TECHNOLOGY TRANSFER IN CLEAN DEVELOPMENT MECHANISM (CDM) PROJECTS: LESSONS FROM CHINA

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Abstract. China has become the largest host country of Clean Development Mechanism (CDM) in the world. This article provides an assessment of international technology transfer (TT) based on 500 registered Chinese CDM projects. It reveals that the projects hosted by large state-owned enterprises (SOEs), not Hydro and Wind projects, with foreign consultants or developers, commonly involve TT. Projects located in the comparatively developed regions such as Eastern China are more likely to involve TT. The findings indicate that the mitigation potential of non-SOEs, energy efficiency (EE) and other projects, has not been fully explored in China, which can be facilitated using advanced mitigation technologies.

Keywords: Clean Development Mechanism, mitigation technology, technology transfer, China.

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Introduction

With the rapid economic growth, anthropogenic greenhouse gas (GHG) emissions from developing countries have become one of the main concerns around the world (La Rovere *et al.* 2011; Štreimikiene, Esekina 2008). Technology transfer (TT) is expected to play an important role in mitigating GHG emissions for developing countries (Halsnæs, Garg 2011; Kim *et al.* 2011; Marconi, Sanna-Randaccio 2011; Schneider *et al.* 2008). Clean

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Development Mechanism (CDM) is one of the international instruments facilitating such transfers (Gangale, Mengolini 2011).

The CDM fosters sustainable developments by channelling new financial resources to promote the use of technologies currently not available in the host countries (Reynolds 2012; Schneider *et al.* 2008). As one of the largest CO_2 emission countries and one of the fastest developing countries, China and its government face the dilemma between economic growth and environmental conservation similar as most of the developing countries (Ward, Shively 2011). China has made use of CDM, not only to receive financial assistance, but also to obtain advanced technologies from developed countries (Wang 2010). Currently, China has become the largest CDM host country in the world (Richerzhagen, Scholz 2008). The number of registered and registering projects hosted in China is about 48% of all 7,520 registered and registering projects around the world (UNFCCC 2013). The expected average annual certified emission reductions (CERs) of Chinese registered projects are about 64% of the total 905,682 $ktCO_2$e per year (UNFCCC 2013).

The TT claims for CDM projects have been extensively studied (Dechezleprêtre *et al.* 2008; Seres *et al.* 2009; Wang 2010). However, this research is different from the previous studies in several important aspects. First, it attempts to differentiate the effects of CDM on TT, including: (1) form of ownership of Chinese participants; (2) foreign participants more than credit buyers; and (3) regional disparities of China. Second, it investigates the trends beyond individual projects and individual aspects. Third, it identifies several aspects that can be improved in the Chinese GHG mitigation activities. The aims are to gain an insight into the mitigation of TT and further understanding in the CDM at its current or modified form in the new negotiation stage.

1. Literature review

The Intergovernmental Panel on Climate Change (IPCC) defined TT as "a broad set of processes covering flows of know-how, experience and equipment for mitigating and adapting climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/ education institutions" (IPCC 2000). Technologies consist of not only the "hardware" such as machineries and equipment, but also the "software" including knowledge, skills, know-how, management arrangements and goods or services (Tébar Less, McMillan 2005). A project can involve both hardware and software (Dechezleprêtre *et al.* 2008). In CDM, "technology transfer" reported in the project design documents (PDDs) are not based on a specific or identical definition, but based on the interpretation of TT by project participants. According to former research, in general, it can be assumed that TT means "the use of equipment and/or knowledge not previously available in the host country" (Haites *et al.* 2006; Seres, Haites 2008; Seres *et al.* 2009).

An extensive body of literature has reported economic, political, methodological and sustainable development aspects of the CDM project performance (Olsen 2007; Schneider *et al.* 2008). Currently, there are two main streams of literature studying TT in CDM projects. The first stream reports empirical analyses which study TT in CDM projects using the data

from the UNEP Risoe Center CDM Pipeline and the project design documents (PDDs), which explore TT on parameters such as project sizes, project types, host countries, technology suppliers, local technology capabilities and partnerships. The second stream collects information from interviews, case studies, policy documents, government information and other sources, using qualitative approaches rather than quantitative, giving us a wide open mind and a big map of TT in CDM projects.

In the studies of the first stream, some significant results are found. The data show that TT takes place in less than half of the CDM projects (Dechezleprêtre *et al.* 2008; Seres, Haites 2008; Seres *et al.* 2009, 2010). Large projects are more likely to involve TT than unilateral or small-scale projects (Dechezleprêtre *et al.* 2008; Haites *et al.* 2006; Seres *et al.* 2010). Slightly varying with the samples, TT possibility is high in agriculture, energy efficiency (EE) own generation, landfill gas, N_2O, HFCs and wind projects, and low in biomass energy, cement, fugitive, hydro, and transportation projects (Das 2011; Dechezleprêtre *et al.* 2008; Seres, Haites 2008; Seres *et al.* 2009). This reflects the variation of average sizes under different project types and technology characteristics. As more projects of a given type are located in the host country, subsequent projects rely more on local knowledge and equipment than imported technologies (Dechezleprêtre *et al.* 2008; Seres *et al.* 2009, 2010). Meanwhile, countries with more experience in the development and applications of mitigation technologies tend to rely on domestic technologies or developing technologies accompanied by foreign partners (Doranova *et al.* 2010). These indicate that the well-developed local technology facilitates the use of foreign technologies and implies availability of technology locally (Dechezleprêtre *et al.* 2008, 2009). A host country can influence TT in CDM through their criteria for approving CDM projects and other factors such as tariff, and protection of intellectual property rights (Seres, Haites 2008; Seres *et al.* 2009, 2010). Projects hosted by the subsidiary of a foreign company or with foreign consultants are more inclined to involve TT (Das 2011; Dechezleprêtre *et al.* 2008, 2009; Doranova *et al.* 2010).

In the second stream, insights about TT in CDM projects are displayed. Four TT barriers: (1) lack of commercial viability; (2) lack of access to capital; (3) lack of information; and (4) lack of institutional framework are identified and the CDM does contribute to TT by lowering these barriers except the last one (Schneider *et al.* 2008). The four barriers are used by other researchers to explain project characteristics' effects on TT in CDM projects (Dechezleprêtre *et al.* 2009; Seres *et al.* 2009). Besides the four barriers, local technology capability is identified by Schneider *et al.* (2008) to explain the TT distribution across geographies and project types. But they could not identify low local technology capability as the fifth barrier of TT in CDM projects. Local technology capability already can be measured by standard index, such as the ArCo technology index (Dechezleprêtre *et al.* 2008, 2009), or a set of indicators specially made for research purposes (Doranova *et al.* 2010).

