Reporting Bias and Monitoring in Clean Development Mechanism Projects

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Abstract: The Clean Development Mechanism (CDM) is a flexible carbon market mechanism managed by the United Nations. The program grants tradable carbon emissions credits (Certified Emission Reductions) for carbon-reducing projects in developing countries. A project can only be admitted to program if it is not financially profitable, and thus would not take place, without the emission credits granted through the CDM. In this paper, we examine how monitoring reduces incentives of companies to bias the reported expected financial viability of potential CDM projects to gain admission to the program. We find that reported rates of return, which are a key factor for admission to the program, tend to be downwardly biased and are negatively associated with the expected benefits stemming from forecasted greenhouse gas reductions. However, monitoring from various sources mitigates some of the distorted incentives and related reporting bias. Furthermore, the monitoring effect becomes much stronger after 2008, when the CDM Executive Board implemented a series of measures to strengthen the additionality testing which provides guidance for program applications.

1. Introduction

The Clean Development Mechanism (CDM) is one of the flexible mechanisms available under the Kyoto Protocol (United Nations 1998).[1] If CDM projects are approved, host firms can earn Certified Emission Reductions (CERs), each of which is equivalent to the reduction of one metric ton of CO_2 and can be used to satisfy obligations stemming from the Kyoto Protocol and European Union regulations. CDM projects include, for example, the installation of energy-efficient boilers or investment in rural electricity plants designed to have low carbon emissions. The most important criterion for a project to be approved by the CDM Executive Board (EB), is that the project would not have taken place without the economic incentives provided by CDM (the concept of "additionality"). The additionality requirement thus generally results in the exclusion of projects that are "business-as-usual" per se (Michaelowa 2009), and that issuance of CERs only occurs for projects that would not otherwise be viable.

There are various methods used by the EB to analyze the additionality of a project, and these methods have undergone many changes and improvements through the years.[2] In this paper, we focus on the method of investment analysis, which requires the project's estimated return on investment to be *lower* than a reasonable benchmark rate. The requirement thus gives project host firms strong incentives to *underreport* estimated project returns to be below the benchmark rate. In addition to empirically examining the incentive for understating the project's forecasted internal rate of return (IRR) in order to qualify for UN approval, we investigate how monitoring mechanisms at both the country- and the project-level can mitigate the incentive.

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[1] Flexible mechanisms refer to the programs designed to reduce greenhouse gas emissions through projects in other countries instead of achieving these reductions through investment in technologies or other initiatives in the host country. As of July 2016, there are more than 8000 projects in 105 countries. The CDM Board continues to promote demand and to broaden the application of the CDM (CDM Executive Board 2016).

[2] See Michaelowa (2009) for a comprehensive review of the concept and implementation of additionality as well as its evolution over the years. We also provide a more detailed discussion in the background section of the paper.

We argue that the CDM reporting process is subject to informational asymmetry between the host firms and CDM authorities, much like the process of reporting accounting information. Theory research in accounting and finance has long examined the effects of informational asymmetry between the providers and recipients of financial information (e.g., Stein 1989; Fischer and Verrecchia 2000; Caskey et al. 2010). In financial markets, managers take advantage of their private information about the firms and bias financial reports for their own self-interest. The amount of reporting bias depends on the potential benefits to be obtained. Monitoring and auditing serve to mitigate the informational problem in the reporting process, although they cannot eliminate the problem entirely.

We identify factors that are likely associated with reporting bias for CDM projects and we empirically examine their significance. Specifically, we hypothesize that host firms with higher expected benefits have stronger incentives to downwardly bias their reported IRRs, and that the bias is mitigated through monitoring at various levels. Using data on 2,120 projects across eight countries, manually collected from the applications filed by host firms, we find that firms manipulate information in a manner that is consistent with their underlying incentives. We find that the reported IRRs of applying firms are negatively associated with the expected emission reductions. This indicates a strong link between potential economic benefit and firms' incentives to underreport.

We also examine the effect of monitoring in the CDM application and approval process. Several sources of monitoring exist, including both official auditing and informal monitoring by various stakeholder groups, who are often driven by environmental objectives. As part of the formal monitoring process, Designated National Authorities (DNAs) from both the country where the project takes place (the "host country") and any country that has non-host participants in the project check to ensure that the proposed project fits within the national sustainable

development criteria of their countries. A project can only be registered with the EB after approval by the local DNA. Designated Operational Entities (DOEs) (who essentially act as auditors) then validate the project design documents and, after the projects are completed, determine rewardable CO_2 emission reduction quantities to ascertain how many CERs should be granted.

We find that increased monitoring appears to mitigate misreporting. At the country-level, we find that countries with characteristics likely associated with higher quality of monitoring, specifically those that are more developed, have host firms that are less likely to underreport. We also find that the quality of monitoring at the project-level impacts reported IRRs: projects where the auditor is affiliated with a Big Four accounting firm have significantly higher reported (less biased) IRRs than other projects.

Additional results indicate that the effects of monitoring become much stronger starting from 2008, when the EB implemented several measures to tighten up the process' general governance. We find that, given the same amount of anticipated benefits and monitoring, CDM host firms underreport significantly less in the period post-2008. This implies that CDM's effort in reforming itself has been successful at least to a certain degree.

Our study makes several contributions. It is the first study to analyze incentives and monitoring factors that are associated with CDM projects from the perspective of reporting bias with asymmetric information. This approach differs from most prior studies on CDM, most of which either analyze project information in depth (e.g., Michaelowa 2007; Michaelowa and Purohit 2007) or evaluate the political-economic aspect of CDM as an institution (e.g., Flues et al. 2010; Michaelowa and Michaelowa 2017). In contrast, we emphasize that the host firms have strong incentives to underreport project IRRs and that the informational asymmetry between the host firms and CDM authorities is the fundamental reason for such underreporting. Monitoring

and auditing can mitigate the problem to some degree, but cannot eliminate the problem completely. While many previous studies on CDM document the existence of this inefficiency, they primarily attribute it to bureaucracy and institutional factors. We argue that such inefficiency is also (at least partially) the inevitable nature of the market mechanism and is similar to financial reporting by firms. Further, we show find evidence that CDM reforms have reduced inefficiencies through continuous efforts, which have led to observable improvements. In fact, while CDM has been severely criticized for its lack of efficiency and governance, it remains the most successful among similar mechanisms (Michaelowa 2012).

We use a large-scale dataset that is manually collected and constructed from an extensive sample of CDM projects. This enables us to use the reported IRRs as the measure of potential bias, so that we can examine a big number of projects. The large dataset and new empirical measure allow us to empirically investigate the extent to which incentives are reflected in the application process. Prior studies typically examine smaller samples, with a focus on reporting irregularities. Our approach provides a more comprehensive and systematic analysis of the incentives issues involved in the CDM process.

