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A Note on the Additionality of Chinese CDM Wind Power Projects

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Abstract

In order to assess the additionality of CDM wind power projects in China, this paper exploits the fact that CDM projects co-exist with wind farms that are not registered under the mechanism. We use quantitative data to characterize the differences between both types of projects and investigate whether these differences may be related to project economic returns. In particular, we estimate a profit model which yields the conclusion that the average CDM project is not additional as its internal rate of return is similar to the rate of the average non-CDM project.

Key-words: Clean Development Mechanism, additionality.

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1 Introduction

The Clean Development Mechanism is a key component of the Kyoto Protocol[1] for it gives flexibility to carry out the mitigation efforts where cost is the lowest, particularly in emerging economies. The CDM was also intended to contribute to the sustainable development of the host countries and to focus developing countries on domestic mitigation opportunities while they have no emissions reduction targets during Phase 1 (2008-12) of the Kyoto protocol. However, since carbon credits created by the CDM are used by developed countries as offsets to meet their own domestic mitigation targets under Kyoto, it is important that CDM projects result in "additional" reductions in emissions to maintain the environmental integrity of the Protocol. By definition, a CDM project activity is additional if "anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity"[2].

Establishing additionality thus requires constructing a baseline scenario predicting the level of emissions in the absence of the CDM project. A project will then be declared additional if it cuts emissions below this threshold due to the financial support the CDM provides. The additionality demonstration is carried out by project developers in Project Design Documents (PDDs). PDDs are among standard documents used by the UN's CDM Board to decide whether the project can be registered. However, establishing emissions baseline is an imperfect science. It can sometimes be difficult to know whether a project is likely to have occurred anyway in the absence of CDM financing. Of course, those who draft these documents have incentives to overestimate baseline emissions in order to increase the quantity of CERs granted to the project. Several recent studies have sought to investigate the question of additionality in the CDM.

Wara and Victor (2008) recently published a much debated study in which they express strong doubts over the additionality of many CDM projects, in particular HFC-23 projects and

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[1] Note that the operational rules for the CDM were set up in 2001 at the COP-7 in Marrakech.
2 Report of the Conference of the Parties held in Montreal in 2005, decision 3/CMP.1, paragraph 3

projects in the Chinese energy sector. Barbara Haya (2007) from International Rivers Network makes the same point about Chinese hydro power projects while Lambert Schneider (2007) claims that additionnality is unlikely or questionable for roughly forty percent of the registered CDM projects. These works have spurred intense discussions in the negotiation arena as CDM-like projects will probably survive in the post-Kyoto regime.

In this paper, we seek to make a contribution to the debate with a systematic analysis of new quantitative evidence on CDM wind power projects in China[3]. Judging the additionality of a given project is a difficult task for an external observer as the counter-factual – ie the emissions that would have occurred in the absence of the project – is, by definition, not observable. But wind power in China has a feature which facilitates a more thorough analysis than has been previously offered in the literature on additionality: CDM wind projects co-exist with wind farms that are *not* registered under the mechanism. It is safe to assume that non-CDM farms are not additional as they have been implemented without the CER revenue. This implies that, if additional, CDM projects cannot but differ from non-CDM projects. In this paper, we use quantitative data to characterize the differences between both types of projects and investigate whether these differences may be related to project economic returns. In doing so, we will thus be able to draw conclusions about the additionality of Chinese CDM wind projects. Albeit basic, this approach is more sophisticated than the methodologies implemented in previous studies (Lambert Schneider, 2007; Wara and Victor, 2008; Haya, 2007).

The paper is organized as follows. In Section 2, we provide a contextual framework by briefly describing the wind power sector in China and the domestic policies which promote its development. Section 3 assesses the quality of the additionality demonstration in the Project Design Documents of the 64 Chinese wind power projects that had been registered as of May 2008. In

[3] China's wind power CDM projects obviously do not account for the diversity of the CDM projects over the world. Still, China is the most important host country with 39% of the CDM projects in the world, before India (25%) and Brazil (8%). And wind farms represent 21% of Chinese CDM projects (UNEP-RISOE CDM Pipeline and database, Sept. 2009)