Although the studies focusing on CDM projects hosted in China are of paucity, some features of TT in CDM projects in China still could be found. When the certified emission reduction (CER) income is low and most of the technologies are locally available, time effect, technology diffusion, governmental involvement, and investors' and brokers' participation play an important role in deciding TT (Wang 2010). The domestic regulations and policies have important influences on the CDM projects, e.g. CDM projects are heavily concentrated

in government priority areas such as renewable energy and energy efficiency in industrial applications (Marconi, Sanna-Randaccio 2011). It also points out that China's technology localization strategies will eventually reduce TT in CDM projects and advance the level of technologies adopted (Wang 2010). Overall, this subject is not sufficiently discussed by previous researchers. This research follows the empirical analyses from the first stream and also inspired by the findings of the second stream researches.

2. Hypothesis development

2.1. Project sizes

According to previous empirical research, project sizes are one of the most important factors that influence the possibility of TT in CDM projects. It is suggested that the larger the project sizes, the more possible the project involving TT (Dechezleprêtre *et al.* 2008, 2009; Doranova *et al.* 2010; Haites *et al.* 2006; Seres *et al.* 2010). Therefore:

   Hypothesis 1: The project size is positively associated with TT in CDM.

2.2. Project types

The TT claim varies widely across project types (Das 2011). On average, there are 40% projects claiming TT, but the share of TT ranges from 13% to 100% across different project types (Seres *et al.* 2010).

   First, industrial regulations and policies directly affect TT in specific project types. For example, the Chinese government implements the large-scale wind farm plan, requiring about 70% local contents for the eligibility of concession bidding, which significantly spurs the localization of wind turbine manufacture (Wang 2010). Second, as the number of CDM projects in a given type grows in a host country, TT probability will gradually be reduced in later projects (Dechezleprêtre *et al.* 2008; Seres *et al.* 2009, 2010). It can be suggested that TT is more likely to happen in some project types than others. Hence, we propose that:

   Hypothesis 2: The attribute of project types is positively associated with TT in CDM.

2.3. Form of ownership of Chinese participants

It is restricted by National Development and Reform Commission (NDRC) and three other ministries of Chinese government that only wholly-owned Chinese companies or Chinese holding companies are eligible for CDM projects in China (NDRC *et al.* 2005, 2011). There must be at least 51% of the company owned by Chinese entities (Wang 2010). In this condition, the CDM owners in China can be classified into three types: state-owned enterprises (SOEs), collective-owned enterprises (COEs) and private-owned enterprises (POEs) (Nee 1992).

   In China, although the SOEs undertake more complex socio-economic mission (Nolan 2001) and more commonly-faced multiple tasks than non-SOEs (Bai *et al.* 2000, 2006), they have the facilities in accessing capital resources (Brandt, Li 2003) and gaining political support from the state and local governments (Li, Zhou 2005). The COEs have fewer advantages than

SOEs, but are still ranked higher in terms of accessing political and financial support than POEs (Poncet *et al.* 2010). They have structural advantages over both SOEs and POEs (Xia *et al.* 2009; Xin, Pearce 1996), because they are affiliated with and are able to gain protection from the local government (Kung, Lin 2007; Nee 1992; Peng *et al.* 2004) and meanwhile they sell products in competitive markets that encourage efficiency (Kornai 1986; Kung, Lin 2007). COEs did benefit from their structural advantages in the early years of reformation (Xia *et al.* 2009). After undergoing a decline in the mid-1990s as the SOEs (Jefferson, Su 2006), COEs have experienced transformations under the central government policy since 1995, including both privatization and corporatization (Lin, Zhu 2001). In the transformation times, local governments may still play an important role in dealing with the agency problems as the controllers of COEs, and the close relationship with the government becomes an obstacle rather than advantages in improving firm performance (Xia *et al.* 2009; Zeng *et al.* 2012). The POEs gain less local policy support from the government and having weak influential power (Xin, Pearce 1996). They cannot enter into certain industries, and are commonly with less tax relief (ADB 2002; Ralston *et al.* 2006). They are harder to obtain loans from state-owned banks (Poncet *et al.* 2010), have less access to market information and have more problems in getting land which is owned by the state and other resources from the government (ADB 2002; Gregory *et al.* 2000; Ralston *et al.* 2006). They can also be large and sophisticated, with much more discretion on hiring, firing people, and exercising market responses than SOEs (Pyke *et al.* 2000). The alternative resources, such as reputation and relationships, are used by POEs as alternative financing channels and governance mechanisms to overcome the imbalance among the three sectors (Allen *et al.* 2005). It is also suggested that the situation is changing over time, the institutional and market infrastructure inspiring both SOEs and non-SOEs are starting to be established in China (Carney *et al.* 2009). In general, the more support they could gain from the government and the stronger their financial power, the easier they can lower the four barriers of TT.

It can be supposed that TT is likely to happen in SOEs, less likely in COEs, and least likely in POEs. It is hypothesized that:

Hypothesis 3: The form of ownership of Chinese participants is associated with TT in CDM.

2.4. Foreign participants

Cooperating with foreign companies can increase the possibility of TT in CDM projects. Beside technology suppliers, there are at least four types of foreign participants, such as project developers, financers, consultants and credit buyers. One foreign entity can play one or more roles at one time in a CDM project. The project developer clearly favours TT, if it is the subsidiary of a company from an Annex I country[1] (Das 2011; Dechezleprêtre *et al.* 2008, 2009; Doranova *et al.* 2010). The subsidiaries have stronger effects on TT than credit buyers (Dechezleprêtre *et al.* 2008). And, the involvement of foreign consultants can also increase the possibility of TT in CDM projects (Das 2011). Thus:

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[1]   According to Seres (2010) and a list of Annex I counties available on UNFCCC website (http://unfccc.int/ parties_and_observers/parties/annex_i/items/2774.php) which include the United States and Canada. This paper will include the United States and Canada for the analysis of the Annex I counties.

Hypothesis 4: The Involvement of foreign companies is positively associated with TT in CDM.

2.5. Disparity of host regions

In this paper, China is the host country of the investigated projects. In China, the degree of reform and openness, geographical locations and infrastructure investments significantly affect economic growth performance across provinces (Démurger 2001). The heavy industry development strategies in China formed a rural-urban gap in the pre-reform period, while openness and decentralization induce and exacerbate the inland-coastal disparity in the reform period (Kanbur, Zhang 2005).

The regional disparity of China may affect TT in CDM projects by lowering barriers on commercial viability, accessing to capital, information and institutional framework. First, the CDM projects located in the economically developed regions can take advantage of active business activities and facility of access to capital. Second, the comparatively developed regions in China have better local technology capability (Qi *et al.* 2012), as they have better educated engineers and better trained skilled workers, and more financial support on research and development. High technology capabilities are necessary to adopt new technologies, but it also implies that the technologies needed may already be available in the local market (Dechezleprêtre *et al.* 2008, 2009). It is hypothesized that:

Hypothesis 5: The regional disparity is positively associated with TT in CDM.

