998) also showed in their studies that learning performance is enhanced when the object of learning is related to what is already known and when there is a common language as the basis for interpreting experience. While studying internal knowledge transfers, Szulanski (1996) found that the ability of the recipient unit to value and apply new knowledge was critical for successful transfers. Lane and Lubatkin (1998) introduced a dyad-level construct which they called 'relative absorptive capacity' and empirically proved its positive effect on inter-organizational learning. In their approach they added the similarities in compensation practices and organizational structures, as well as the knowledge/technology recipient or buyer firm's familiarity with the technology seller firm's set of organizational problems, to prior related knowledge. Prior knowledge has also been explored in such contexts as entrepreneurship and technological innovation. For instance, Shane (2000) found that prior knowledge of entrepreneurs plays a significant role in the number of opportunities that they discover following a technological change.

Based on the theoretical findings described above, one would expect that companies having experience with the technologies applied in CDM project before initiating the actual project, would be more progressive in their technological capability building. Similarly it is expected that companies that are implementing more CDM projects would have better experience and knowledge in project related activities, including the technology component. Therefore we hypothesize that:

(H1a) The recipient's prior level of knowledge about relevant technology positively influences technological learning outcomes of CDM projects

However, studies emerged in the 1990's on technological distance and technological overlap have suggested that the relationship between learning results and prior knowledge in dyadic technological contracts is more complex than just linear (Noteboom, 1992, 1999; Mowery *et. al* 1996, 1998). They argue that a small difference in the technological knowledge bases of two companies (in other words small technological distance or large technological overlap) does not result in a great deal of learning, as there is not much to learn from each other. In a technology provider-recipient dyad this would translate into a case in which the recipient is largely familiar with the technology delivered by the provider and therefore no big dynamics in learning is expected. Furthermore, knowledge transfer has been found to occur to a lesser extent also in the case of a very large difference (or dissimilarity) in levels of knowledge of two partner companies. This recalls the main idea of the absorptive capacity concept explaining why a company that has very small or no prior knowledge in a certain area would not be able to absorb more sophisticated knowledge in this area. The most fruitful learning takes place in the case of a certain level of difference in knowledge base that allows companies to understand and absorb the knowledge from each other. This difference is referred to as the optimal technological (or cognitive) distance. Thus the relationship between the technological distance and technological learning results can be graphically shown as an inverted U-shaped function. In similar vein several studies have found that for effective knowledge transfer, partners need to have a balance of similarity and dissimilarity in their knowledge bases (Szulanski, 1996; Lane and Lubatkin, 1998; Ahuja and Katila, 2001).

These observations have the following implication for the case of technological learning in CDM projects: the company's prior knowledge, being a determinant of technological distance between technology recipient and supplier companies would also have an inverted U-shaped relationship with learning outcomes of CDM project related technology acquisition processes. In other words we can expect that technology recipients with no or very small prior knowledge would not be able to efficiently benefit in terms of learning as they would miss absorptive capacity, while the ones having very extensive prior knowledge in technology and CDM projects would not gain much new knowledge. The group in the middle, with a balanced (optimal) level of prior knowledge, would have the largest gain in learning.

Thus we hypothesize that:

(H1b) In CDM projects technological learning is an inverted U-shaped function of a recipient organization's prior knowledge level

Another distinction has to be made in the quality of prior knowledge, which would have an implication on absorptive capacity of the learner and consequently on the learning outcomes of the CDM project. The technological capabilities literature distinguishes between innovative and production capabilities (Lall, 1992; Bell and Pavitt, 1993), assigning the quality of 'advanced' to the prior and 'basic' to the latter. Technological learning (which is also defined as a capability building process) is an evolutionary self reinforcing, path-dependent process, in which the level of learning or technological capability building results, depends on the level or quality of pre-learning technological capabilities (Figueiredo 2003).

Qualification of personnel

An organization's absorptive capacity is related to the ability of its individual employees to assimilate, process and transform external knowledge flows. Therefore the human capital definition of absorptive capacity has found frequent application in empirical studies. The definition of absorptive capacity proposed by Mowery and Oxley (1995:70) is the one having the human capital in its focus '…a broad array of skills, reflecting the need to deal with the tacit component of transferred technology, as well as the frequent need to modify a foreign-sourced technology for domestic application'. Among measurements of the human capital dimension of absorptive capacity are investment in scientific and technical training and the number of scientists and engineers (Mowery and Oxley, 1995; Keller, 1996), and the number of doctorates within the R&D department (Veugelers, 1997).

Zahra and George (2002) who provided a comprehensive review of key dimensions of the absorptive capacity construct noted that its human capital dimension received recognition in studies on firm level, as well as in studies addressing national level technology transfer deliberates (Glass and Saggi, 1998; Keller, 1996; Kim and Dahlman, 1992; Luo, 1997; Veugelers, 1997). The assumption applied in these studies is that companies and countries with a higher number of technical and managerial experts would be able to absorb, utilize and improve an acquired technology faster and more effectively because qualification of these personnel allows them to understand the principles behind the functioning of this technology. In organizational knowledge management literature a noteworthy consideration is given to tacit knowledge as an important supplement to codified knowledge in maintaining an effective knowledge base of a company (Jensen *et al,* 2007). The central point is that tacit knowledge is a form of knowledge that is highly personal and deeply rooted in individual experiences, ideas, values and emotions (Gourlay, 2006).