Finally, our paper contributes to research on environmental disclosure by examining the CDM host firms' incentives to underreport their projects' return on investment. Prior research often examines environmental disclosures in a voluntary disclosure setting (e.g., Clarkson et al. 2008; Plumlee et al. 2015; Clarkson et al. 2013; Dhaliwal et al. 2011; Matsumura et al. 2014).[3] In our setting, while firms voluntarily submit projects to gain acceptance into the CDM program, they must report projected financial viability of their projects when they do so. The insights we gain are not only relevant for CDM and other instruments targeting climate change but also

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[3] An exception is Johnson et al. (2019) who use an experimental setting to explore investors' attitude toward firms' greenhouse gas emission reduction strategy. They find that investors place a higher value on firms when the firms make operational changes rather than when they simply purchase carbon offsets.

illuminate the development of accounting standards and monitoring mechanisms for environmental issues (Cook 2009).

The next section provides further background on the CDM. Following that, we discuss related accounting issues and provide a literature review. We then provide theoretical and hypothesis development and describe our empirical method. Subsequent sections describe our sample and provide our results. The final section concludes.

2. CDM Background

CDM Institutional Setting and Procedure

The CDM was developed as a means of achieving carbon emission reductions to satisfy requirements of the Kyoto Protocol. It facilitates reduction of greenhouse gas emissions through investments in green technologies in developing countries. From an economic perspective, the program helps to lower marginal abatement costs (since emission reduction is often less costly in developing countries) (Rahman and Kirkman 2015) and to promote the transfer of technology (Kolk 2015) and resources between developed and developing countries.

There are several major agencies responsible for the implementation of CDM. While the nominal head of the CDM is the Conference of the Parties, consisting of contracting parties (countries) of the Kyoto Protocol, the EB supervises the actual implementation, including tasks such as the approval and registration of projects and the issuance of CERs. DNAs represent the contract partners (countries) of the Kyoto Protocol. Their main task is to determine whether a CDM project is consistent with the host country's sustainable development goals. If so, the DNAs issue a letter of approval to the EB. The DOEs are independent organizations that audit all project documents. In contrast to traditional auditors, their activities are not limited to evaluation of compliance with accounting standards but include both assessment and approval of the project proposals. This demands considerable technical and financial expertise. During our sample

period, on average, more than 700 project applications were evaluated each year. The sheer volume of work alone makes it difficult for the EB to thoroughly analyze each project. The board therefore must rely on expertise of and monitoring by the DOEs to ensure that it admits only eligible projects to the program.

Figure 1 depicts stages in the development of a CDM project. Each project requires a Project Design Document (PDD). The PDD provides the basis for the project's validation and registration. It includes a project description, information about the applied baseline and monitoring methodologies, duration of the activity and proposed crediting period, calculation of greenhouse-gas emission reductions, information on environmental impacts, stakeholder comments, and results of the project's financial analysis. Upon completion of the PDD, the project developer submits the project to a DOE for validation, along with approval letters from the DNAs from the host and partner countries. If the criteria are met, the DOE validates the project and sends the approval letters and all documentation to the EB with a request for registration. After the project is registered, the project developer monitors the project activity to facilitate calculation of emission reductions, which are used to determine the amount of CERs requested. The project developer provides a monitoring report to a second DOE for verification. The second DOE uses the monitoring report and information collected during on-site inspections to develop a verification report. If the activity level documented is deemed satisfactory, the DOE certifies the claimed reductions. Finally, based upon the verified reductions, the EB issues CERs which project participants can then use or sell. Ownership of CERs is registered by the responsible national registries.

Additionality and Evolution over Time

Additionality is the primary requirement for projects to be approved. It is defined as "*anthropogenic emissions of greenhouse gases by sources are reduced below those that would*

have occurred in the absence of the registered CDM project activity." (UNFCC 2001).

Additionality thus includes justification from both an emissions reduction and an investment standpoint. From the investment standpoint, to be accepted into the program, a project should require the granted CERs to become financially viable.[4] Otherwise, companies would have basic economic incentives to pursue the project, and the CERs would be unnecessary to make it economically attractive. While the additionality requirement justifies the subsidy granted to host firms, it also provides incentives for companies to understate the financial benefit of their projects to satisfy the additionality criterion.

The CDM has undergone many changes and reforms since it was first established, and the additionality requirement has evolved over time (Michaelowa 2009). Initially, there were many disagreements on the interpretation and implementation of additionality. The EB responded by adopting a methodological tool for establishing additionality (hereafter "guidance" or "additionality tool") on October 22, 2004 (CDM Executive Board 2004).[5] The additionality tool directs project developers to identify alternatives to the project activity and then, depending on the nature of the project, to analyze financial aspects of the proposed project relative to the alternatives or to a benchmark, to identify barriers to implementation, and to compare the proposed project to common practice in the relevant sector and region.

In essence, there are three tests stipulated in the 2004 tool to assess a project's additionality:

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[4] Initially, an exception existed if there were significant barriers (e.g., social or political) to implementing a project. In these cases, even financially beneficial projects were included in the program and earned CERs. However, due to perceived manipulations by project developers, the barrier test fell out of use after 2007.

[5] The latest version pertaining to our sample (7.0) dates from November 23, 2012 (CDM Executive Board 2012).

1. Investment analysis, which compares the reported IRR with the benchmark IRR and deems those projects that have IRRs lower than the benchmark to be additional;[6]

2. Barrier analysis, which examines whether there is any significant barrier that blocks a project from taking place. If there is, then the project is additional;

If either or both of the analyses are conducted with a favorable outcome, the project must also be examined for

3. Common practice analysis, which considers whether there are similar activities being observed. If there are not, then the project is additional.

The additionality tests have been criticized as unreliable, especially at the beginning of the CDM program. Barrier analysis was especially abused until it was disallowed by the EB in 2007. In fact, during the first few years of the CDM, 60% of the projects became additional through barrier analysis (Schneider 2009). To address these misaligned incentives, the additionality requirements were modified and sharpened over the course of time. For example, in 2006, the EB approved a "Combined tool to identify the baseline scenario and demonstrate additionality" (CDM Executive Board 2006), which became the most commonly used tool for CDM projects. In 2007, the benchmark used in investment tests was redefined and made much more strict and standardized. In 2008, the EB provided further detailed guidance in the additionality tool for implementation of investment tests.

In summary, CDM has continuously changed and evolved over time. As a result, the program has improved significantly in all aspects, including environmental integrity, efficiency, and governance. Despite the many criticisms it received during its early development stage, the

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[6] While other financial methods were at least initially allowed for justifying additionality (e.g., Net Present Value analysis), IRR is the predominant reported metric.

CDM is a continuing and successful carbon market mechanism (Michaelowa 2012). In this paper, we investigate whether there remain biases in reported project profitability that could be the focus of further improvements.

3. Literature Review

Prior Research on CDM Additionality

There has been extensive research conducted on the CDM since its establishment. Rather than covering the entire literature, we focus on those studies that examine the additionality requirement and are thus more closely related to our paper.

The majority of studies examining CDM projects have focused on analyzing information included in applications and documenting related problems. For example, Schneider (2009) investigates whether detailed costs have been reported versus only the result of calculations, and concludes that about 40% of the projects and 20% of the CER volumes are unlikely to be additional. Michaelowa (2007) and Michaelowa and Purohit (2007) find that project developers can obscure the attractiveness of their projects to increase the likelihood of the projects being admitted to the CDM program. Carmichael et al. (2016) provide a technical analysis of the impact of uncertainties in the cash flows associated with determining project IRR by CDM host firms and find that using reported IRR can lead to both erroneous acceptance and rejection of projects.