3. Methodology

3.1. Data collection

In this paper, 500 recently-registered projects were chosen from the CDM pipeline by the end of 2010. There are 27 projects without credit buyers (unilateral project), or located in more than one province of China which were excluded and replaced by another 27 recently-registered projects. The information about host regions, project types, credit buyers, consultants, methods and planned annual reductions were listed in the CDM pipeline[2]. TT claims made by CDM projects participants can be seen in "Section A.4.3. Technology to be employed by the project activity" of their PDDs and other possible parts of PDDs are also covered in "Section A.2.", "Section A.4.2.", "Section B.5.", "Section B.7.", "Section E.", "Annex", *et al.*[3] Although a recent survey suggests that the actual rate of TT may be higher than it is reported in PDDs (Kirkman *et al.* 2013), this research follows the former empirical analyses using the TT information from PDDs, and only the projects with information confirming

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[2]   CDM pipeline can be downloaded from the website of UNEP RISØ CENTRE (http://cdmpipeline.org/).

[3]   See in the PDDs download from UNFCCC website using the titles of sampled projects. If there is no statement which confirms TT in "Section A.4.3.", the keywords "technology", "technologies", "transfer", "equipment", "service", "train", "serve" "supplier", "import", "manufacturer" are used to make this process more efficient. If no information is found, the whole PDDs are covered and been read accordingly. If there is any equipment and/ or knowledge from another country involved, it is recorded as involving TT.

TT are coded as involving TT. The form of ownership of Chinese participants and foreign project participants are verified by searching the Internet with the information of project owners and foreign participants in "Section A.3. Project participants" of PDDs.

3.2. Measurements

3.2.1. Technology transfer

The projects in number and estimated annual emission reductions can be used as crude proxies to measure TT (Seres, Haites 2008). This paper analyses the TT claims made by CDM projects participants in their PDDs. In the following regression analysis, if any foreign equipment and/or knowledge are employed in the project activities, a value of '1' will be assigned, '0' otherwise.

Overall, there are 195 projects out of the 500 CDM projects (about 39%) claimed TT. These 39% projects account for almost 61% of the estimated annual emission reductions which are 49,346 $ktCO_2$e per year out of all 80,948 $ktCO_2$e per year of the sampled 500 projects. The average size of projects involving TT and not involving TT are about 253.06 and 103.61 $ktCO_2$e per year, significantly different under independent-samples T test, $p < 0.01$.

3.2.2. Project sizes

In this paper, the project size is measured by the estimated annual emission reductions in terms of $ktCO_2$e per year. The projects are classified into small-scale and large-scale based on the methodologies used in calculating emission reductions. There are two projects used both small- and large-scale methodologies, which are classified as large-scale projects. Both the natural log of the estimated annual emission reductions and the classification of small-scale and large-scale projects based on the methodology of calculating emission reductions are used as the proxies of project size in the following regression analysis. The results of project size analysis are shown in Table 1.

Table 1. Project size analysis

| Size | Number of projects % | Annual emission reductions % | Number of TT projects % | TT projects as percentage of | | Average size ($ktCO_2$e per year) |
				Number of projects%	Annual emission reductions %	
Small-scale	25.40	5.35	11.28	17.32	19.89	34.093
Large-scale	74.60	94.65	88.72	46.38	63.28	205.412
Total	100.00	100.00	100.00	39.00	60.96	161.897

Table 1 indicates that over 74% of projects are large-scale, accounting for more than 94% of the annual emission reductions. More than 88% TT happen in large-scale projects. About 46% large-scale projects and only 17% small-scale projects involve TT, which means large-scale projects are indeed more likely to involve TT than small-scale projects. In large-scale

projects, about 46% projects involve TT accounting for about 63% annual emission reductions of all large-scale projects. In small-scale projects, about 17% projects involve TT which account for about 20%. The average sizes of small-scale and large-scale projects are 34.09 and 205.41 $ktCO_2e$ respectively per year, significantly different under independent-samples T test, $p < 0.001$.

3.2.3. Project types

According to UNFCCC, the CDM projects can be classified into 26 different project types, of which 15 are involved in this study. Limited by this sample, they are classified into four categories: 252 hydro projects, 156 wind projects, 27 EE projects and 65 other projects.[4] Three dummy variables are used to measure Hydro, EE and the Others with Wind as the base category. If the project is from one of the three categories except Wind, a value '1' is assigned, '0' otherwise. The variable Similar which is natural log of the projects in number using the same technology of the 15 project types in China, is used as a proxy of local mitigation technology availability of China in the regression analysis. Project type analysis is reported in Table 2.

Table 2. Project type analysis

| Type | Number of projects % | Annual emission reductions % | Number of TT projects % | TT projects as percentage of | | Average size ($ktCO_2e$ per year) |
				Number of projects %	Annual emission reductions %	
Hydro	50.40	36.28	32.31	25.00	40.93	116.547
Wind	31.20	25.65	36.92	46.15	46.06	133.118
EE	5.40	4.52	8.72	62.96	83.69	135.383
Others	13.00	33.55	22.05	66.15	90.95	417.796
Total	100.00	100.00	100.00	39.00	60.96	161.897

From Table 2, Hydro and Wind are the two main CDM project types in China, account for more than 81% projects. Hydro projects have the lowest rate of projects involving TT, only 25%. Though the TT rate of Wind projects drops in the recent years (Wang 2010), it still apportions about 46%. The EE and the Other projects have the highest TT rate, more than 63% and 66% of the projects involving TT and respectively account for about 84% and 91% of annual emission reductions. Except the high rate of TT in EE projects, the average size of EE projects is not much different with Hydro and Wind projects. The average size of the Other projects is significantly larger than Hydro, Wind and EE projects, tested by one-way ANOVA, $p < 0.05$. The Other projects category contains some very large projects such as HFCs and fossil fuel switch which all involve TT.

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[4]   The EE projects include 25 EE own generation and 2 EE households projects. The rest 65 projects include 13 landfill gas, 12 biomass energy, 11 coal bed/mine methane, 8 fossil fuel switch, 7 N_2O, 5 methane avoidance, 3 solar, 2 cement, 2 reforestation, 1 fugitive and 1 HFCs project. The four categories are classified with the limit of the sample.

In the end of 2012, 3,479 CDM projects in China are registered. There are 1,445 Wind and 1,244 Hydro projects, which are 42% and 36% of the 3,479 projects. The other projects are the 191 EE own generation projects, 132 solar projects and 121 biomass energy projects. The rest projects are less than 100 in each project type. The Wind projects are significantly growing in China. In the end of 2010, there were only 338 Wind projects registered. In 2011 and 2012, 477 and 473 Wind projects started their first CDM comment, and 274 and 833 Wind projects were registered.[5] The dynamic changes of Wind project located in China from 2005 to2012 are shown in Figure 1.