In regards to technological knowledge, engineers and technical personnel form the core of the company's technological knowledge base, and are carriers of the organization's tacit knowledge. While acquiring new technology, as is in the case of CDM projects, it is particularly important to have employees with engineering and technical qualification and experience, as they are carriers of tacit knowledge allowing them to understand the technology, adjust and improve it, and to utilize it to full efficiency. Hence, they are an important element in a company's overall absorptive capacity. Thus for the CDM related knowledge transfer and competence building the role of human resources is expected to be important:

(H2) A higher representation of human resources such as engineers and technical personnel in an organization is positively associated with more dynamic technological learning in CDM projects

Training efforts

Kim (1998) identified that the intensity of effort to increase prior knowledge is one of the essential determinants of a firm's absorptive capacity. Training of employees is a crucial element of learning activities aimed at improving the technological and managerial knowledge of employees, which in turn contributes to better absorptive capacity of the whole company. As a general practice most successful companies develop individual and group skills and knowledge by promoting learning at every level and making the competency acquisition a part of the company's business strategy (Nevis *et al.*, 1995). The acquirement of cutting-edge and relevant knowledge accelerates teams' and individuals' capability to assimilate more new knowledge and subsequently develop innovative products and processes (Cohen and Levinthal, 1990).

The acquisition of new technology is often complemented with training, on job coaching, and instructing by the technology supplier which is usually aimed at teaching about how to operate the acquired technology. In this way it assures acquisition of new knowledge related to completely new or renewed functions. Training, being the interactive form of knowledge delivery has a big advantage over delivery of paper manuals or guidelines, because during the interactive training a lot of tacit knowledge and information is made available to the knowledge recipient (Leonard-Barton, 1995; Jensen et al, 2007).

It is important to distinguish purpose and scope of the training activity, as this can define its learning impact. As a common case the knowledge delivered through training,, complementing new technology, contributes to the formation of basic technological capabilities, such as the capability to operate a technological/production process, assure quality control, do preventive maintenance, debugging and adjustments of the equipment to the local conditions or to the technological line (Lall, 1992). Training can help not only in proper utilization of the technology, but also to gain a better understanding of processes on which the technology is based, which might give possibilities for further improvement and efficiency increase. Hence, there are chances that more profound technological capabilities make incremental innovation possible (e.g. equipment stretching, efficiency improvement and cost saving, adaptation of process by introducing changes). However the training delivered along with new machinery is usually rather narrow in its scope, as it is specifically aimed at teaching how to operate the technology, therefore its contribution to the building of advanced innovative skills, such as design of facility or/and equipment or turnkey project design might be weaker in comparison to basic and intermediary capabilities. Based on these considerations we hypothesize that:

> *(H3) Training delivered by the technology provider contributes more to the building of basic technological capabilities and less to the advanced capabilities of the CDM project recipient organizations.*

3 Methods

3.1 Data collection

The present study is based on data collected through the survey of CDM project host companies which are the unit of analysis. Analysing micro-level impact of the CDM projects in terms of technological learning, of understanding the importance of characteristics of project recipients required us to collect specific information and data that are not available in project documents and any other sources. In studying the learning impact of the CDM projects it is more logical to contact companies that are beyond the stage of installation, and have already started day-to-day operation of the CDM facilities. Since the number of projects was constantly increasing, we decided to restrict our sample to the number of projects that had been registered by February 2007. In this way we tried to approach projects that had a higher probability of being on the advanced stage of the project realization.

The focus of the survey was on the four countries that are involved in about 70% of all CDM projects: Brazil, China, India, and Mexico. They gave us a total of 380 projects. Examination of documentation of these 380 projects revealed several cases when two or more CDM projects were run by the same company. This fact tells us that the number of operators, our potential respondents, is less than the number of facilities. Preliminary estimates of the number of operators gave us the sample size of 361 companies with the following distribution across the four countries: 88 in Brazil, 153 in India, 48 in China, and 72 in Mexico.

The survey preparation process involved a number of activities including design of the questionnaire, consulting with experts, choosing a method of questionnaire distribution, preparation of the address list, testing questionnaire in pilot survey stage, after test improvement, surveying, and activities for increasing the response rate. In the survey process the respondents were contacted by electronic letter and/or phone-call inviting them to take part in the survey followed by e-mail containing a link to the online questionnaire, a unique ID and a password and the attached the questionnaire file.

Excluding the not-responded questionnaires and the ones that had incomplete answers, we acquired a final dataset containing 104 observations, representing a 28.8% response rate. Non-response analysis, which is required to have in dealing with data collected from this type of surveys, showed that the working sample is quite representative of the initial population and can be used without much statistical bias for further analysis.