Another set of studies evaluate CDM additionality from a political-economic perspective. Flues et al. (2010) find evidence that the EB decisions to approve CDM projects are functions of political-economic variables, especially factors arising from countries of origin and special interest groups. Michaelowa and Michaelowa (2017) take a principal-agent approach and show that the UNFCC Secretariat has gained significant influence over the decision-making processes.

However, it is difficult to assess whether these changes benefit parties with special interests or serve the general interests of society.

Given the significant amount of criticisms targeted toward CDM, Drew and Drew (2010) call for the need for more stringent monitoring to prevent the rampant opportunistic behavior in CDM reporting. Wara and Victor (2008) raise doubts that carbon offset mechanisms are even effective at all, based on the many documented failures and errors in CDM. However, other research has also shown that CDM has its own merits, especially based upon its continuous effort in reforming and improving itself (Michaelowa 2012).

Reporting Bias

Informational asymmetry between the providers and recipients of financial information has been studied extensively in accounting and finance (Stein 1989; Fischer and Verrecchia 2000; Caskey et al. 2010). In the financial market setting, the providers of financial reports are typically managers of the firm, who possess private information that cannot be verified without cost. They take advantage of their private information and bias financial reports for their self-interest. Recipients of the reports, typically the firms' investors, rationally anticipate the existence of such bias and adjust their valuation and investment strategies accordingly.

Empirical research on reporting bias focuses on identifying factors that contribute to the bias, including both benefits and costs for the managers. For example, managers engage in earnings management to maximize their own bonuses (Healy 1985), or for private insider trading benefits (Beneish and Vargus 2002). Teoh et al. (1998a, b) find that firms manage earnings right before the initial and secondary public offerings. DeFond and Jiambalvo (1993) find evidence that managers bias reports for the sake of debt contracts. Beatty and Weber (2006) provide evidence that firms use accounting direction to avoid debt covenant violations.

Studies also indicate that monitoring from various sources affects reporting quality, albeit to different degrees. For example, firms with better corporate governance tend to have better reporting quality. The independence of the board members is also associated with higher quality of the firms' financial reports (Klein 2002; Dechow and Dichev 2002), as is the financial expertise of the boards' audit committees (Dhaliwal et al. 2010; Cohen et al. 2014). DeAngelo (1981) and Palmrose (1988) find that audit quality provided by the large accounting firms is superior to that of smaller firms, which results in higher quality of reported financial information for the larger firms. External macro-level factors, which are a function of the social environment, also play an important role in the reporting quality, (e.g., Ali and Hwang 2000; Ball et al. 2000; Feng et al. 2011). This is due to different degrees of monitoring resulting from the country's legal system and culture. We explore the role of both internal and external monitoring on CDM reporting incentives.

4. Hypotheses Development

When a potential host firm files for CDM program approval, it has private information about its project's true future value. To pass the investment test of the additionality requirement and become eligible to earn CERs, the host firm must report an internal rate of return lower than the benchmark. The additionality requirement thereby provides the host firms with incentives to downwardly bias the reported IRR of their projects. At the same time, host firms also face potential costs from manipulating the reported information, which include possible rejection if such manipulation is detected.[7] In the absence of explicit monitoring, host firms have an

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[7] Application for the CDM program is not cost free. It includes a direct application fee, so firms are unlikely to apply if they have a project that they do not think has a chance of being accepted. Application also does not guarantee acceptance. In our sample, over 100 projects were rejected. Another indirect cost is due to reputational damage if there are specious or exaggerated claims made in the publicly available PDD. This reputational damage may be to the host firm, the DOE, or the CDM Board/CDM program. For example, some Indian projects were rejected in 2005 because the PDDs contained text that had been directly copied from projects in distant districts. The text provided quotations from villagers and labor union leaders about the potential local impact of the projects (Michaelowa and Purohit 2007).

economic incentive to underreport their IRR.[8] Even when the projected IRR is actually lower than the benchmark rate, underreporting creates a buffer in case some of the assumptions, practices, and resulting economic outcomes are subject to further scrutiny.

We argue that the host firms' reported IRRs reflect the trade-off between incentives and external monitoring. Specifically, we argue that a project that expects a higher amount of granted CERs has greater incentives to understate its project IRR, since CERs represent the benefits associated with EB approval. These incentives have two components. First, the more profitable is the admission to the CDM program, the larger is the incentive to reduce the reported IRR to justify additionality. Second, while admission to the program is not based upon the magnitude of the CER benefit, projects that become extremely profitable from CER revenues may draw additional scrutiny. This provides additional incentive to understate the IRR for more profitable projects. We thus predict a negative association between reported IRRs and CER profitability.

HYPOTHESIS 1. *Reported IRRs are negatively associated with the expected profit from CERs related to the project.*

We also predict that reported IRRs are generally positively associated with the level of external monitoring, since more stringent monitoring likely reduces the host firm's ability to report a falsely low IRR. Two levels of monitoring are especially important in the CDM process: explicit monitoring by the DOEs, who assess the quality of the PDD; and implicit monitoring provided by the host country and other interested stakeholder groups, such as environmental NGOs.

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[8] It may seem that the host firms only need to report an IRR lower than the benchmark. However, as benchmarks were chosen initially by the firms, in later stages (after 2008) benchmarks were defined for sectors and host countries (Michaelowa 2009). As a consequence, several benchmarks were refuted by the EB or DOE and related projects were rejected. Thus the host firms still have incentives to report as low an IRR as possible.

The first level of monitoring comes from DOEs. The DOE essentially acts as an auditor, evaluating the documentation used to justify additionality.[9] There is a growing body of research examining factors related to the quality of auditing for fair values and other estimates (Bratten et al. 2013). While the forward-looking IRRs reported under the CDM are not a part of traditional financial statements, they share characteristics of fair value since the estimates are not verifiable and no level of guidance is sufficient to eliminate all potential biases. We argue that a good DOE is more likely to either have the expertise to properly conduct a thorough assessment of the reported IRR or to have access to superior audit technologies that can be adapted for the task. The quality of the DOEs should therefore be positively associated with the applying firms' reported IRRs. We thus hypothesize:

HYPOTHESIS 2A. *Reported IRRs are positively associated with DOE quality.*

The second level of monitoring is related to the country's macro environment. Extensive research in finance and accounting has shown that the reporting quality is a function of the social environment of the country (e.g. Ali and Hwang 2000; Ball et al. 2000; Feng et al. 2011) due to the different degrees of discipline or monitoring resulting from the country's legal system and cultural tradition. If a host firm resides in an economically and institutionally more developed country there will be more monitoring and as a result, less underreporting of IRRs. Bratten et al. (2013) suggest that regulatory and/or cultural differences across countries can impact both manager's propensity to bias estimates and the auditor's exercise of professional skepticism. Scully (1988) argues that the institutional environment is related to execution and enforcement of legal norms and standards. In the CDM setting, countries with stronger institutional environments related to corporate auditing and monitoring, and therefore stronger scrutiny of project

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[9] Even though they have no formal decision-making power, the Secretariat as well as the CDM's Registration and Issuance Team (RIT) are also involved in the monitoring process. Since we cannot observe their informal influence, we concentrate on the role of the DOEs (for further discussion, see Flues et al. 2010).

investments, are less likely to have managers who report biased IRRs—partly due to prevailing legal norms and standards, and partly due to the greater ability of DOEs to detect misrepresentation when it occurs.