3.2.4. Form of ownership of Chinese participants

The CDM project involves the effect of the ownership of the project owners. According to the entities from the Chinese side, they are classified into three basic types of ownerships including SOEs, COEs and POEs. Two dummy variables are used to measure different ownerships in the following regression analysis with COEs as the base category. If the project is from one of the two categories except COEs, a value of '1' is assigned, '0' otherwise. The results of ownership analysis are reported in Table 3.

Table 3. Ownership analysis

Owner-ship	Number of projects %	Annual emission reductions %	Number of TT projects %	TT projects as percentage of		Average size (ktCO$_2$e per year)
				Number of projects %	Annual emission reductions %	
SOEs	73.40	73.15	80.51	42.78	61.52	161.343
COEs	17.60	11.73	9.23	20.45	29.48	107.867
POEs	9.00	15.12	10.26	44.44	82.71	272.069
Total	100.00	100.00	100.00	39.00	60.96	161.897

From Table 3, over 73% CDM project hosts are SOEs, accounting for the same amount of annual emission reductions. Over 80% TT projects are hosted by SOEs. But the projects hosted by POEs have the highest portion of projects involving TT, more than 44% and accounting for 83% annual emission reductions. The average size of the projects hosted by POEs is larger than projects hosted by SOEs, and significantly larger than projects hosted by COEs, tested by one-way ANOVA, $p < 0.1$.

3.2.5. Foreign participants

In this research, all the 500 samples are the projects with at least one credit buyer. There are 184 projects which involve foreign consultants in this sample. In 105 projects, the foreign consultants act as both the consultants and the credit buyers. There are 17 projects in which

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[5]   Data are collected from CDM pipeline. URL: http://cdmpipeline.org/

the foreign participants act as project developers or financers.[6] Thirteen out of the 17 projects hire foreign consultants, the rest 4 projects hire local consultants, and in two projects the foreign consultants also act as credit buyers. All the 17 projects are classified into the category of projects with foreign project developers. All samples are classified into the four categories. They are consultants (including 68 projects), consultants and buyers (including 103 projects), project developers (including 17 projects) and the Other projects (including 312 projects). Three dummy variables are used to measure different foreign participants in the following regression analysis with the Other 312 projects as the base category. If the project is from one of the three categories except the Other projects, a value of '1' is assigned, '0' otherwise. The results of foreign participant analysis are reported in Table 4.

Table 4. Foreign participant analysis

Foreign participant	Number of projects %	Annual emission reductions %	Number of TT projects %	TT projects as percentage of		Average size (ktCO$_2$e per year)
				Number of projects %	Annual emission reductions %	
Consultant	13.60	17.70	16.41	47.06	81.46	210.709
Consultant and buyer	20.60	23.46	27.69	52.43	70.46	184.370
Project developer	3.40	6.61	6.67	76.47	93.42	314.936
Other projects	62.40	52.23	49.23	30.77	45.64	135.500
Total	100.00	100.00	100.00	39.00	60.96	161.897

Except the technology suppliers and credit buyers, there are about 38% of the projects involve other types of foreign participants (consultants, consultants and buyers, and project developers). These projects have higher TT shares than the Other projects, and the TT projects in these three categories account for larger portions of emission reductions than the Other projects. Especially the projects in consultants and project developers categories, the TT projects account for 81% and 93% of the annual emissions reductions in each category. The average sizes of the project with foreign participants are much larger than the Other projects.

3.2.6. Disparity of host regions

In the host country, the regions or provinces have different economic development level and technology capabilities, which can influence TT in the projects. The GDP per capita (in 10 thousand of RMB) and the GDP growth are used as the proxies of local economic development, which are the average data of each province from 2006 to 2010.[7] The research

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6   In four of these 17 projects, the projects' foreign developers are also the financers.

7   Data is collected from China Statistical Yearbook published on the website of National Bureau of Statistics of China (http://www.stats.gov.cn/tjsj/ndsj/).

and development (R&D) investment (the average percentage of R&D per GDP from 2006 to 2010[7]) of each province and the ArCo technology indexes of each province[8] are used as the proxies of local technology capabilities. The variable Similar in province which is the natural log of the projects in number adopting the same type of technology in each province is used as the proxy of local mitigation technology availability in provinces in the following regression analysis.

In this paper, the CDM projects involve 30 regions/provinces in China. As National Bureau of Statistics of China stated, all the regions/provinces can be classified into four economic regions (NBSC 2011) according to their geographical locations, economic development and institutional environment.[9] The East is a region with a comparatively high level of economic and institutional development. The West is a region with comparatively low level of economic and institutional development. The development level of Midland is between the East and West. And the Northeast is a region of traditional heavy industry and large-scale agricultural production. There are 56% of the projects that are located in the West. The West region can be further classified into two sub-regions, which are the Mid-west (including Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan and Shaanxi) and the Wild-west (including Gansu, Xinjiang, Ningxia, Qinghai and Xizang). The results of host region analysis are reported in Table 5 and Table 6.

Table 5. Host region analysis

Region	Number of projects %	Annual emission reductions %	Number of TT projects %	TT projects as percentage of		Average size (ktCO$_2$e per year)
				Number of projects %	Annual emission reductions %	
Wild-west	12.80	10.46	11.79	35.94	54.40	132.334
Mid-west	42.80	36.02	35.90	32.71	42.00	136.262
East	20.40	30.64	28.72	54.90	87.23	243.136
Midland	16.40	15.13	14.36	34.15	60.32	149.398
Northeast	7.60	7.74	9.23	47.37	55.37	164.958
Total	100.00	100.00	100.00	39.00	60.96	161.897

From Table 5, more than 42% of the CDM projects are located in the Mid-west and account for about 36% of the annual emission reductions. Only 20% of the projects are located in the East but account for 31% of the annual emission reductions. More than one third of the TT

8   The ArCo technology index includes eight sub-indexes (a1 patens, a2 scientific articles, b1 internet penetration, b2 telephone penetration, b3 electricity consumption, c1 tertiary science and engineering enrolment, c2 mean years of schooling, c3 literacy rate) (Archibugi, Coco 2004). We can only acquire data of sub-indexes from 2009 and 2010. From the limited available data, we use the average of two years standardized indicators to compute the local technology capability.

9   NBSC (2011) stated that the East includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan; the Midland includes Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan; and the West includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Xizang, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang; the Northeast includes Liaoning, Jilin and Heilongjiang.

projects are located in the Mid-west, but the highest TT rates are in the East region. Over 54% of the projects in the East involve TT which account for 87% of the annual emission reductions in this region. The average size of projects located in the East is much larger than other regions.