3.2 Definition of variables

In our study we describe the technological learning or capability building level as a discrete outcome typical of a qualitative dependent variable model. We model the probability of increase in a certain level of technological capability as a function of a set of explanatory factors measured via independent and control variables described below. Both, dependent and independent variables used in the econometric analysis in this paper are based on the data collected during the survey.

Dependent Variable: Technological Capability Building

Our study aims to measure the impact of the experience with CDM projects on companies' technological capabilities level, and further to investigate determinants of it. The technological capability building level is the dependent variable in our econometric model. In defining and examining the technological capabilities we distinguish between companies' abilities to use and operate technologies (day-to-day operation, or basic capabilities), abilities to implement more creative work such as stretching equipment, improving efficiency and cost-cuts by introducing novelties in the production process (process improvement, or intermediate capabilities), and abilities to implement designing machines, production technologies, and turnkey facilities which require more sophisticated R&D expertise (innovation or advanced capabilities). The complete list includes ten types of technological capabilities, four of which belong to the group of operational capabilities, three to the process improvement capabilities, and the other three to innovation capabilities.

To capture the technological capability building impact of experience with CDM projects, the respondent was asked to assess this impact on each of ten capabilities using a Likert-type scale ranging from 0 (zero impact) to 6 (very high impact). It was important for us to capture the technological capability building dynamics for each of the three groups as we wanted to see how CDM related experience influences building of simpler and more sophisticated groups of capabilities. Therefore the final dependent variables *basicTC, intermediateTC* and *advancedTC* were constructed by taking a simple arithmetic mean for each of the three groups. This is also justified by high correlation (>0.85) among variables within each of the three groups and by the factor analysis which showed that variables within each of these groups fall into one factor.

Independent Variables

Prior experience proxies.

Following the hypothesis about the relevance of a company's absorptive capacity for technological capability building under the CDM project we defined the independent variables that refer to absorptive capacity. The first is the *relevant prior experience* that we tried to measure by asking if the company had certain technological capabilities before CDM experience. Most studies following Cohen and Levinthal (1990), have considered the level of prior related knowledge as the determinant of absorptive capacity. In our study we determined relevant prior knowledge by asking if the CDM host companies already had any of the ten described above capabilities prior to CDM experience. Existence of the capabilities would obviously be associated with prior experience. Thus the variable will be the indicator of one of the dimensions of absorptive capacity. By taking the average of all ten capabilities we obtained the unified variable *previousTC* which is a continuous variable ranging between 0 and 1. Given the prediction for an inverted U-shaped relationship between prior knowledge and learning outcomes, in our regression model we include both prior knowledge variable and its squared term as a second order measure. However these two variables showed a high correlation between each other. Therefore to reduce the possible multicollinearity between the single term and squared term, we used the squared term of a deviation from the mean and obtained the variable $previousTC^2$.

Another indicator that captures the prior experience component of absorptive capacity is a CDM host company's *involvement in other CDM projects*. Naturally the companies with more CDM projects would have more experience in the application of technology and hence a better understanding of this technology. Thus we introduce the binary variable *Other_projects* indicating if the CDM project host company has implemented more than one projects (=1) or not (=0).

Human resources related proxies.

One of the most popular indicators of absorptive capacity is related to the human resources of a company. It has been widely accepted that a skilled and educated work force enhances the firm's absorptive capacity (Cohen and Levinthal, 1990). This is because the endowment of human and knowledge capital within a company determines its overall ability to appropriate the acquired technology as well as opportunities related to it. The endowment of human capital can be proxied by the share of the trained staff having university degrees/engineering qualifications and technical school education among the total pool of employees. We expect that the higher the proportion of trained personnel in the organization is, the greater the organization's ability to absorb the knowledge will be. Thus we adopt the *Qualification* variable (qualification of employees) and expect it to be positively related to technological capability building scores.

Training

Training is another important factor that is directly associated with human resource quality and absorptive capacity. Since technology transfer involves technology and the entire scope of embodied and disembodied knowledge associated with it, it relies on human resource input, which is considerably more difficult to transfer than equipment. Moreover, it has been recognized that human resource development should be at the very heart of any technology transfer endeavour because it is the personnel that needs to be taught how to use the equipment. One of the evaluation measures for human resource capability in technology transfer is the training offered by the technology provider (Chen, 1997; Lyles and Salk, 1996; Lyles *et al*., 1997; Lane *et al*., 2001). In our case the provision of training, the on-job coaching and the other capacity building activities by technology provider was captured by the *Training* variable calculated as an average of binary variables associated with these three types of activities.

Control Variables

A set of variables was used to control for other factors which could influence technological learning by CDM project host companies. We categorized them as micro or project host company characteristics related variables and macro factors that capture country related differences.

CDM project host company characteristics related variables

Size of company. In the literature, firm size has been traditionally regarded as a crude measure of the extent to which a firm may be said to be resource-rich. This may suggest that larger firms would have advantages in accessing, and also possessing, better and more diversified knowledge. However, some authors also suggest that sometimes the size of an organization may contribute to its inertia and thus inhibit learning (Lane et al, 2001). In CDM project related learning the project host company's size may have either of the above effects.