HYPOTHESIS 2B. *Reported IRRs are positively associated with the host country's institutional environment.*

The CDM has changed significantly over time. The additionality tool has become more detailed and clarified for determination of IRRs, and more generally, monitoring within the CDM program has become more stringent. Starting approximately in 2007, criticism reached its peak, targeting CDM's poor governance and loose standards (Michaelowa 2009). In response, the EB implemented a series of reforms to improve overall performance, such as redefining benchmarks, providing more guidance on investment tests, and clarifying the procedure of validation and verification. Perhaps most important of all, barrier analysis, which was criticized as the weakest link in the CDM additionality flow chart, began to fall from use. By 2008, barrier analyses were seldom used for approving CDM projects.

The clarifications and increase in guidance are analogous to a tightening of accounting standards. Prior accounting research indicates that such tightening reduces the level of misreporting (Ewert and Wagenhofer 2005). In our setting, we argue that the incentive to misreport is related to the profitability from the CERs (H1). As an indication of the higher quality of reporting, we expect that managers will be less likely to bias their reported IRRs. We thus expect a less negative association between the CER incentive and reported IRRs subsequent to the program changes. Most of the reforms took place around the years 2007 and 2008, so we predict that the association between reported IRRs and the expected profit from CERs declined after 2008.

HYPOTHESIS 3. *Ceteris paribus, after 2008, the association between reported IRRs and the expected profit from CERs related to the project is less negative.*

5.   Research Method

Research design

Additionality requires that the investment be financially unviable without CER revenues (or have sufficient barriers that make the project otherwise unviable). Our empirical model (1) investigates factors associated with reported IRR. Controlling for factors such as project type, country, and year, we investigate whether the reported IRR is systematically related to CER benefit, DOEs, and country-level institutional development. Specifically, we conduct a two-stage analysis to first establish the "expected" levels of IRR and then link the excess reported IRRs with the variables of interest. In the first stage, we regress the reported internal project rates of return on project characteristics including country, year, mitigation type, and registration status.[10] These factors are most likely to systematically affect the reporting behavior of the CDM host firms. As discussed earlier, the countries where the host firms reside have different political and cultural environments and differ in the amount of discipline the firms are subject to. The years when the host firms file for applications vary in the degrees of monitoring stringency. The mitigation types of the projects result in different returns on investment. The registration status (including 1. withdrawn by company, 2. rejected by the EB, or 3. registered for the program) likely captures the severity of perceived manipulation in the reported IRRs.

The second-stage model is presented as follows.

$$IRR\_RES = \beta_0 + \beta_1 BENCHMARK + \beta_2 BARRIER + \beta_3 IRRDIFF + \beta_4 MONITOR$$
$$+ \beta_5 DOEBAD + \beta_6 DOEACCT + \varepsilon \tag{1}$$

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[10] Project categorizations are based on CDM Executive Board (2010), which describes the methodologies authorized by the EB. Example methods include ACM0003, emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement or quicklime manufacture (a fuel switch method), and AMS-I.C., thermal energy production with or without electricity (renewable energy). We group the 45 methods into eight different types of mitigation, such as greenhouse gas destruction, and renewable energy.

where:

        IRR_RES = residual from the first-stage regression model where the reported internal
                project rate of return (excluding CER benefits) is regressed on project mitigation
                type, registration status, country, and year;
        BENCHMARK = reported benchmark IRR;
        BARRIER = 1 if the host firm reports a barrier analysis, 0 otherwise;
        IRRDIFF = incremental internal rate of return stemming from the CERs;
        MONITOR = factor score from the first principal component of the country-level
                variables for HDI_RANK (Human Development Index rank), CO_2 (CO_2 emissions
                per capita), and GDP (Gross Domestic Product);
        GDP = Gross Domestic Product of host country in thousands of \$US per capita;
        CO_2 = country level CO_2 emission per capita;
        HDI_RANK = host country's rank of Human Development Index among all countries,
                with 1 being lowest level of development;
        DOEBAD = 1 for every year up to and including the year that the DOE was sanctioned,
                0 if the DOE was never sanctioned or for the years following reinstatement of a
                previously sanctioned DOE;
        DOEACCT = 1 if DOE is affiliated with a Big Four auditor, 0 otherwise;

Residuals from this first-stage model are then used as "unexpected" IRRs in the second-stage regression to test whether the incentives of applying firms to bias the reported IRRs are related to the benefits they hope to receive. This specification provides an expected IRR based upon individual project characteristics, and the coefficients of our test variables indicate the association between the test variables and unexpected IRR. Where possible (depending on the sample characteristics), we also include fixed effects for registration status.

Hypothesis 1 predicts a negative association between CER benefit and the reported IRRs. We use *IRRDIFF*, the incremental benefit of project investment return, to proxy for the projected CER benefit.[11] We expect *IRRDIFF* to be inversely associated with *IRR_RES*, since a higher

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[11] The construction of *IRRDIFF* is the same as the variable *ΔIRR* in Au Yong (2009). Au Yong (2009) proposes that this variable is very important in capturing the additional profitability CDM brings to the projects, and suggests "that the credibility of CDM additionality can be enhanced by adopting a minimum ΔIRR threshold, e.g. 2%, below which the additionality of a project is deemed uncertain and the project is therefore rejected (unless proven to be additional

benefit from the granted CERs may result in increased potential scrutiny of the project design document and the IRR calculation. The relation we estimate between *IRRDIFF* and *IRR_RES* is more likely driven by reporting incentives rather than project characteristics related to acceptance into the program, since the magnitude of the benefit from CERs is not included in the EB's decision to accept a project.[12] Additionality requires that there must be some level of carbon reduction and that the project must be financially unviable in the *absence* of CERs. Profitability including CERs is not considered. However, as we argue in the development of hypothesis 1, existence of excessive profits from the program may result in more intense scrutiny of the claims in the design document.

We include two measures of DOE quality to test hypothesis 2A. During our sample period, several DOEs were removed from the list of approved auditors. These DOEs were sanctioned for a variety of reasons, including failure to survey projects before authorizing them and inability to prove that staff had audited projects properly (or were qualified to do so) (Murray 2009). We expect that a sanctioned DOE is of lower quality and, therefore, is a less effective monitor. We set *DOEBAD* = 1 in years before and including the year of sanction. If the DOE is reinstated, we assume that improved monitoring is a requirement for reinstatement and set *DOEBAD* = 0 for subsequent years. We argue that less effective monitoring will be less likely to deter firms from downwardly biasing their reported IRRs. *DOEBAD* should thus be negatively related to *IRR_RES*.