Table 6. Regional disparity of China

	China	Min.	Max.	East	Mid-land	North-east	Mid-west	Wild-west
GDP per capita	2.23	0.97	6.45	3.45	1.84	2.63	1.95	1.48
GDP growth	13.43	10.58	17.60	12.77	13.23	14.23	14.29	11.39
R&D	1.00	0.26	5.35	1.39	1.04	1.17	0.82	0.82
ArCo index	0.24	0.12	0.84	0.40	0.20	0.27	0.19	0.19
Similar in province	2.78	0.00	5.02	1.85	2.00	2.06	3.69	2.62

Table 6 shows the regional disparity of China in economic development, local technology capabilities and local mitigation technology availability described by five variables. The GDP per capital of the East is 3.45 which is significantly higher than all other four regions. The GDP growth of the Wild-west is 11.39 which is significantly smaller than all other four regions. The R&D investment of the Mid-west and the Wild-west are both 0.82 which is significantly lower than other three regions. And the ArCo index of the East is 0.40 which is significantly higher than all other four regions. In the opposite, the values of the Similar in the provinces of the Mid-west and Wild-west are significantly larger than other three regions. All are tested by one-way ANOVA, $p < 0.001$.

The dynamic changes of the distribution of Wind projects and the distribution of all CDM projects in China are shown in Figure 1. Most of the 1,445 registered Wind projects are located in Inner Mongolia, Hebei, Shandong, Liaoning, and Ningxia. The number of Wind projects was growing very fast in these regions during 2011 and 2012. The Wind projects located in other provinces are fewer than 100 in each province. Most of the registered CDM projects are located in the Mid-west, the Wild-west, the Bohai Rim (Shandong, Hebei and Liaoning) and Hunan province.

4. Results and analysis

Table 7 shows correlations among variables. All the bivariate correlations are lower than the recommended 0.7 threshold. The variance inflation factors (VIFs) are below the recommended ceiling of 10 (Cohen *et al.* 2003). The individual variables can be used in the regression analysis.

The dependent variable has values of either '0' or '1'. The logistic regression analysis is used for the following regression analysis. The results are reported in Table 8.
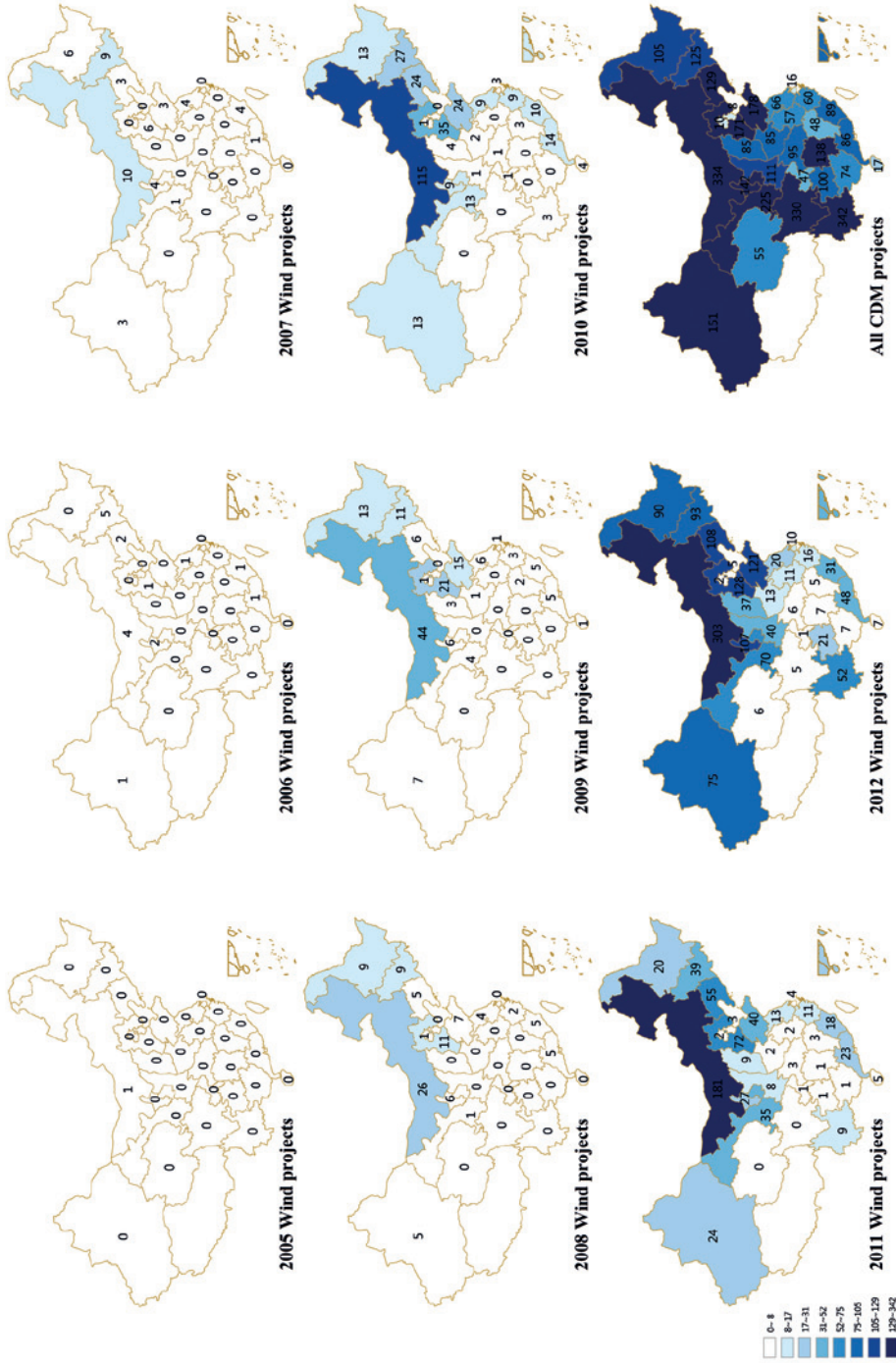
Fig. 1. The distribution of wind projects in cumulated numbers from 2005 to 2012 and the all registered CDM projects in China

Note: The numbers in the maps are the cumulated numbers of registered projects located in each province; these numbers are divided equally into eight ranks coloured by blue; the data is collected from the CDM pipeline.