We define the size of a company by the number of employees.. Other measurement options used as a size indicator in many studies, such as financial resources and range of activities, have been considered to be less relevant especially in the context of diversified technology industries that CDM projects comprise. Size variable showed a very large variance across firms constituting our sample. For further analysis the group was divided into two groups: the group small-size including companies with 10-50 employees and the group larger-size counting for 51 employees and more (Table 1).

Table 1. Distribution of project host companies according to size

Size (N employees)	*Freq.*	*Percent*
Small(10-50 employees)	59	56.7
Larger (>=51 employees)	45	43.3
Total	104	100

Age of company This is another company specific variable that can be used as a determinant factor of technological learning. However the impact of age on technological learning is difficult to predict. It may generate a positive effect for older companies who have more experience hence better prior knowledge, but contrarily, the company may not learn anything new from the project. Company age was calculated as the number of years since the company was established. The age variable ranges from 1 to 83, with mean = 15.94. 50% of the companies are ten years old or less. In order to standardize the variable for further regression analysis we transformed it by taking its natural logarithm.

Ownership status of company. Foreign equity participation often increases chances for the company to acquire more advanced knowledge and technologies. This fact may also diversify the channels of knowledge flow by involving a greater number of technology providers and imposing the technology recipient to more interaction. In our sample we categorized companies in two groups: one with 100 percent local ownership and the other with foreign (which includes joint ventures and 100 percent foreign companies). We may expect that companies with foreign equity would be associated with higher technological learning. To capture the ownership effect we introduced the dummy variable indicating domestic technology as 1 and foreign technology as 0.

Table 2. Distribution of CDM project host companies according to their ownership status

Ownership	*Freq.*	*Percent*
Foreign	14	13.46
Local	90	86.54
Total	104	100

Country related control variables

Country related differences have been captured by introducing country dummies *India, China, Mexico* and *Brazil* .

The importance of the national institutions (or policies) in promotion of technological capability building and learning have been largely acknowledged in the literature (Biggs et al. 1995; Bell, 1984; Lall, 1992). Respondents have been asked to evaluate the quality of a number of policies presumably relevant for CDM and to associate them with technological learning. The list of policies included the ones on CDM capacity promotion, such as capacity building and finance schemes, renewable energy stimulation, general environmental policies, education related to clean and renewable energy technologies, increasing awareness about CDM among companies and local municipalities, incentives for foreign companies to invest in CDM projects and active involvement of civil society organizations in CDM activities. Each policy was evaluated by respondents using Likert-type scale from 0-6; 0 (absence of policy), 1 (poor)…. 6 (very good). By taking the average score for all listed institutions we calculated the unified variable *Policy* for measuring quality of the institutions as perceived by the respondents.

Table 3. Quality of policies relevant to CDM
(based on evaluation of respondents)

Policies	*Mean*	*St.Dev.*
CDM promotion (e.g. capacity building, financing schemes, etc)	3.35	1.72
Renewable energy technologies promotion	3.70	1.50
Environmental policies	3.67	1.48
Education related to clean and renewable technologies	3.33	1.60
Increasing awareness of companies about CDM	3.39	1.59
Increasing awareness of local municipal authorities about CDM	3.08	1.64
Incentives for foreign companies to be involved in CDM projects	2.84	1.77
Active cooperation with civil society organizations	2.80	1.54

3.3 Regression model

Table 4 summarizes the information on all variables, their descriptive statistics and hypothesized effect on the outcome. For the econometric analysis we applied the Ordinary Least Squares (OLS) regression technique. Being the simplest, OLS method is the most frequently used approach to regression analysis (Greene, 2003). We used this technique because dependent variables *BasicTC, IntermediateTC*, and *AdvancedTC* consist of continuous data ranging between values of 0 and 6.

This classical multivariate linear regression model stipulates a linear relationship between dependent variables and a set of independent variables and can be described as

$$y_i = \sum_{h=1}^{K} x_{ih} \beta_h + \varepsilon_i$$

Formally for each observation i , the value of the dependent variable, y_i is related to a sum of K explanatory variables, x_{ih} , with $h = 1, \ldots, K$, each multiplied with a regression coefficient, β_h , and the random error term, ε_i . Typically, the first explanatory variable is set equal to one, thus its coefficient is referred to as the intercept.

Within the constraints of the OLS model there are several assumptions. One of them is an independence of covariates which otherwise causes multicollinearity problem in the regression. Table 5 presents the results of the correlation test for all independent and control variables included in the regression analysis. No high correlation between dependent and independent variables are observed indicating that the results of the regression are robust. Other assumptions of OLS concern the hypothesis about normal distribution and homoskedasticity of the residuals. Examination of the Q-Q plot of Studentized residuals for dependent variables confirmed normal distribution assumption ($p<0.001$) thus allowing us to avoid bias in parameters estimation in the regression. Therefore we think that OLS technique proves to be appropriate for our analysis.