The majority of the DOEs are engineering consultants, who focus more on the technical aspects of the projects than on the financial ones. Relative to accountants, they are less

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in other ways)." Of course, in reality, to be deemed additional, the CDM's investment analysis method still only requires the project's estimated return on investment to be *lower* than a reasonable benchmark rate.

[12] We note that less profitable projects are also more likely to apply to the program. However, our controls for country, project methodology, and year reduce the likelihood that the coefficient we estimate is driven by inherent project characteristics rather than by bias.

knowledgeable about project finances and are less likely to detect a bias in estimates.

Accountants, in particular those from firms that provide higher audit quality, should be more

likely to detect bias. These auditors should have better audit policies and procedures, even in the

face of a complex audit task, such as evaluating IRR disclosures.[13] We code the dummy variable

DOEACCT as 1 if the DOE is affiliated with an accounting firm.[14] In the presence of more

stringent monitoring, managers should be less likely to follow incentives to decrease reported

IRR. *DOEACCT* should thus be positively related to the reported IRRs.

   MONITOR is our explanatory variable capturing country-level monitoring factors for our

test of H2B. It is the factor score from a principal component analysis of the three country-level

variables, Human Development Index (*HDI-RANK*), CO_2 emission per capita, and Gross

Domestic Product (*GDP*).[15] *HDI-RANK* is derived from the United Nations Development

Program's Human Development Index (http://hdr.undp.org/en/content/human-development-

index-hdi). It measures average achievement in key dimensions of human development: life

expectancy (a measure of health), education, and standard of living. Acemoglu et al. (2003) argue

that health status has an impact on institutional development, and others (e.g., Bloom et al. 2014)

find that health and longevity are positively associated with economic development. *HDI* is

coded so that a higher rank equates with more development. CO_2 emission per capita is based

upon metric tons per capita of carbon emissions from burning fossil fuels and manufacture of

cement. GDP per capital measures a country's wealth. Wealthier and more-developed countries

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[13] The accounting firms have "iron walls" between auditing and consulting sections of their business to avoid conflict of interest. Nonetheless, we argue that a DOE affiliated with an accounting firm has more financial expertise and higher concern for market reputation.

[14] All of the DOEs that are affiliated with accounting firms are associated with a Big Four accounting firm, so we cannot distinguish between the monitoring quality between Big Four auditors vs. small auditors.

[15] We employ a factor analysis technique because the country-level variables tend to be correlated. For example, richer countries are likely to have higher carbon emissions, and the (untabulated) correlation between CO2 and GDP is 0.39. In addition, because HDI includes wealth, there is probable multicollinearity between it and the other monitoring variables. Indeed, the (untabulated) correlation between HDI and GDP (CO2) is 0.83 (0.47).

tend to have stronger institutions and more resources for monitoring. Countries with relatively high carbon emissions also tend to be more developed and are likely to face more scrutiny worldwide in their environmental initiatives, resulting in more monitoring. GDP per capita and CO_2 emissions per capita (*CO2*) are available from the World Bank website (World Bank 2014). We expect *MONITOR* to be positively associated with *IRR_RES,* as higher macro-level scrutiny prevents the applicants from acting egregiously.[16]

We also include control variables for report aspects that are likely to be related to the reported IRRs. Our first control is the benchmark IRR (*BENCHMARK*). We expect the coefficient of *BENCHMARK* to be positive, since having a benchmark allows a higher IRR to be reported and to still satisfy the financial aspect of the additionality criterion. We also expect *BARRIER* to be positively associated with the reported *IRR*, since the barrier analysis could qualify a project as "additional" even without a reported rate of return lower than the benchmark rate. An applying firm with a significant investment barrier therefore does not have any incentives to downwardly bias estimated IRR.

Additional Tests

While model (1) examines whether monitoring has a main effect on IRR, it is possible that the CDM applicants' incentive to bias as result of the potential reward can be moderated by the external monitoring and auditing factors. To investigate this, we estimate model (2), which interacts the monitoring variables with *IRRDIFF* in the IRR regression. If this is the case, we expect the interaction term *MONITOR*IRRDIFF* to have a positive effect on *IRR_RES*, as a disciplinary country-level monitoring environment can further mitigate the CDM applicants' incentives to bias the reported IRRs as a function of the potential benefit. We expect

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[16] Our models include country-level main effects, so the results on the country-level variables are related to the underlying construct rather than driven by differences by country alone.

DOEBAD*IRRDIFF to have a negative effect, as an ineffective DOE can amplify the CDM applicants' intention to bias. The effect of *DOEACCT*IRRDIFF* should be positive, since we expect that DOEs associated with the accounting firms are more effective in preventing the bias:

$$
\begin{aligned}
IRR\_RES = {} & \beta_0 + \beta_1 BENCHMARK + \beta_2 BARRIER + \beta_3 IRRDIFF + \beta_4 MONITOR \\
& + \beta_5 MONITOR\text{*}IRRDIFF + \beta_6 DOEBAD + \beta_7 DOEBAD\text{*}IRRDIFF + \beta_8\, DOEACCT \\
& + \beta_9 DOEACCT\text{*}IRRDIFF + \varepsilon
\end{aligned}
\tag{2}
$$

where variables are described as above.

As we discuss earlier, *IRRDIFF* represents the potential benefits that an applicant obtains from CERs granted. Using models that explore factors associated with *IRRDIFF,* we further examine whether monitoring impacts managers' bias in reported profitability to reduce scrutiny. We employ two different specifications of the regression model. The first model investigates the impact of monitoring on projected profitability *IRRDIFF*. The second model controls for the projected excess carbon reductions (*REDUCTION)* and therefore focuses more on the accounting aspects of the projected profitability, albeit in a less direct way than our models that directly examine the assumption about price:

$$
\begin{aligned}
IRRDIFF = {} & \beta_0 + \beta_1 BENCHMARK + \beta_2 BARRIER + \beta_3 MONITOR + \beta_4 DOEBAD \\
& + \beta_5 DOEACCT + \varepsilon
\end{aligned}
\tag{3a}
$$

$$
\begin{aligned}
IRRDIFF = {} & \beta_0 + \beta_1 BENCHMARK + \beta_2 BARRIER + \beta_3 REDUCTION + \beta_4 MONITOR \\
& + \beta_5 DOEBAD + \beta_6 DOEACCT + \varepsilon
\end{aligned}
\tag{3b}
$$

where

REDUCTION = residual from a regression of the annual expected carbon reduction on dummy variables for each mitigation method.
Other variables are defined earlier.

In model (3a), we analyze the relation between *IRRDIFF* and the monitoring and auditing factors. We use *MONITOR* for country-level monitoring factors, and *DOEBAD* and *DOEACCT*

for DOE quality. We expect *MONITOR* to be negatively related to *IRRDIFF*, since a more disciplinary institutional environment can prevent egregious behavior. The signs for the accounting-related monitors are less clear, however. On the one hand, a DOE of low quality (*DOEBAD* = 1), may be less likely to detect misreporting, which would lead to a positive coefficient of *DOEBAD.* On the other hand, lower quality DOEs may be associated with lower quality (less profitable) projects, which would result in a negative coefficient. Similarly, the sign for *DOEACCT* is unclear. On one hand, a DOE with accounting expertise is likely to prevent misreporting; on the other hand, the nature of carbon reduction related to the technology may require knowledge beyond accounting. Thus, accountants may be less likely to detect any misstatement. Further, higher quality DOEs may be associated with higher quality (more profitable) projects. We also control for *BENCHMARK* and *BARRIER*.