Table 7. Means, standard deviations, VIFs, and correlations[a]

	Mean	Std. Deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 TT	11.41	0.95	1.000																
2 Project sizes	0.25	0.44	0.337	1.000															
3 Small-scale projects	0.50	0.50	-0.259	-0.663	1.000														
4 Hydro	0.05	0.23	-0.289	-0.271	0.358	1.000													
5 EE	0.13	0.34	0.117	-0.043	-0.017	-0.241	1.000												
6 Others	0.73	0.44	0.215	0.233	-0.062	-0.390	-0.092	1.000											
7 SOEs	0.09	0.29	0.126	0.137	-0.107	0.043	-0.048	-0.024	1.000										
8 POEs	0.14	0.34	0.043	-0.076	0.087	-0.088	0.179	0.102	-0.546	1.000									
9 Consultants	0.21	0.40	0.066	-0.045	0.077	0.020	0.112	0.090	-0.051	0.132	1.000								
10 Consultants and credit buyers	0.03	0.18	0.140	0.094	-0.025	-0.108	0.010	-0.006	0.009	0.037	-0.202	1.000							
11 Project developers	2.23	1.00	0.144	0.103	-0.084	-0.167	-0.045	0.321	-0.006	0.008	-0.074	-0.096	1.000						
12 GDP per capita	13.43	1.90	0.243	0.155	-0.185	-0.557	0.105	0.104	0.024	0.067	-0.028	0.110	-0.026	1.00					
13 GDP growth	5.15	1.27	0.006	0.069	-0.124	-0.275	-0.061	-0.114	0.071	-0.122	-0.125	0.168	-0.046	0.407	1.000				
14 Similar	1.00	0.50	-0.301	-0.230	0.133	0.536	-0.234	-0.676	0.037	-0.184	-0.128	0.020	-0.263	-0.226	0.037	1.000			
15 R&D	0.24	0.12	0.145	0.010	0.091	-0.037	0.113	0.137	-0.005	0.076	0.089	-0.019	0.028	0.383	-0.147	-0.144	1.000		
16 Local technology capability	2.78	1.42	0.228	0.113	-0.095	-0.420	0.138	0.174	-0.019	0.140	0.034	0.065	-0.018	0.606	0.100	-0.268	0.579	1.000	
17 Similar in province			-0.227	-0.025	0.033	0.400	-0.246	-0.558	0.015	-0.150	-0.095	0.064	-0.215	-0.229	0.235	0.695	-0.305	-0.390	1.000
Variance Inflation Factors VIFs[b]				2.072	2.096	2.818	1.477	3.550	1.481	1.584	1.120	1.120	1.175	6.797	2.453	4.551	1.886	5.157	2.811

Notes: [a] *N* = 500; [b] None of these correlations exceed 0.70 and all of the VIFs are much less than the recommended maximum threshold of 10.

Table 8. Results of logistic regression analyses

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
Constants	−8.329***	(2.15)	−6.061***	(2.34)	−5.039**	(2.46)	−7.975***	(2.27)	−5.689**	(2.55)
Project sizes	0.685***	(0.17)	0.695***	(0.17)	0.666***	(0.17)	0.738***	(0.18)	0.706***	(0.18)
Small-scale projects	−0.382	(0.38)	−0.385	(0.39)	−0.432	(0.39)	−0.369	(0.39)	−0.396	(0.39)
Project types: Hydro	−0.323	(0.30)	−0.132	(0.32)	−0.046	(0.35)	−0.072	(0.35)	0.025	(0.35)
EE	0.891*	(0.49)	0.343	(0.54)	0.298	(0.54)	0.648	(0.51)	0.280	(0.54)
Others	0.463	(0.39)	−0.608	(0.58)	−0.617	(0.59)	0.110	(0.45)	−0.629	(0.59)
Ownerships: SOEs	0.921***	(0.32)	0.866***	(0.32)	0.848***	(0.32)	0.858***	(0.32)	0.832***	(0.32)
POEs	0.829*	(0.45)	0.653	(0.46)	0.698	(0.46)	0.832*	(0.46)	0.704	(0.46)
Foreign participants: Consultants	0.689**	(0.31)	0.661**	(0.31)	0.667**	(0.31)	0.725**	(0.32)	0.694**	(0.32)
Consultants and credit buyers	0.849***	(0.27)	0.913***	(0.27)	0.954***	(0.28)	0.935***	(0.27)	0.974***	(0.28)
Project developers	1.522**	(0.66)	1.487**	(0.66)	1.445**	(0.67)	1.384**	(0.67)	1.402**	(0.67)
GDP per capita	0.469***	(0.14)	0.472***	(0.15)	1.143**	(0.49)	1.269**	(0.49)	1.262**	(0.50)
GDP growth	−0.151**	(0.06)	−0.159**	(0.06)	−0.232**	(0.09)	−0.197**	(0.09)	−0.222**	(0.09)
Similar			−0.419**	(0.17)	−0.454***	(0.17)			−0.369**	(0.19)
R&D					0.547*	(0.31)	0.447	(0.30)	0.513*	(0.31)
Local technology capability					−6.621*	(3.92)	−7.952**	(4.03)	−7.785*	(4.09)
Similar in province							−0.248**	(0.12)	−0.136	(0.13)
Pseudo R²	0.3479		0.3577		0.3642		0.3597		0.3658	
Correctly classified	81.00%		82.40%		82.80%		81.60%		82.80%	

Notes: Standard errors are in parentheses; $N = 500$; * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 9. Results of logistic regression analyses, with Wind projects only

Variables	Model 6		Model 7		Model 8	
Constant	4.372	(5.70)	−2.777	(4.82)	5.159	(6.27)
Project sizes	0.262	(0.40)	0.311	(0.40)	0.240	(0.41)
Small-scale projects	−0.076	(1.23)	−0.266	(1.24)	−0.056	(1.22)
Ownerships: SOEs	0.565	(0.46)	0.681	(0.45)	0.562	(0.46)
POEs	−0.780	(1.02)	−0.799	(1.02)	−0.768	(1.01)
Foreign participants: Consultants	−0.210	(0.72)	−0.248	(0.71)	−0.219	(0.72)
Consultants and credit buyers	1.175***	(0.44)	0.921**	(0.42)	1.168***	(0.44)
Project developers	0.406	(1.09)	0.375	(1.11)	0.419	(1.09)
GDP per capita	1.328*	(0.73)	1.668**	(0.82)	1.198	(0.85)
GDP growth	−0.290*	(0.15)	−0.248	(0.15)	−0.299*	(0.16)
Similar	−1.238**	(0.55)			−1.358**	(0.68)
R&D	−0.036	(0.56)	−0.069	(0.54)	0.010	(0.59)
Local technology capability	−4.537	(6.09)	−6.871	(6.45)	−3.692	(6.70)
Similar in province			−0.308	(0.28)	0.109	(0.36)
Pseudo R^2	0.2711		0.2519		0.2715	
Correctly classified	77.95%		74.10%		78.59%	

Notes: Standard errors are in parentheses; $N = 500$; * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

From Table 8, the results of Model 1 indicate that TT commonly increases with project sizes. EE projects are significantly more likely to involve TT than Wind projects. TT is significantly more likely to happen in the project hosted by SOEs and POEs than COEs. The projects with foreign participants which act as consultants, both the consultants and credit buyers, and the project developers are significantly more likely to involve TT. The projects hosted in the regions with high GDP per capita are significantly more likely to involve TT, such as projects in Chinese Eastern provinces. But the TT possibility is significantly negatively related to the host province's GDP growth rate. Of the five hypotheses, four are well supported by the results of Model 1 except Hypothesis 5.

In Model 2, the variable Similar is added. The results of Model 1 are stable, except the significance of project types which becomes weak. Similar is a variable which has stronger influence on TT in CDM projects than project type. TT is significantly negatively related to the number of projects using the same type of technology.