Table 4. Definition of variables and summary statistics

Variables	*Description*	*Mean*	*Std. Dev.*	*Min*	*Max*	*Expec. outcom*
basicTC	Dependent variables, indicating the accumulation of basic, intermediary and advanced technological capabilities (TC) after CDM project experience	2.99	1.90	0	6	
intermediateTC		2.85	1.87	0	6	
advancedTC		2.47	1.77	0	6	
previousTC	TC level prior to CDM project experience, estimated as simple mean of ten previous TCs.	0.46	0.40	0	1	+
previousTC^2	Squared term of *previousTC*	0.16	0.10	0.001	0.287	-
Other_projects	=1 if the project host company had another project, 0 otherwise	0.34	0.47	0	1	+
Qualification	Share of personnel with higher qualification	0.23	0.20	0	0.8	+
Training	average of binary variables associated with training, on-job coaching and other capacity building efforts	0.46	0.50	0	1	+
Size	= 1 if company is larger scale and =0 if it is small scale	0.43	0.50	0	1	+/-
Age	Natural log of the actual age of company	2.43	0.84	0	4.42	+/-
Local_ownership	=1 if company has local ownership status, 0 if foreign	0.87	0.34	0	1	+/-
Local_technology	=1 if the technology of local origin, 0 if it is partially or fully imported	0.55	0.50	0	1	+/-
India	=1 if project is implemented in India, 0 otherwise	0.34	0.47	0	1	
China	=1 if project is implemented in China, 0 otherwise	0.13	0.33	0	1	
Brazil	=1 if project is implemented in Brazil, 0 otherwise	0.38	0.49	0	1	
Policy	Simple mean of perceived quality of institutions evaluated on 0-6 scale	3.23	1.35	0.33	6	+
N = 104						

Table 5. Correlation matrix of variables

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
(1) basicTC	1.00														
(2) intermediateTC	0.86	1.00													
(3) advancedTC	0.70	0.78	1.00												
(4) previousTC	0.48	0.41	0.37	1.00											
(5) previousTC^2	-0.13	-0.11	0.00	0.09	1.00										
(6) Other_projects	0.08	0.11	0.14	0.23	0.11	1.00									
(7) Qualification	0.20	0.17	0.11	0.35	-0.34	0.33	1.00								
(8) Training	0.00	0.00	0.13	-0.15	-0.01	-0.09	-0.05	1.00							
(9) Size	-0.26	-0.18	-0.18	-0.02	0.06	-0.01	-0.25	0.01	1.00						
(10)Age	-0.20	-0.15	0.00	-0.08	0.01	-0.09	-0.22	0.12	0.11	1.00					
(11)Local_ownership	0.00	-0.02	0.08	0.24	0.08	0.16	0.03	0.30	-0.03	0.04	1.00				
(12)Local_technology	0.07	0.02	-0.09	-0.28	-0.31	-0.26	-0.16	0.14	0.00	0.02	-0.08	1.00			
(13)India	0.34	0.35	0.32	0.41	-0.13	0.18	0.19	-0.01	0.08	0.11	0.03	0.16	1.00		
(14)China	0.14	0.14	-0.02	0.07	-0.17	-0.15	0.33	0.00	-0.15	-0.29	-0.12	0.15	-0.27	1.00	
(15)Brazil	-0.21	-0.24	-0.10	-0.13	0.13	-0.02	-0.24	0.26	0.11	0.08	0.36	-0.21	-0.56	-0.30	1.00
(16)Policy	0.35	0.40	0.26	0.30	0.10	0.04	0.17	-0.06	-0.09	-0.07	-0.05	0.10	0.23	0.41	-0.39

4 Results

Table 6 displays the estimation results of the OLS model. As a base to compare our results against, we first ran a regression with only control variables. Models 1.1, 2.1, and 3.1 in Table 6 represent the impact of the control variables on increase in basic, intermediate, and advanced technological capabilities. Models 1.2, 2.2, and 3.2 present the results for the model that also include independent variables.

Hypothesis 1a argues that a CDM projects recipient's prior level of knowledge about relevant technology positively influences technological learning outcomes of CDM project. The regression results on the effect of prior knowledge level measured by *previous TC,* on post-project TC building outcomes show a positive sign in all three basic, intermediary and advanced TC building cases. Statistical significance of the results are on a 1% level in case of basic TC, and on a 10% level for intermediary and advanced TC building. Thus these results confirm the hypothesis 1a. Results for the magnitude of the effect (the coefficients) demonstrate that prior TC have higher effect on increase of basic TC, less on intermediate TC, and even less effect on advanced TC.

Results on quadratic term of the prior knowledge level ($previousTC^2$) seek to test the hypothesis 1b which argues for a parabolic, inverted U-shaped relationship between prior and post project TC levels of the project host company. This hypothesis implies that technology recipients with no or very small prior knowledge would not be able to benefit efficiently in terms of learning as they would miss absorptive capacity, while for the ones having very extensive prior knowledge in technology and CDM projects would not acquire much new knowledge; and the recipients with close to optimal (not too high and not too low) level of prior knowledge would be the nearest to achieving highest learning outcomes. The regression results for squared term of previous TC show negative and statistically significant (10% level) coefficients for models 1.2 and 2.2. The result for model 3.2 is not statistically significant. Considering significant and positive coefficient in case of *previousTC* and negative significant effect for its squared term we found support for Hypothesis 1b in the case of basic and intermediary TC building, though not for advanced TC. The magnitude for the coefficients in both bases slightly differs, showing stronger effect in intermediate TC case.