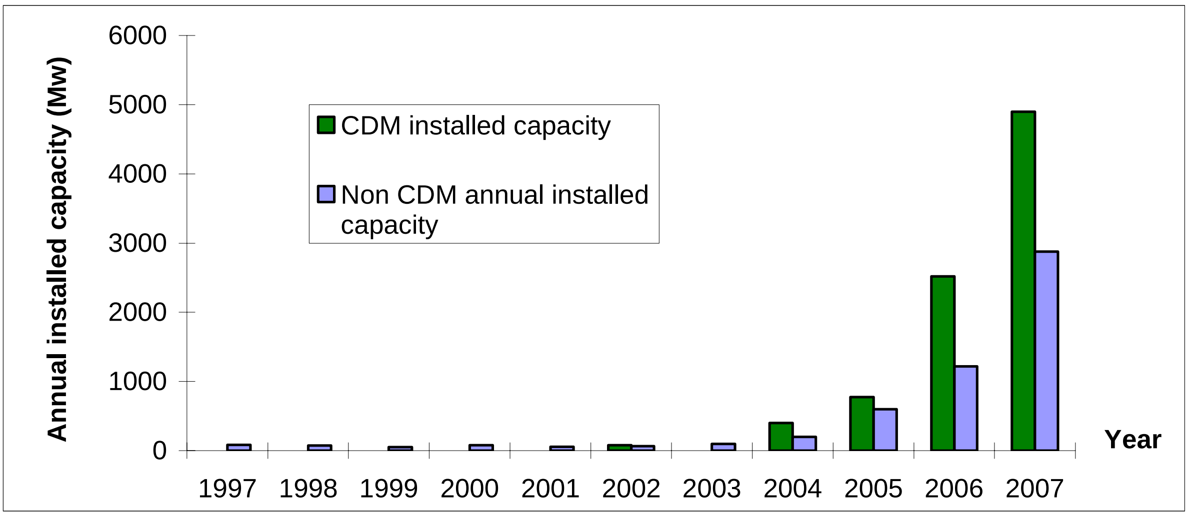
Section 4, we use quantitative data to compare the nature of CDM projects with those of non-CDM projects. Section 5 develops a basic model to simulate the economic return of a wind power project. The model is used to compare the profitability of both types of projects. Section 6 gathers the main findings.

2 The development of wind power in China

The Chinese wind power installed capacity started to boost in 2004. Since then, the cumulative capacity is more than doubled each year as shown in Figure 1. Most importantly for our analysis, around 40% of the capacity installed each year corresponds to projects not registered under the Clean Development Mechanism.

These figures are impressive, however wind only accounts for 0.8% of the sources of power generation in 2007. Nevertheless, China plans to have 100 GW of wind power in installed capacity 3.by 2020, as compared to 12GW at the end of 2008, and to generate 15% of its energy from renewables.

Figure 1 - Evolution of the CDM and non-CDM annual wind added capacity in China from 1997 to 2007



Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects

The development of wind energy is mainly driven by public policies which do not differentiate CDM and non-CDM projects. Feed-in tariffs mandating grid operators to purchase the wind electricity generated were introduced in 1988. But they remained too low until the beginning of the 2000s to induce a significant growth of wind energy. Since 2003, the tariffs are different for small farms of less than 50 MW of installed capacity than for bigger ones. For small farms, the electricity tariffs are fixed by provincial governments and approved by the National Development and Reform Commission (NDRC)[4].

In contrast, the central government determines the electricity tariffs for installations of over 50MW through competitive auction, with the developer offering the lowest electricity price winning the tender. The concession lasts for 25 years and the bid price is guaranteed as a feed-in tariff for the first 30,000 full load hours achieved. Depending on the site's wind resource, this could cover about 10-15 years. This competitive auction bidding has frequently led to lower prices than the fixed feed-in tariffs for smaller farms. As a result, these projects are now too risky for developers other than public companies (Recknagel, 2008).

Other economic incentives are a reduced Value Added Tax (VAT) for wind generation equipment (8.5 percent instead of 17 percent) and a reduced income tax for wind projects (15 percent instead of 33 percent).

Finally, to help develop a local industry, the NDRC indicated in 2005 that all of the turbines installed in China should have 70% local content (Baker and Mc Kenzie, 2007.). This means that wind power projects must have over 70% of their wind turbine components locally made, and the wind turbine generator (WTG) must be assembled in China.

[4] 2007 and 2008 China Wind Report; http://www.gwec.net/uploads/media/wind-power-report.pdf
http://www.gwec.net/fileadmin/documents/Publications/Report_2008/Global_Wind_2008_Report.pdf

Figure 2 clearly shows that this policy design has strongly influenced the size of wind farms, with a high proportion of projects in the 45-50 MW capacity range. These projects can exploit economies of scale but without going through the competitive bidding process.