In model (3b), we add the variable *REDUCTION*. For every project, the amount of potential benefits from the granted CERs is determined by the amount of carbon reduction generated. Specifically, *IRRDIFF* is calculated as the incremental internal rate of return generated from additional cash flows stemming from the value of granted CERs. Since different carbon-reducing technologies result in different efficiency outcomes, we compute the expected annual carbon reduction for each project by running a regression based on the mitigation method. We then calculate the difference between the reported carbon reduction and the expected carbon reduction for each project, and create a new variable using the difference called *REDUCTION*. We expect *REDUCTION* to capture the over- or under-statement of carbon reduction generated by the investment projects, thus isolating the project developer's incentive from the technological nature of the projects. The reporting bias represented by *REDUCTION* should be positively related to *IRRDIFF*, since higher expected reductions are used for contracting on how project activities convert to CERs. This model provides a basis from which to investigate the impact of

monitoring on the reporting bias. All models include fixed effects for year, country, mitigation type, and registration status.

Finally, we run several sensitivity analyses using different specifications or different samples of the same tests. The first sensitivity analysis is to re-run the regression model 1 with each component of variable *MONITOR* separately. The regression model is as follows:

$$IRR\_RES = \beta_0 + \beta_1 BENCHMARK + \beta_2 BARRIER + \beta_3 IRRDIFF + \beta_4 GDP +$$
$$\beta_5 HDI\_RANK + \beta_6 CO_2 R + \beta_7 DOEBAD + \beta_8 DOEACCT + \varepsilon \qquad (4)$$

where all variables are defined earlier.

We also run our primary models on a subsample comprised of only renewable energy projects. As different technologies produce inherently different carbon reductions and investment returns, we explore the robustness of our inferences using a single technology.

Sample

We draw our sample of projects from the IGES CDM Project Database (U.N. Development Program 2014). The first CDM project was registered in late 2004 (Dinar et al. 2013), and the projects represented in the entire database span late 2004 through December 2012. Our sample period begins in 2005. To ensure the representativeness of our sample, we select eight countries as the hosts of our sample firms. These are Brazil, China, India, Indonesia, Malaysia, Mexico, Peru, and Thailand. We selected these countries because they provide a broad representation of countries in Asia and South America. African countries host only very few projects, so they were not included. Together, the sample countries host a large proportion of the CDM projects. For projects listed as of March, 2012, these eight countries represent over 84% (4,886 out of 5,790) of the CDM projects worldwide.

Table 1 presents our sample selection procedure. We start with all 5,790 projects available during the years 2005 to 2012. We then delete the projects that are initiated outside the eight

22

countries of our choice, which results in 4,886 projects. Once we delete projects that do not have complete data or, due to their nature, do not have a reported IRR (e.g., projects with no associated revenues are only required to do a cost analysis), our sample reduces to 2,510 projects. We also delete 164 projects that report negative IRRs, and 53 projects that do not report benchmarks. The final sample comprises 2,067 projects. Table 2 summarizes the final sample by the type of carbon mitigation. Different methods to reduce carbon emission may result in different investment incentives and returns for the projects. More than 84% of our sample projects involve renewable energy, while the second and third most prominent methods target energy efficiency improvements and greenhouse gas destruction. Out of our sample, 20 projects were withdrawn from consideration by the host, 93 were rejected from the program, and 1,954 were registered and can earn CERs. Table 3 summarizes the sample by year and by host country. China and India have the largest number of projects (1,381 and 483, respectively). The number of total projects reaches its peak in year 2010 and declines afterwards, due to the financial crisis and growing difficulties in funding risky projects.

Panel A of Table 4 presents descriptive statistics for the project-level variables. The average reported *IRR* of the sample firms is 7.6%. The potential CER subsidy generates a significant amount of additional profit. The average of *IRRDIFF*, the incremental rate of return stemming from the CER subsidy, is around 5.2%. The average reported benchmark IRR rate is 10.7% and 45.6% of the firms use a barrier analysis in their reports. The average project's expected amount of CO_2 emission reduction is 126,161 tons per year (untabled). 1.3% of the projects are audited by DOEs affiliated with an auditing firm, and 12.6% of the projects had DOEs who were subsequently sanctioned.[17] Panel B of Table 4 presents descriptive statistics at

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[17] Since all sanctioned DOEs were readmitted to the CDM program, projects using these DOEs subsequent to readmission are not coded as DOEBAD = 1.

country-level. The average *GDP* of the eight countries during our sample period is $5,210. The

average *HDI* is 87.57 and the average CO_2 is 3.51 metric tons per capita.

Table 5 provides the correlations among all key variables. *IRR* is significantly and

negatively correlated with *IRRDIFF*, and significantly and positively correlated with

BENCHMARK and *BARRIER*. The variable *MONITOR*, the first principal component of the

country-level variables, is negatively correlated with *IRR*. These correlations are indicative that

reported IRR is significantly impacted by monitoring at the country-level.

Figure 2 provides a histogram of the difference between reported IRR and the benchmark

for the project. The histogram indicates that most projects are reported to be 1-3% below the

benchmark. Financial additionality means that the projects should have an IRR below the

benchmark. However, rather than a smooth distribution of IRRs below the benchmark, the

histogram is consistent with managers manipulating the IRR to be below the benchmark, with a

small cushion, allowing satisfaction of financial additionality even if monitoring results in an

upward revision of the reported IRR.

Figure 3 provides preliminary evidence that managers avoid scrutiny related to excessive

profits from admission to the program. The figure provides a histogram of the project profitability

relative to the reported benchmark including cash flows from expected CERs. The histogram

shows a significant spike directly above 0 return in excess of the benchmark.

Multivariate Results

Table 6 reports results of a robust regression estimation of models (1) and (2).[18]

Consistent with hypothesis H1, projects with greater benefit from CERs have lower reported

IRRs in both (1) and (2), indicating that the magnitude of the potential reward increases the

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[18] The untabulated first-stage regression model estimating expected *IRR* using project mitigation type, registration status, country, and year is significant with an adjusted R^2 of 0.31.

applicants' incentives to bias. The coefficient estimates of *IRRDIFF* are highly significant in both models. Results for hypothesis H2A are not as strong. While projects with accounting firm-related DOEs have higher reported IRRs, sanctioned DOEs do not seem to have a significant effect on the reported IRRs. *MONITOR*, the country-level monitoring measure, is significantly positive, providing support for hypothesis H2B. In addition, consistent with expectations, projects with an explicit benchmark and with a barrier analysis have significantly higher reported IRRs.[19]

Results in Table 6 for model (2) are consistent with monitoring providing a moderating effect for the association between reported IRR and *IRRDIFF*. The interaction term *MONITOR*IRRDIFF* is significantly positively associated with reported IRRs, consistent with more intensive monitoring at the country-level, disciplining managers to report higher IRRs when projects have high potential returns from the CDM program. *DOEBAD*IRRDIFF* is also significant and negative, implying that applicants with high potential rewards from the CDM projects report especially low IRRs when they have ineffective DOEs. *DOEACCT*IRRDIFF* does not appear to have a significant effect on the reported IRRs. In both regression models, we control for fixed effects by year, country, mitigation type, and registration status.