The test for the relevance of experience with other projects (*Other_project*) to learning outcomes did show statistical significance. But we note that the coefficients obtained a positive sign in the regression results.

Table 6. OLS regression estimates for three groups of outcome

	BasicTC		*IntermediateTC*		*AdvancedTC*	
	Model 1.1	Model 1.2	Model. 2.1	Model 2.2	Model 3.1	Model 3.2
previousTC		2.206 (0.542)***		1.415 (0.567)*		1.137 (0.573)*
previousTC^2		-3.195 (1.819)*		-3.555 (1.902)*		-1.428 (1.920)
Other_projects		0.109 (0.360)		0.322 (0.377)		0.254 (0.380)
Qualification		1.438 (1.111)		2.082 (1.162)*		0.992 (1.172)
Training		0.394 (0.353)		0.412 (0.370)		0.711 (0.373)*
Size	-1.036 (0.329)**	-1.027 (0.318)**	-0.696 (0.330)*	-0.743 (0.333)*	-0.785 (0.328)*	-0.783 (0.336)*
Age	-0.406 (0.199)*	-0.405 (0.191)*	-0.301 (0.199)	-0.325 (0.199)	-0.014 (0.198)	-0.038 (0.201)
Local_ownership	-0.391 (0.368)	-0.631 (0.360)*	-0.402 (0.369)	-0.584 (0.377)	-0.140 (0.366)	-0.378 (0.380)
Local_technology	-0.021 (0.482)	-0.389 (0.566)	-0.361 (0.484)	-0.378 (0.592)	-0.732 (0.480)	-0.602 (0.597)
India	2.291 (0.546)***	0.928 (0.666)	2.063 (0.548)***	1.239 (0.696)*	1.930 (0.543)**	1.114 (0.703)
China	1.144 (0.695)	0.232 (0.807)	0.943 (0.697)	0.563 (0.844)	0.521 (0.692)	0.002 (0.852)
Brazil	1.319 (0.552)*	0.527 (0.575)	1.053 (0.554)*	0.457 (0.602)	1.123 (0.550)*	0.503 (0.607)
Policy	0.320 (0.141)*	0.272 (0.140)*	0.401 (0.141)**	0.378 (0.147)*	0.284 (0.140)*	0.255 (0.148)*
_cons	2.200 (0.825)**	2.579 (1.016)*	1.897 (0.828)*	2.786 (1.063)*	1.494 (0.821)*	1.745 (1.073)
Number of obs	*104*	*104*	*104*	*104*	*104*	*104*
Prob > F	*0.0000*	*0.0000*	*0.0000*	*0.0000*	*0.0007*	*0.0020*
R-squared	*0.3352*	*0.4465*	*0.3087*	*0.3754*	*0.2401*	*0.2888*
Adj R-squared	*0.2792*	*0.3665*	*0.2505*	*0.2852*	*0.1761*	*0.1860*

*significant at 10%; **significant at 5%; *** significant at 1% level
Robust standard errors in parentheses

Hypothesis 2 states that a higher representation of human resources such as engineers and technical personnel is positively associated with more dynamic technological learning in CDM project. The coefficient for the variable is indeed positive in all three models, but statistically significant (on 10% level) only in model 2.2, thereby providing support for the hypothesis 2 in case of intermediate TC and no conclusion in the other two cases.

Hypothesis 3 argues that training activities provided by the technology providers under CDM projects would have positive effect on building TC. Coefficients for the training variable shows a positive sign in all three models, however the results are statistically significant (10%) only in model 3.2. Thus these results acquired partial support for hypothesis 3.

Results for the control variables demonstrate the following: size variable, which is a large firm dummy, shows negative and statistically significant (5% and 10% level) association with learning outcomes. This implies that experience with CDM projects does not result in higher technological learning in larger companies. This supports the argument of Lane *et. al* (2001) saying that large companies tend to be more inert which inhibits their learning. Another explanation could be that larger companies are too large or too experienced to be influenced by the experience with CDM projects. From the other point of view, it can also be interpreted that small sized companies implementing CDM projects tend to benefit more in terms of TC building, which might be due to their flexibility or lack of experience.

Our prediction for the *Age* related variable was either of opposite outcomes. The results showed negative effect of age on technological learning outcomes of CDM projects. This is perhaps because older companies have more experience and knowledge and CDM does not increase their base of skills and knowledge. Coefficients of the dummy specifying local ownership status have a negative effect on technological capability building which is statistically significant on the 10% level only in model 1.2 (basic TC's). This proves that companies with foreign ownership participation have a higher probability to get their basic technological capability increased.