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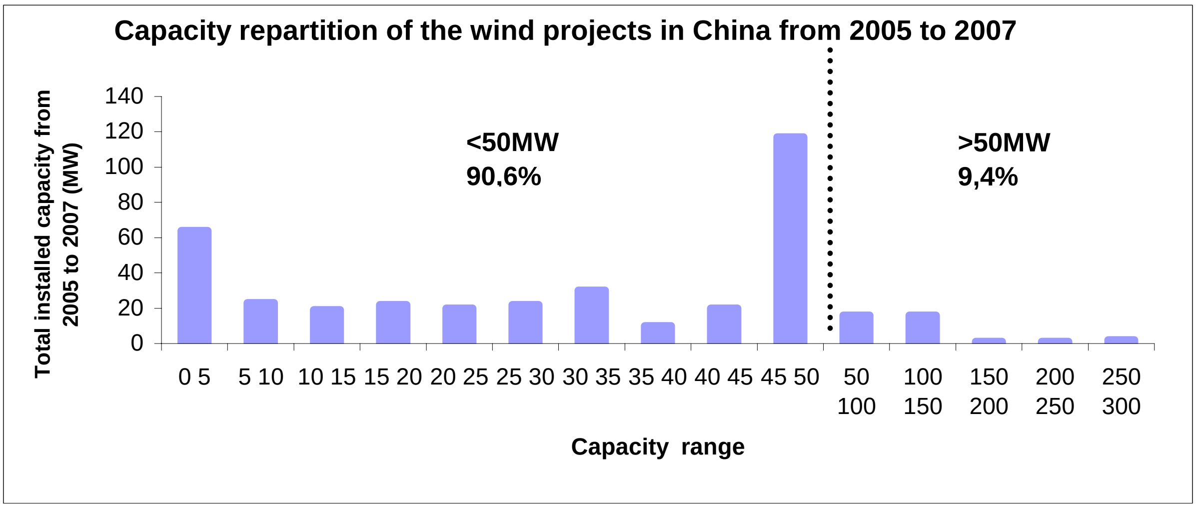
Figure 2 - Capacity distribution of the wind projects in china from 2005 to 2007



Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects

As mentioned previously, all these measures and incentives apply to any projects whether it is registered under the CDM or not. But there also exist specific measures for CDM projects, whether it is a wind farm or not. First CDM revenue is taxed by the government. However, as renewable energy projects are in the priority area[5], the tax rate on CER transfer benefits is only 2% whereas the rate is for example 30% from nitrous oxide projects (N2O) and 65% from HFC and PerFluoroCarbon (PFC) projects. This suggests very limited impact on CDM project profitability. Besides, the project has to be at least 51% Chinese-owned in order to qualify as a CDM-project. This effectively forces foreign investors to hand over control of the project to a Chinese partner. But it is unclear whether this damages or improves wind farms' economic returns.

3 Additionality demonstration in Project Design Documents

A careful examination of Project Design Documents is an obvious way to investigate the profitability of CDM projects as they all include a demonstration of the project's additionality. All but four registered wind power CDM projects in China rely on the same guidelines to determine additionality: the methodology ACM0002. This comprises the "Consolidated baseline methodology for grid-connected electricity generation from renewable sources", the "Tool to calculate the emission factor for an electricity system" and the "Tool for the demonstration and assessment of additionality". In CDM parlance, a methodology is a standard procedure agreed by the CDM board which describes in detail how to establish additionality in Project Design Documents.

The overall principle of the methodology used for wind power projects is simple. Emissions reductions are calculated by multiplying the electricity generated by the wind farm with an emissions factor which can be calculated in different ways. In practice, most projects use a factor equal to the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the same regional grid[6]. That is, the baseline scenario corresponds to the continuation of the current average situation. Then the non-profitability

[5] Defined in article 4 of the "Measures for Operation and Management of Clean Development Mechanism Projects in China", in 2005 by the National Coordinating Committee on Climate Change (NCCCC)

[6] Regional grids are officially defined by the Chinese DNA (Office of National Coordination Committee on Climate Change).

of the project is established by comparing the Internal Rate of Return (IRR) without CDM revenue and a benchmark rate.

How is this method implemented in existing Project Design Documents? The overall quality of the documents is satisfactory.[7] They all give many details on the calculations-which can easily be replicated and justify the (numerous) assumptions. They all use the same benchmark financial rate of 8% which is said to be the official rate to assess investments in China power industries[8]. In addition to this, a sensitivity analysis is usually performed.

Table 1 compares the IRR calculated with and without revenue for 62 CDM projects. As expected, the 8% financial benchmark lies in between the mean value without CER and the mean value with CER incomes, which indicates that these projects are not profitable without CDM revenue, but become profitable with this revenue.