In Model 3, the R&D and Local technology capability are added. The results of Model 1 and Model 2 are stable. The TT possibility is significantly positively related to the R&D investment of the host province, but significantly negatively related to Local technology capability.

In Model 4, the variable Similar is substituted by Similar in province. The result of Model 1 and Model 2 are stable. The TT possibility is significantly negative related to Similar in province. In Model 5, both Similar and Similar in province are added. The significance of Similar in province becomes weak. Other results are stable.

In Table 9, the regression models only include 156 Wind projects. The relation between TT and Similar in province becomes not significant, but the Similar is still significantly related to TT.

Robust tests are conducted. When the GDP per capita is substituted by log of GDP, log of FDI, or log of export and import, the results of the regression models are stable. And it is shown in Model 1 that Hydro projects are significantly less inclined to involve TT than Wind projects. When the Local technology capability is substituted by the percentage of tertiary educated local population, the results of the regression models are stable. Other influence of regional disparity have also been considered, such as the percentage of fossil fuel in local energy consumption, the local resource consumption (the log of energy consumption and the log of water consumption), the local pollution control investment, and the local emission compliance (the pollution control percentage of industrial wastewater discharge, industrial and domestic emissions, industrial solid waste disposal, and domestic rubbish disposal).[10] The variables are added in the regression model, the results are still stable. TT is significantly positively related to fossil fuel percentage and energy consumption, but negatively related to pollution control investment, the pollution control percentage of industrial and domestic emissions, and the pollution control percentage of industrial solid waste disposal. Four dummy variables East, Northeast, Mid-west and Wild-west are used as the proxies of regional disparity, with Mid-land as the base category. When other regional variables are substituted by these four dummy variables, the regression results are still stable. It is shown that Hydro projects are significantly less inclined and projects located in the East region are more inclined to involve TT.

5. Discussion

Project sizes are one of the main factors affecting TT in CDM projects. Large-scale projects can obtain more financial support and have more opportunities in gaining investment to use advanced mitigation technologies because large-scale projects can supply CERs more steadily than small-scale projects. Globally, about 40% of CDM projects are small-scale projects, about 25% of small-scale projects involve TT and overall 40% of projects involve TT (Seres *et al.* 2010; UNFCCC 2013). In China, only 25% are small-scale projects, 17% of small-scale projects involve TT, and the overall percentage of TT is about 39% which is close to the global level. The percentages of small-scale projects and its TT in China are comparatively low. This means that the large entities in China are more likely to implement CDM projects and involve TT than small entities. This also means that the mitigation potential of small-scale projects is not fully explored in China. In small-scale CDM projects, the transaction costs of CDM and TT has a higher impact on its commercial viability than in large-scale projects at current

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[10]   The average of five years' data is used, which from 2006 to 2010. Most of the data is from China Statistical Yearbook published on the website of National Bureau of Statistics of China. URL: http://www.stats.gov.cn/tjsj/ndsj/. The fossil fuel consumption data is from China Energy Yearbook 2011.

CER price (Das 2011; Dechezleprêtre *et al.* 2008, 2009; Schneider *et al.* 2008). And CDM is criticized for its project-by-project crediting process which is inefficient to avoid dangerous climate change (Lewis 2010). To reduce the transaction costs of mitigation activities and in response to these criticisms, bundling and programming are allowed in CDM (Lewis 2010). But these forms of activities are not widely used in CDM. Till the end of June 2013, there were only 220 programme activities registered and only 33 of them were located in China (UNFCCC 2013). The increasing implementation of these reformed activities will help to explore the mitigation potential of China. But it still needs flexible and diversiform emission reductions. To maintain the integrity of the emission reduction credits in the more flexible and diversiform crediting forms, the future mechanism should devote to the reduction of the asymmetric information between the participants and regulator (MacKenzie, Ohndorf 2012).

TT is different among CDM project types in China. EE projects are more likely to involve TT than wind projects. This category includes the project types (EE own generation and EE households projects) which are new in China, for more than 81% CDM projects in China are Hydro and Wind projects. The technologies of these new types of projects are not available in the local market or inefficient as foreign technologies. China is the main hydro technology supplier for CDM projects in the world (Seres *et al.* 2010). Most of the hydro technologies are locally available. The Hydro projects hosted in China do not incline to adopt foreign technologies than other project types. There are still about 25% of Hydro projects involving TT. This is the result of the efficiency, quality or other virtues of foreign technologies. Wind projects are more likely to involve TT than Hydro projects, but still less likely involve TT than EE and Other projects. The large-scale wind farm plans and the local content requirements of the Chinese government significantly spur the localization of wind turbine manufacture, but the inferiority of components' quality still troubles the local turbine providers in China (Wang 2010). Hence, there are still about 46% of the Wind projects involving TT. The Other projects category includes some very large projects, such as HFC and N_2O projects. But it doesn't show that the project types have any significant influence on TT in CDM projects. There are about 66% of projects in this category involving TT for their large project sizes, not for their project types. The influence of project types becomes weak when the variable Similar is added into the regression model. Similar is a proxy of local mitigation technologies availability of the 15 project types in our sample. It shows that TT is significantly negatively related with the number of projects in the same type. The more projects are implemented, the later projects in this type are more inclined to use local technology, especially for wind projects which grow very fast in China. The GHG mitigation potential of EE and Other project types have not been fully explored in China. Giving policy support of TT in these project types will help explore the mitigation potential. When the number of projects of certain types is small, the policies, such as tax relief for these projects or lowering tariff on foreign equipment, will help spur their development and increase the possibility of involving TT. When the number of projects in this type is growing, policies, such as the requirements of local content levels or the use of local equipment, will help spur the localization of foreign advanced technologies and promote local technology diffusion.

The form of ownership of Chinese participants is a significant factor which influences TT in CDM projects in China. Projects hosted by SOEs and POEs are more likely to involve TT

than COEs. Most SOEs are very large and in a monopoly position nationally or locally. They have advantages in financing mitigation activities (Xu *et al.* 2012; Zeng *et al.* 2012), gaining support and resources from the government, and obtaining investment and long term loans, which make them more capable to involve TT than POEs. POEs can gain the least support from the government and banks, but they are more likely to involve TT than COEs. There are only 9% of the 500 CDM projects hosted by POEs and only 20 of them involve TT. It is hard to exclude that these projects may actually be very special and they may be hosted by POEs which have some similar attributes as SOE, e.g. some EE and cement projects are hosted by large-scale POEs. The advantages of SOEs cannot be learned entirely by other enterprises. POEs and COEs should implement mitigation projects according to their actual needs and capabilities. If the government supports the mitigation activities according to the importance and actual need of projects other than enterprise's ownership, the results will be better for both mitigation activities and public resources efficiency. Nearly three quarters of the CDM projects in China are hosted by SOEs. The participations of non-SOEs in mitigation activities are insufficient. The institutional and market infrastructure which inspire both SOEs and non-SOEs are very important to promote economic developments in China, and are also important to fully explore the mitigation potential of China.