The results for technology origin did not show statistical significance, thus we do not interpret them. Country dummies show positive and statistically significant effect (in most of the cases for India and half of the cases for Brazil). This means that Indian and Brazilian companies tend to achieve progress in technological learning as a result of CDM project implementation. Results for China are also positive, but statistically not significant. The indicator for quality of polices relevant to CDM implementation and technological development demonstrate a positive, stable and statistically significant (on 5-10% level) effect in all models.

5 Discussion

In this paper we have tested the effect of various dimensions of absorptive capacity on technological capability building of CDM project host companies. We based our results on a sample of 104 companies in Brazil, China, India and Mexico; countries which are most active in initiating these projects. Several hypotheses about the impact of absorptive capacity in technological learning were tested and the results provided varying levels of support for these hypotheses.

In the discussion leading up to the first hypothesis we argued that there is a positive relationship between prior knowledge and technological capability building as a result of CDM project implementation. Results of our study largely support the prediction that prior knowledge being an important element of organizational absorptive capacity eases further learning. This result is consistent with widely recognized results of studies on absorptive capacity (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Kim, 1998).

Hypothesis 1b can be seen as an extension of the first hypothesis. It seeks to investigate the relationship between prior knowledge and learning results in more detail by studying patterns of the learning function. We followed the suggestions by the literature that learning outcome is not linear, but curvilinear function of the organization's prior knowledge (Noteboom, 1992, 1999; Mowery *et. al* 1996, 1998). Our findings confirm that the learning opportunity is greater when there are some differences between the knowledge base of the organization and the knowledge that is embedded in the new technology arriving along with the CDM project. The learning outcomes are rather limited in the case of very poor and very rich prior knowledge bases. Thus our results established an inverted U-shape relationship between prior knowledge and learning outcomes. In reality CDM project host companies drastically vary in their knowledge base, which is determined first of all by their experience in CDM specific technologies. For some companies (e.g. ones specialized in wind or hydropower generation) CDM experience does not produce any value-added in their technological capabilities, while in many cases a CDM project is a mean of introducing a new technology in the company's production cycle, which also requires fostering new expertise and capabilities. Our survey and supplementary in-depth interviews also revealed that some companies had prior experience in introducing CDM related technologies long before this mechanism was put into work (e.g. experiments with biogas utilization in animal farms), which allowed them to accumulate some expertise and build absorptive capacity for larger and more sophisticated projects.

However it is necessary to note that while a positive relationship has been proved for prior TCs and all three types of TC building outcomes, the inverted curvilinear relationship were obtained only for the cases of basic and intermediate level skills appropriation, but not for advanced/innovative capability building. The (simple) explanation we suggest is that the relationship between prior knowledge and learning of advanced knowledge is not curvilinear, but linear and positive. This suggests that when it comes to learning of advanced technological expertise companies still learn a lot independently from richness of their prior knowledge base, in other words they don't reach their knowledge saturation level. However further investigation would be helpful in finding out if this is the case only specifically for CDM project experience or this can apply to other practices of new technology acquisition.

Another indicator for prior knowledge which we included in the regression analysis was the experience with other CDM projects. The fact of having more than one project did not prove to contribute to technological learning in CDM projects. This might be because in our sample we included companies that implemented projects in 2005-2006, meaning a rather short time span between projects which does not allow the building of more solid knowledge based on earlier project experience.

The third hypothesis addresses the human resource dimension of an organization's absorptive capacity. It predicts that companies with a larger share of highly qualified personnel such as engineers and technical experts would benefit from more extensive technological learning during CDM project implementation. The hypothesis found statistically significant confirmation only in the case of intermediate TC building thus finding partial support and consistency with earlier studies (e.g. Glass and Saggi, 1998; Kim and Dahlman, 1992; Luo, 1997; Veugelers, 1997). Besides, we note that the magnitude of the coefficient is larger in the intermediate TC group related model in comparison to the other two. These results might be related to the scope of capabilities covered in the intermediate TC group such as process improvement and incremental innovation. If the company has a pool of engineers, an increase in basic capabilities during the project experience might not happen as they already possess them, while improvement in intermediate capabilities benefits from the CDM experience. In the same way higher qualifications could influence advanced technological competences building, however this was not proved in our results. Earlier studies investigating the human capital dimension of absorptive capacity draw on learning in innovative activities (e.g. Glass and Saggi, 1998; Keller, 1996), therefore it is puzzling that in our study we did not find statistically strong results. Possibly this has to do with the fact that in CDM projects design and development activities are often implemented by the technology providers, rather than by the recipient. However this finding needs to be kept open for further investigation.

Testing the last hypothesis addressing the relevance of training activities in TC building impact of CDM project showed rather surprising outcomes. Higher and statistically stronger coefficient is associated with role of training in building advanced technological capabilities, while results for basic and intermediary TC groups were not proved with sufficient confidence level. Positive sign of the coefficients imply positive association between qualification factor and technological learning, which in its turn allows for an argument about the relevance of training in an absorptive capacity concept and its role in technological learning. However strange results achieved by us might be caused by narrow presentation of the training data (we used a dummy variable for capturing the training effect), in other words the qualitative information about the training, on-job coaching and other activities such as content, duration, intensity, etc. was not addressed in the survey. We believe the training activities provided by the technology provider very much varied across the projects which may have caused a rather diverse effect on knowledge transfer. It is therefore advisable to further investigate and capture various qualitative aspects of training activities that technology recipients acquire.