The variability of the IRR is quite low (standard deviation of 0.61% without CER and 0.74% with CER incomes) because only a project with an IRR that might go from under 8% to over 8% with the CER incomes can apply for CDM registration with reasonable chances to be accepted. The IRR of the applying projects are then all close to 8% but still below.

Table 1 - Comparison of the IRR with and without CER incomes for 62 Project Design Documents (PDD) registered between 2003 and 2009

	IRR without CER	IRR with CER
Mean	6,75%	9,01%
Standard deviation	0,61%	0,74%

Source : the PDDs

[7] Our judgment differs from that of Lambert Schneider (2007) who states that, ofn the 93 projects that he studied over the world, “about 30% of the projects using the investment analyses […] do not provide the necessary information to repeat the calculation or understand the assumptions.”. But the sample is different: they Schneider considers randomly chosen projects across all sectors and countries whereas we only examine wind power projects in China.

[8] “With reference to the Interim Rules on Economic Assessment of Electrical Engineering Retrofit Projects, the financial benchmark rate of return (after tax) of China’s power industries is 8% for the IRR of total investment or 10% for the IRR of equity. Presently, the financial benchmark rate of return is used in the analysis of wind power projects in China. Source:http://cdm.unfccc.int/UserManagement/FileStorage/JL694VF0I1STX3G7M3RL8W0TMHVOAR

In some PDDs, the quantitative assessment is supplemented by a more qualitative analysis of the barriers which hinder the investment. The most-frequently mentioned barrier is the use of new technologies which is said to present a financial risk: those new - and often imported - technologies supposedly lead to higher maintenance cost because there are no spare parts in China. Another barrier is high initial investment cost. This sounds reasonable as wind power is particularly capital-intensive compared to other energy sources.

Although the assessment carried out in most PDDs is clearly explained, the validity of the assumptions underlying the calculations is not easily verifiable by an external observer. For instance, the PDD of Project 1446 (Liaoning Xingcheng Haibin Wind Farm Project) claims that total investment is RMB 441.13 million with an equity/debt ratio of 20/80 while operational and maintenance costs are equal to RMB 9.9485 million per year[9]. How is it possible to check the validity of these figures? It is simply not possible to reach a firm conclusion on actual additionality based solely on information available in PDD. In the next section, we try to overcome this difficulty by comparing CDM and non-CDM projects.

4 Comparison of CDM and non-CDM wind farms

A straightforward method to assess the reliability of PDDs would consist in comparing the profitability of CDM projects with that of non-CDM projects. Unfortunately, data is lacking for doing so. Thus, our approach sought to try to indirectly do so with data on non-CDM projects provided by the China Wind Power Center[10]. This data gives us the following information on all non-CDM projects started between 2002 and 2007:

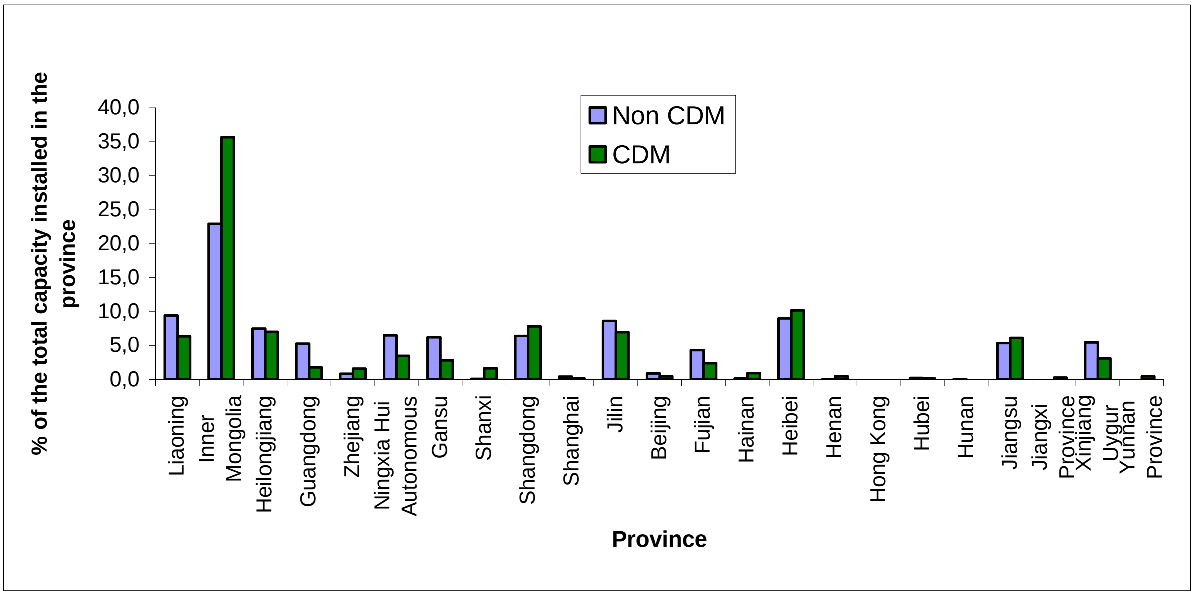
- Starting date
- Location, by province

[9] Note that all PDDs assume zero transaction costs although the size of these costs is viewed as the main drawback of the CDM approach.
[10] Available at http://www.cwpc.cn/cwpc/en/information/reference/database/windfarms

- Total installed Capacity (MW)
- Number of turbines
- Turbine size (kW)
- Turbine manufacturers

Albeit limited, this information can give indications on the comparative profitability of CDM and non-CDM projects. Let us consider first the location variable. Figure 3 compares the installed capacity of CDM and non-CDM wind farms in the different provinces. The share of CDM projects varies significantly across regions. If we restrict our attention to the ten provinces whose total capacity exceeds 500 MW, the share of CDM projects ranges from 49% in Gansu to 75% in Inner Mongolia.

Figure 3- Cumulative installed capacity of CDM and non-CDM projects, by province.

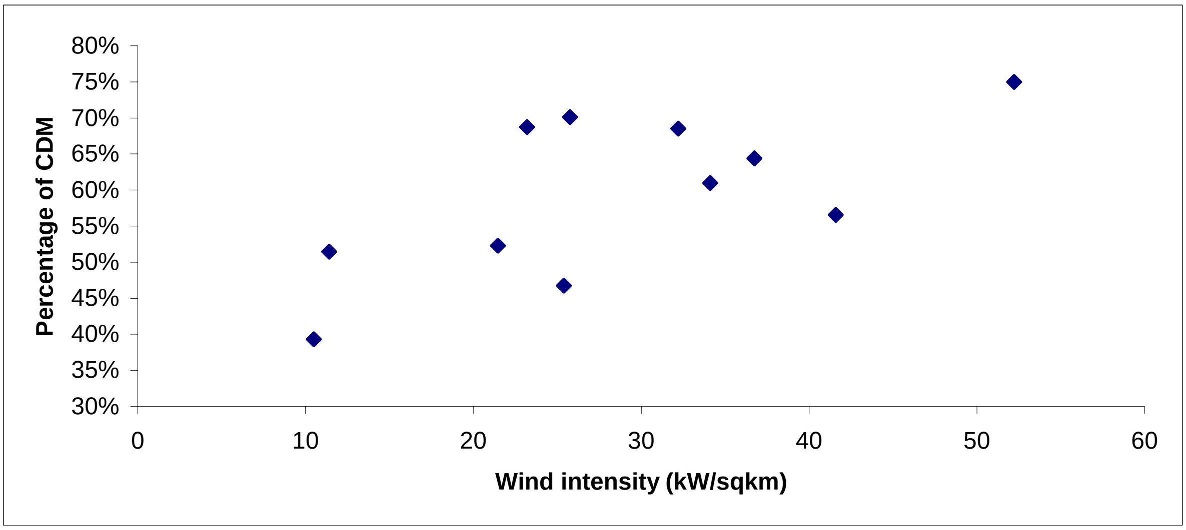


Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects

Can this distribution pattern reflect differences in wind power profitability? Location is potentially related to two factors that influence a project's economic return: the wind potential, which varies much across Chinese provinces, and feed-in tariffs, which are determined at the regional level as explained above. These two factors may be considered independent from each other as they are weakly correlated.[11]

Figure 4 relates the percentage of CDM in a given province to its average wind resource potential.[12] We would expect this percentage to be higher in the low potential provinces as it reduces the profitability and thus justify the need for CER incomes. But the proportion of CDM is actually higher in the high potential provinces. This is partly due to the high proportion observed in Inner Mongolia.

Figure 4 - CDM/non-CDM ratio as a function of provinces' average wind intensity



Each point represents a province. The wind intensity has been calculated by dividing the province wind potential by the provinces' area. Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects and **http://www.newenergy.org.cn/english/wind/resource/** for the wind potential.

Then Table 2 compares the average tariff in CDM projects with the average tariff across all types of projects in twelve provinces. There is no clear-cut specificity of CDM projects: tariffs in CDM projects are higher or lower than in the average wind projects, depending on the province. On average, the difference is -0.02 RMB/kWh, which is not negligible (3.6%). Besides, the deviation

[11] According to our calculations, the bivariate correlation coefficient on wind potential and average electricity tariffs is -0.29.