Table 7A presents the results of estimating models (1) and (2), but based upon subsamples for the time periods 2005-2007 and 2008-2012. Our hypothesis H3, that CDM host firms exercise more caution starting from 2008 due to the tightening of CDM regulation, is strongly supported by the results in Table 7A. Specifically, the coefficients of *IRRDIFF* decreased in magnitude from -0.285 during 2005-2007 to -0.244 during 2008-2012. These results indicate that the host firms are less likely to underreport IRRs, given the same amount of expected benefits. In addition, the coefficients of *MONITOR* became positive and significant during 2008-2012. This

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[19] We also ran equation (1) including fixed effects by method, rather than mitigation type. Results are qualitatively similar. We report estimation of model (1) using mitigation type fixed effects to be consistent with the fixed effects used in model (2). We do not run the model (2) with method fixed effects due to sample considerations.

provides evidence that firms pay more attention to monitoring factors starting in 2008; given the

same amount of monitoring, they are less likely to underreport. Further, there are no DOEs

associated with the accounting firms in our pre-2008 subsample, and the effect of monitoring by

DOEs associated with accounting firms is strong and significant in the 2008-2012 subsample.

Overall, this test provides evidence that the CDM reforms from around 2008 have reduced

biasing behavior. We also perform an alternative robust regression with a dummy variable

Pre2008 on reported IRRs and interactions with our variables of interest. The test of H3 is the

interaction variable *IRRDIFF*Pre2008*. Results reported in Table 7B show a significantly

negative coefficient of *IRRDIFF*Pre2008*. This implies that for a given level of CER

profitability, reported IRRs were relatively lower prior to the increase in monitoring in 2008,

indicating a higher level of reporting quality.

Table 8 reports results of estimating models (3a) and (3b) via robust regression. In model

(3a), consistent with increased scrutiny of projects that can reduce egregious behavior, we find

that *MONITOR* is significantly negatively associated with *IRRDIFF*, indicating a strong

disciplinary influence of a country's institutional environment on a project's reporting. *DOEBAD*

and *DOEACCT* are not significant. Focusing on the accounting aspects of *IRRDIFF* by

controlling for *REDUCTION (*model 3b*)* provides similar results.[20] In both models, the control

variables *BENCHMARK* and *BARRIER* are both significantly positive.

Table 9 presents a variation of model (1) with *MONITOR* replaced with each of its

component country-level variables, i.e. *GDP, HDI_RANK*, and CO_2. Since these variables are

highly correlated, we cannot include them in the same regression simultaneously. In general, the

results are consistent with our main analyses in model (1). Specifically, *GDP* and *HDI_RANK* are

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[20] The regression model estimating expected *REDUCTION* using mitigation methods is significant with an adjusted R^2 of 0.29.

both significant and positive, confirming that an economically and socially more developed country provides an overall higher level of institutional monitoring. All other variables remain significant as before.

The technologies involved in the CDM projects vary greatly. To rule out any effect that can be attributed purely to technological differences across projects, in untabulated analyses, we estimate models (1) and (2) with the subsample of renewable energy projects alone. These projects comprise the most commonly used mitigation methods among CDM projects. The results are largely consistent with our main analyses, indicating that the difference in mitigation methods does not drive our main results.

6. Discussion and Conclusions

It its 2020 meeting, the World Economic Forum listed extreme weather and climate action failure as the two most likely long-term risks to the world economy (World Economic Forum 2020). Managing these risks will require accounting regulators and practitioners to help the market understand and properly evaluate climate risk, and provide tools for managers to make decisions that take climate risks into consideration. However, models to understand and disclose climate-related information are still immature. Academic research can play an important role by informing model development through analysis of proposed and extant models. In this study, we examine the model used for valuation of CDM projects. We employ a broad cross-section of financial projections for CDM projects to investigate reporting bias and the model's underlying incentives.

Consistent with our expectation, we find evidence suggesting that reported rates of return by host firms tend to downwardly bias the value of their projects, which increases the probability of acceptance into the CDM program. However, monitoring at multiple levels appears to mitigate the distorted incentives and related misreporting. We find evidence that both country-level factors

within the host country and project-level monitoring by project participants and auditors improve reporting. These results underscore the importance of monitoring in diverse settings to mitigate adverse incentives. Last, but not least, we find that CDM reforms around the years 2007 and 2008 effectively reduced the opportunistic behavior of host firms, and at least partially improved the overall CDM governance and efficiency.

Our results are particularly relevant as the CDM evolves. The absolute cap for CERs imposed by the EU was reached in 2013, which led to a sharp reduction of CER prices to less than 0.2 €. Further, after the second trading period of emissions allowances in Europe (in 2013), the EU decided that CDM credits that are tradeable on the EU ETS will only be granted for projects in the least developing countries (excluding countries such as China, India, and Brazil) (Manea 2012). This decision has already resulted in a shift towards CDM projects in less developed countries. These countries tend to have weaker institutional frameworks, with potentially negative consequences for the monitoring process and auditing quality. Our results suggest that given the weaker country-level monitoring in the countries that are hosting CDM projects, the UN should strengthen requirements for technical *and* financial expertise of the auditing firms and perhaps consider developing alternative means of counterbalancing the weak institutional environments in these countries.

Our paper also has some caveats. In particular, the scope of our research is limited to the financial analyses in the CDM project applications, while the potential for manipulation also lies in the technical aspects of the submissions. Specifically, the technical assumptions and evaluations can also be used to bias the applications submitted by host firms. An area for future research would be to examine the interplay between the financial and technical aspects of the submissions.