As an overall observation of the regression results it is necessary to highlight the singled out effect of each variable. Prior technological knowledge captured by the previous technological capabilities proxy showed the strongest effect on learning outcomes in comparison with other components. Qualification of personnel also obtained a larger coefficient indicating its stronger effect. This suggests that absorptive capacity of the organization is represented to a larger extent by a combination of prior knowledge and the presence of highly qualified employees, and to a lesser extent by experience with CDM projects and training efforts.

6 Conclusion and implications

Overall we feel that our paper contributed to answering the research question in the following way: we have highlighted an important but previously unstudied topic of absorptive capacity in technological learning in CDM projects. Our study demonstrated the methodological suitability of combining various indicators for absorptive capacity and considering them as dimensions of an organization's absorptive capacity. Authors who introduced the concept of absorptive capacity defined it as a complex factor, representing a company's knowledge, accumulated through its experience and formal and informal learning, and residing in its employees (Cohen and Levinthal, 1990; Zahra and George, 2002; Van Den Bosch *et. al,* 2005). Unlike approaches in earlier studies which compiled a single factor for absorptive capacity compiled out of several measurements (e.g. Daghfous, 2004; Whangthhomkum *et al.*, 2006), in our study we tried the opposite by singling out effects of different dimensions of absorptive capacity on technological capability building dynamic. By doing this we revealed the strong role of prior knowledge and skills in relevant technology in further learning and appropriation of the technology. Also the importance of availability of highly qualified personnel for more effective learning was partially assured. While these findings do not bring big news in organizational learning literature, they can have implications for the CDM and technology transfer related discourse and policies. Thus based on our results we argue that promotion of the domestic knowledge base in climate friendly technologies and fostering human resources would create a fruitful ground for more effective technological learning and spillovers from further CDM project experience.

The important goal of CDM is contributing to sustainable development in project host countries. Technology and knowledge transfer is considered as part of the sustainable development agenda. An increasing segment of CDM literature discusses the possibility of measuring the sustainable development impact of CDM. The approach we used in our study is based on the technological capability taxonomy widely acknowledged in technical change and innovation studies (Lall, 1992; Bell and Pavitt, 1993; Figueiredo, 2003). Assessing the range of technological capabilities allowed us to measure the technological learning impact of CDM project. This framework showed its viability and reliability and can potentially be used in studying technological development aspects of CDM.

Considering the impact of CDM projects in terms of technological learning and capability building from the sustainable development angle we can suggest the following implications: once companies in developing countries take part in CDM projects they accumulate a range of technological capabilities and competences which may have spillover effects on the country's economy and facilitate diffusion of clean technologies. Although these effects might hardly be traced at the current moment, future prospects and research avenues are there.

As a policy implication we suggest governments and company leaders to steer and invest in building local absorptive capacity which would further ensure better appropriation of new knowledge and technologies. This is particularly becoming important for the clean technologies niche as the trend in demand for these technologies is lately increasing along with globalization of environmental governance and strengthening of environmental standards. In this regard we found our result on the effect of policies promoting CDM and renewable energy expertise and technologies to be very relevant. All our results show strong positive association of policies with technological learning and capability building, which suggests that institutional environment matter also for micro level technological learning.

Talking about limitations of the study, we have noted in the discussion above the possible misspecifications and limitations of certain data we have collected. As we discussed in the case of training data, the problems seem to be caused by missing data on quality of training.

Other limitations of our study are related with our sample. In our study we covered only four countries, though as the largest recipients of CDM projects these covered around three quarters of the global CDM projects pool. Many countries were not covered by our survey, among them countries which are small and economically less developed. Thus results we acquired in this paper despite being insightful might not be relevant for these countries.

Second, the statistics of CDM projects have somewhat changed since 2007. Recent developments in the CDM market show growing leadership of China in initiating CDM projects. In contrary to our sample which was based on statistics of 2007, the share of China is rather modest, which implied a small sample representing this country. Re-sampling and new similar research may have different observations for this country.

Above mentioned limitation may translate into opportunities for further research with improved questionnaire and enlarged sample covering larger range of countries. Besides, the interesting and promising results obtained with policy variables may give a motivating ground for deeper investigation of the role of policies in technology and knowledge transfer in CDM projects.

In conclusion it is necessary to note that in the literature strand addressing technology and knowledge transfer in CDM projects this study is believed to be unique in terms of obtaining company level data and pioneering in terms of applying the organizational learning approach. Our most important lesson that follows through this experience is that well established and conceptually and methodologically rich organizational learning literature can provide a solid ground for studying technology transfer and learning issues in CDM projects and suggest a good opportunities for further research.

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