[12] Note that this potential is just indicative as wind potential is very heterogeneous within each province.

from the average can be huge (e.g., -0.16 in Guangdong). Contrary to the wind potential, this (slightly) supports the demonstration of additionality.

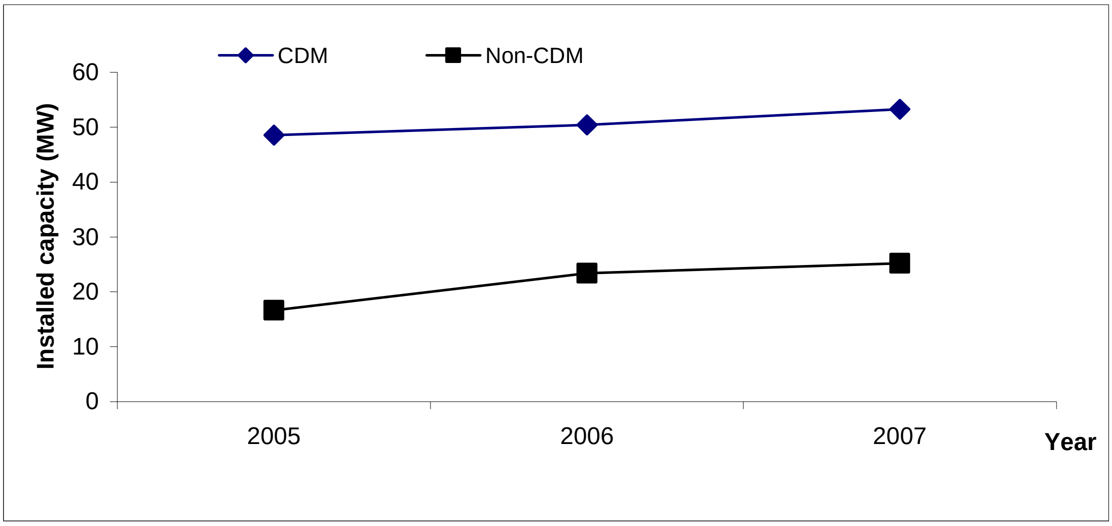
Table 2 - Average tariffs in all projects and CDM projects in twelve provinces (RMB/kWh)

Province	CDM (1)*	All projects (2)**	Difference (1)-(2)
Fujian	0.54	0.58	-0.04
Gansu	0.56	0.54	0.02
Guangdong	0.52	0.68	-0.16
Hebei	0.61	0.54	0.07
Heilongjiang	0.63	0.61	0.02
Inner Mongolia	0.52	0.53	-0.01
Jiangsu	0.48	0.48	0.00
Jilin	0.58	0.61	-0.03
Liaoning	0.63	0.61	0.02
Ningxia	0.52	0.56	-0.04
Shandong	0.56	0.61	-0.05
Xinjiang	0.44	0.51	-0.07
Average	0.55	0.57	-0.02

* Source: the PDDs; ** Source: New Energy Finance and CWP

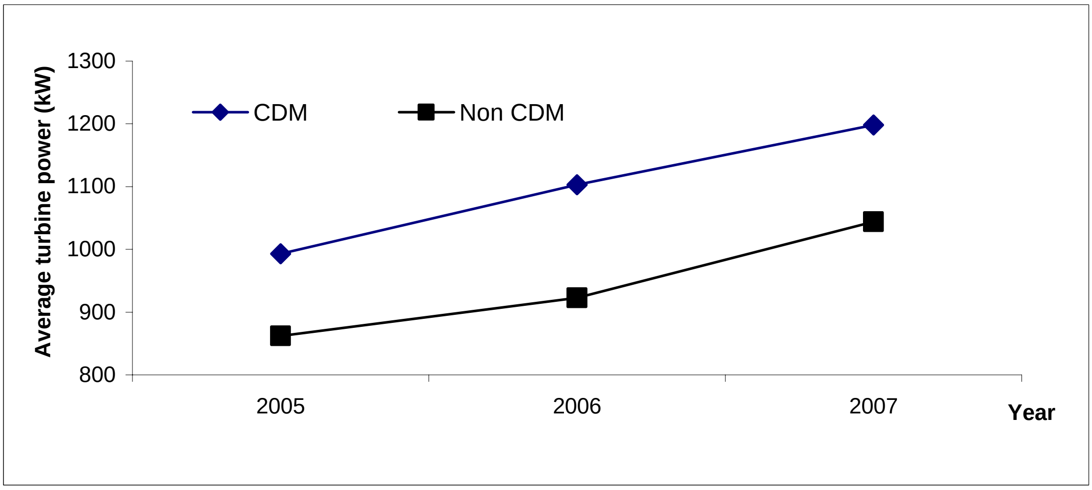
In Figure 5, we show the average installed capacity of individual farms, a variable which directly reflects total investment cost. We give statistics by year as the size of wind farms tends to grow over time. CDM and non-CDM projects sharply differ: on average, the former are three to four times larger than the latter. This is mainly due to differences in the number of windmills installed by farm. As shown in Figure 6, the gap is only around twenty percent (200 kW) between the turbines used in the non-CDM installations and the ones used in the CDM installations.