In addition to the credit buyers, some types of foreign participants are important to increase TT possibility in bilateral CDM projects, which are foreign consultants, both consultants and buyers, and project developers. The entities from the Annex I countries which participate in CDM projects more than being credit buyers in these ways, cannot only promote the transfer of advanced mitigation technologies to developing countries, but also reduce the asymmetric information between CER buyers and suppliers. It is good for enhancing the environmental integrity of the CER suppliers, but may increase the risk of losing control of the integrity of the CER buyers and widening the information gaps between the participants and regulators. Today, only Chinese or Chinese holding companies can be the host of CDM projects in China (NDRC *et al.* 2005, 2011). The Chinese government should encourage additional foreign participants to engage in mitigation activities in China, but should also enhance their abilities to supervise these activities.

The projects located in the developed regions, such as Chinese Eastern provinces, can easily involve TT. The general explanations are that the developed regions have better financial ability to support the utilization of foreign technologies, have better ability to access the information of these foreign technologies, are much easier to access capital, gain more support from the government for their environmental conservation activities, and even have better local technology capabilities which facilitates the use of foreign technologies than other regions (Zeng *et al.* 2010a, b). However, additional findings have been obtained in this research. The high level of economic development indeed can increase the possibility of TT in CDM projects. But high economic growth may reduce this possibility. This might be for the reason that the high economic growth is earned by increasingly investing resources in economic growth and reducing the investment of resources in environmental conservation. The local technology capability in China is in a relatively high level which can reduce the possibility of TT, because the technologies are already available locally. But the R&D investment is still one of the positive factors that influence TT in CDM projects. The influence

of Similar in province on TT is much weaker than Similar. This implies that the mitigation technologies are diffused at the country level rather than the province level, though it might be diffused at the province level first, such as the number of Wind projects first increases in Inner Mongolia then in the whole country as shown in Figure 1. In general, the advantages of the developed regions cannot be copied by all other local governments and enterprises of the undeveloped regions, which are limited by their geographical locations, technology capability, as well as economic and institutional development (Xu *et al.* 2012). Cooperating with companies or institutions from developed regions is a good way of CDM project hosts from other regions to take advantage of economic, technological and institutional development of the developed regions. The cooperation of different regions can help explore the mitigation potential of undeveloped regions and promote the mitigation technology diffusion in China.

Conclusion

This article focused on GHG mitigation technologies transferred by the CDM in China. China as one of the biggest developing countries with fast economic growth plays a significant role in GHG mitigation. Technology is an important and irreplaceable factor in striking a balance between economic development and environmental conservation. The Chinese government has tried its best to promote the mitigation of TT to China.

CDM project characteristics (such as project sizes, project types, the form of ownership of Chinese participants, and the participation of foreign companies) and the characteristics of host regions (such as economic development levels, local technology capabilities, and local mitigation technologies availability) can affect the possibility of TT in CDM projects. The projects in large sizes, of comparatively new project types (like EE own generation and EE households projects), hosted by SOEs, or with foreign participants (such as foreign consultant and project developer), are more likely to involve TT. It was clear that the projects located in the comparatively-developed regions such as Eastern China are more likely to involve TT than in other regions, because of their advantages in economic development and R&D investment.

In addition to the above results, three lessons were identified. First, the non-SOEs rarely participate in mitigation activities in China. More than 73% of CDM projects were hosted by SOEs. The non-SOEs are significantly growing in China, which nearly 72% of the industrial outputs were produced by non-SOEs in 2008 (NBSC 2009). If mitigation activities of non-SOEs are supported by the government policies and banks equally as SOEs, these activities and technology transfer of non-SOEs will immensely be spurred. Second, the mitigation potential of CDM projects in EE and Other projects categories was not fully explored in China. More than 81% of CDM projects in China were Hydro and Wind projects with only 18% of CDM projects being EE and Other projects. The mitigation potential of these CDM projects can extensively be explored by the transfer, utilization and development of new mitigation technologies. Third, some projects are growing very fast and the technologies are widely diffused and localized in China, such as Wind projects. It is important to develop mitigation technologies locally and promote the mitigation activities, but the Wind projects in recent years are growing too fast in China (Li 2012). The rate of abandoned wind energy is very high, which is about 11.12% on average and about 22.99% in Inner Mongolia at the end of 2011 in official documents (Li 2012), and is

unofficially estimated as high as 40% to 50% in the middle of 2012 (Tong 2012). The current crisis of the photovoltaic industry (Liu 2012) and the recent deficit of wind turbine manufacture industry combining with the high rate of abandoned wind energy in China demonstrate that with the absence of general plans and industrial regulations on the mitigation activities, the fast growth rate can end in tragedy. When the government signals the policy preference on mitigation technologies and green energy, the capital will flow into these industries and trigger rapid growth in these industries, which may result in overcapacity and industry crises. If the government has not prepared for the fast growth rate and no general plan to regulate the growth, the faster the growth, the more serious the crises it will trigger.

Other developing countries can learn from China. First, the mitigation activities should cooperate with the country's resource endowment and industrial development. Before the implementation of CDM projects, the Chinese government has invested a lot of money in investigating and exploiting hydro resource. The CDM helps further explore the mitigation potential of hydro power in China. If the country has no such resource endowment or has no adequate local technology capability to use the mitigation technology, the CDM cannot help much to explore the mitigation potential of the country just using CER income or TT. Second, the implementation of mitigation activities should accommodate the country's development. The expansion of large wind farms in China is much beyond the absorption capability of the Chinese market. The CDM does support the development of local mitigation activities, but it cannot support the development of the whole industry of a country, such as wind energy in China.

CDM was criticized for its problems in excluding new projects, its inefficiency in GHG emission reductions, its insufficiency in supporting sustainable development, and its negative effects on the development of domestic low carbon policies in developing countries and the low-carbon transformation in developed countries (Lewis 2010; Vasa, Neuhoff 2011). Some new mechanisms need to be effective, encourage mitigation actions, eliminate bottlenecks and bureaucracy, and maintain the integrity of emission reduction credits (Lewis 2010). When the new mechanisms are not established and matured, CDM will still play a significant role in GHG emission reduction in its present or reformed structures (Bakker *et al.* 2011).

Further research is required in several areas. Some factors which may have important influence on TT are not sufficiently discussed in our study, such as the regulation of local government on environmental conservation activities, the regional disparity of institutional development, the technology capability of project owners with different ownerships. Local mitigation technology capability is not directly measured only using the number of similar projects as a crude proxy, and it has not been sufficiently discussed in this study. Besides these issues, improving the efficiency of TT in/by CDM and the reforming of CDM are interesting issues which need to be explored in further studies.

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