Figure 5 - Comparison of the CDM and non CDM installed capacity of a wind farm from 2005 to 2007



Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects

Figure 6 - Comparison of the CDM and non CDM turbine power from 2005 to 2007



Sources: UNEP-RISOE CDM Pipeline for CDM projects; China Wind Power Center for non-CDM projects

How could we interpret these differences? Turbine size should probably be related to the wind profile of the location. Larger turbines are more suitable for windier areas while we have seen that CDM windmills tend to be located in provinces with a higher wind potential. This would imply higher returns for CDM projects, which offers further evidence against additionality.

Turning next to the average installed capacity, the difference in project size, and thus in investment cost, is one the one hand in line with the PDDs which stress the capital constraint as barriers to getting projects started. This offers some evidence for additionality.

On the other hand, assuming the same average wind speed and identical wind turbine sizes, it has been argued that a large wind farm is more economical than a small one, at least in industrialized countries (American Wind Energy Association, 2005). Any project has (fixed) transaction costs that could be spread over more kilowatt-hours with a larger project. Similarly, one might expect that a larger project would have lower operations and maintenance costs per kilowatt-hour because of the efficiencies of managing a larger wind farm. In the end, it seems difficult to conclude over the impact of this variable on IRR.

Finally, we have data on the manufacturers of the turbines used in the project. This allows identifying whether the project relies on a local or a foreign technology. As shown in Table , the percentage of domestic windmills is significantly higher in non CDM projects, although the gap is getting narrower over time.

Table 3 - Percentage of domestic wind turbines in CDM and non-CDM projects, by year

	CDM	non-CDM
2004	14%	40%
2005	25%	44%
2006	32%	44%
2007	39%	43%

Domestic turbines are windmills produced locally by Chinese manufacturers with Chinese technologies: Dongqi, DEC, FD, Goldwind, Huachuang; ABO, Sewind, Shenxin, SUT, Windey. Sources: The PDDs for CDM projects; China Wind Power Center for non-CDM projects

In summary, CDM projects tend to be located in windier provinces, which is in line with higher turbine size. They are larger in terms of total capacity, but face slightly lower feed-in tariffs. Increasingly, turbines are less frequently developed in China.

What does it imply for the additionality of CDM projects? It is difficult to conclude as the different patterns may have opposite impacts on economic returns. To clarify this question we estimated an empirical profit model to identify the relationships between project profitability and these variables. This is the subject of the following section.

5 A basic profit model

For the CDM projects, the PDDs yield information on both forecasted profitability (IRR) and variables previously discussed that might affect the IRR. It is then possible to regress the internal rate of return on these variables to derive a basic profit model. Then we will use this model to compare the profitability of CDM and non-CDM projects.

More specifically, we estimate the following linear equation using ordinary least squares:

$$IRR = \alpha + \beta_1 \cdot tariff + \beta_2 \cdot capacity + \beta_3 \cdot turbine\_power + \beta_4 \cdot china + \gamma \cdot wind$$
$$+\delta_1 \cdot y2006 + \delta_2 \cdot y2007 + \delta_3 \cdot y2008 + \varepsilon$$

where:

- *IRR* is the internal rate of return of the project as estimated and reported in the PDD of each project (%),
- *tariff* is the feed-in tariff (RMB/kWh),
- *capacity* is the installed capacity of the project (MW),
- *turbine_power* is the size of the turbine (MW),
- *china* is a dummy variable equal to 1 if the turbine uses a local technology,
- *wind* is the average wind intensity in the province where the project is located (kW/sq.km),
- *y2006* is a year dummy with *y2006* = 1 if the project was registered under the CDM in 2006, 0 otherwise, etc.,
- ε is a zero-mean normally distributed error term which captures unobserved heterogeneity.

This model is estimated on a sub-sample of 59 projects that are registered under the CDM.[13] This sampling could lead to biased results as information in PDDs is arguably not reliable. However, we believe that this is not a very serious issue when using least squares as the error in variables problem mainly concerns the dependent variable, that is, the IRR. Information on the explanatory variables either come from external sources (*tariff* , *wind,* the year dummies) or are easily verifiable so that false reporting in PDDs is risky (for the variables *capacity, china, turbine_power*).

Regression results are displayed in Table . The R2 is equal to 0.35, meaning that the model gives a plausible explanation of the data. We have also performed a RESET test which reveal no omitted variable biases (Prob > F = 0.0264).

The tariff unsurprisingly increases profitability (significant at 0.00%) as does the year dummies. This is mainly due to the fact that the two projects launched in 2005, which is the base year, were more profitable for unobserved reasons. Importantly, the results do not reflect the existence of any economies of scale – at least in so far as the IRRs are reported by the PDDs – as the coefficients of *turbine_power* and *capacity* are not significant. The same is true for *china,* which suggests that the origin of the turbines has no influence on internal rate of return.

Table 4 - Regression results of the IRR model

Variables	Coefficient	Std. Error	P>|t|
tariff	2.207403	.7464122	0.000
capacity	.0016539	.0020114	0.198
turbine_power	-.1062112	.1560733	0.552
china	.0877921	.098887	0.379
wind	.0020756	.0040187	0.608
y2006	-.9247006	.407707	0.028
y2007	-1.050508	.4059782	0.013
y2008	-1.096278	.4823822	0.027
intercept	6.478204	.643911	0.000

59 observations. R2 = 0.3680

[13] We exclude three outliers with IRR below 5%.

It is then possible to use this model to compare the IRR predicted by the model of CDM and non-CDM projects. In Table 5, we report the average values of the explanatory variables of CDM and non-CDM projects, which we use to simulate the IRR.

The model gives an average predicted IRR of 6.96% for CDM projects and 7.04% for the others. The difference between the two figures is too low to provide strong evidence that, ignoring CER revenues, CDM projects are more profitable than other projects. But, it clearly casts some significant doubt over the additionality of wind power CDM projects in China.

Note that the IRR of non-CDM projects predicted by the model is below the official benchmark financial rate of 8%, which suggest they are not profitable. This is not the case in reality as they have been developed without CER revenue. As argued previously, this may not be a serious problem. The profit model has been estimated on a sample of CDM projects which probably present underestimated IRR in PDDs. As a result, predicted IRR are downward-biased. But this should not alter the difference between the two predicted IRRs: recall that the RESET test has not identified any omitted variable bias. This suggests that the unobserved propensity to underestimate is captured by the intercept (which disappears when calculating the difference).

Table 5 - Average characteristics for CDM and non-CDM projects and predicted IRR

	CDM	non-CDM
tariff	0.564	0.574
capacity	52.74	21.51
turbine_power	1.022	1.182
china	0.51	0.60
wind	37.94	33.15
y2006	0.260	0.225
y2007	0.453	0.455
y2008	0.132	0.000
Predicted IRR	6.96%	7.04%

Conclusion

Are Chinese wind power CDM projects additional? To answer the question, this paper has exploited the fact that certain wind farms are registered under the Clean Development Mechanism while others are not. If CDM projects are additional, the two sets of projects necessarily differ. We have studied available data to characterize the potential differences and whether they could be related to differences in individual project economic returns.

Data show that the two project types face the same regulatory conditions although the feed-in tariffs of CDM projects is slightly lower. However, CDM projects tend to be located in windier provinces, which can be related to the fact that they rely on larger turbines. Moreover, these turbines are more likely to use a foreign technology but the gap is getting narrower over time. The average installed capacity of CDM farms is also three to four times larger than for non-CDM.

What do these stylized facts tell about the relative profitability of CDM projects? Certain patterns support the theory that CDM farms are not additional: their location in windier provinces, the turbine size. But others have opposite implications: lower tariffs, the use of foreign technology, which may be more expensive.

In order to clarify the overall impact of these variables on the economic returns of individual projects, we have estimated a basic profit model. The model is then used to compare the Internal Rate of Return of CDM projects, ignoring CER revenue, and that of non-CDM projects. Results show no significant differences: the average CDM project and the average non-CDM project present a very similar rate of return. As non-CDM projects are arguably not additional - they have been developed with CER revenues –, this suggests that the same is true for CDM projects.

Due to the lack of data, our analysis is rough. In particular, CDM projects might be less profitable than other projects because of factors that are not observed in the data we have used. Keeping these limits in mind, the available evidence however suggests that wind projects in China that were registered as CDM projects before May 2008 are not genuinely additional.

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