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FIGURE 1

Project Stages for a Successfully Implemented CDM Project*

Project Status	Participants	Resulting documents
Development	Project owner/project developer	Project design document
Approval	Host country Designated National Authority (Host and Annex 1 country)	Letter of approval
Validation	Designated Operating Entity (DOE$_1$)**	Validation report
Registration	CDM Executive Board (EB)	CDM Executive Board decision
Monitoring	Project owner	Monitoring report
Verification	DOE$_2$	Verification report
Certification	DOE$_2$	Certification report
Issuance of CERs	CDM Executive Board (EB)	CDM registry

* Projects that fail to pass a stage can be revised and resubmitted.
** DOE$_1$ and DOE$_2$ may or may not be the same organization.
Adapted from: UNFCCC (2001)

FIGURE 2

Histogram of Deviations from Benchmark IRR
Positive IRR Projects

FIGURE 3

Expected Gain from CERs relative to Reported Benchmark IRR
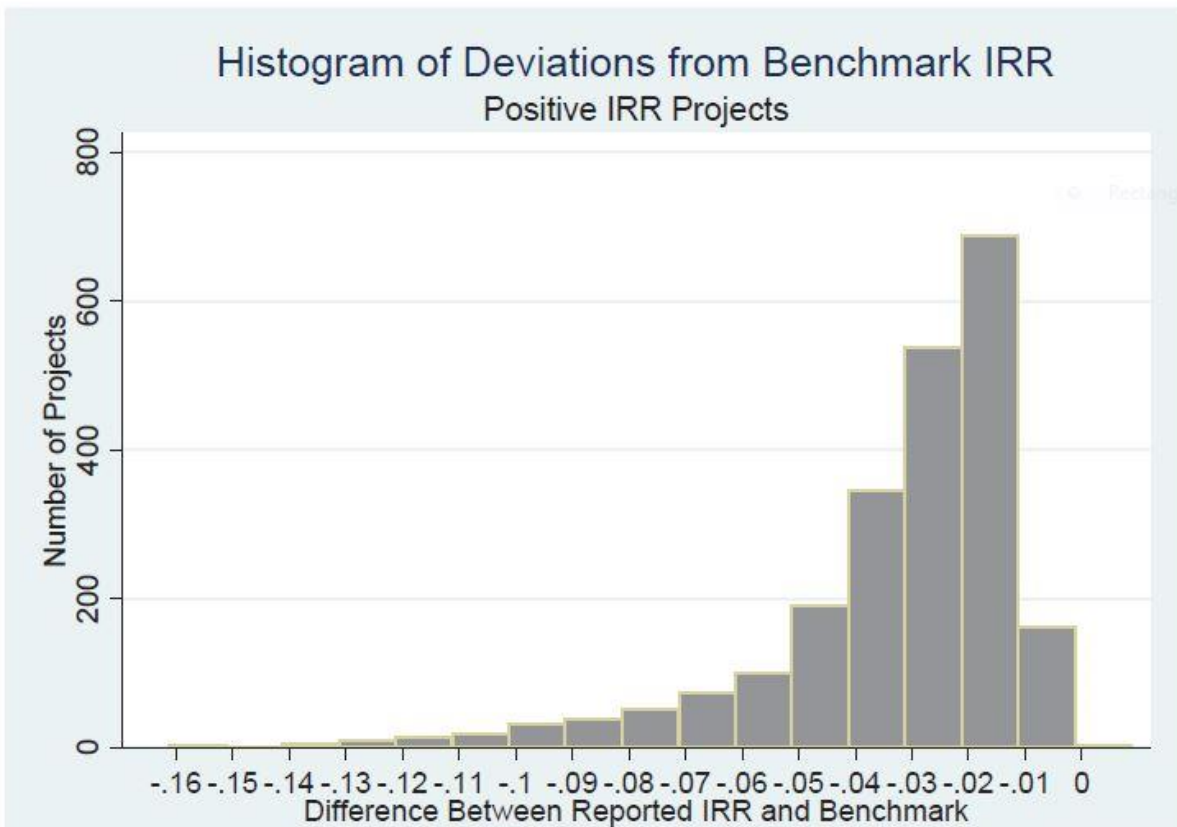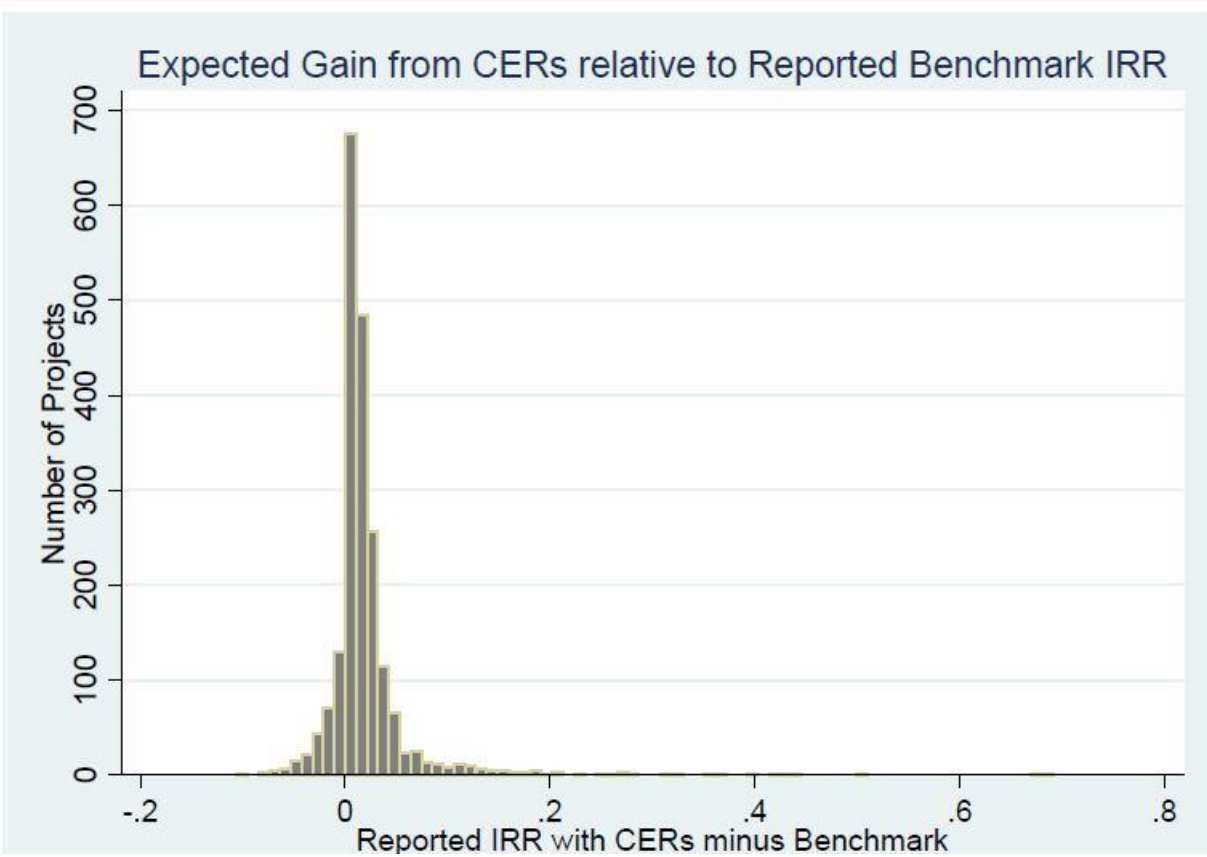
TABLE 1

Sample Development

	Reductions	**Remaining**
Projects Available 2005-2012		**5,790**
Projects in non-sample countries	904	**4,886**
Basic data about project missing, or IRR is not required	2,376	**2,510**
IRR is negative	164	**2,346**
Projects missing incremental IRR due to CERs	226	**2,120**
Missing benchmark	53	**2,067**

TABLE 2

Carbon Mitigation Types

Method	Title	# projects
Greenhouse Gas (GHG) destruction		114
Examples:	Flaring or use of landfill gas	
	Abatement of methane from coal mines	
	Wastewater treatment in new anaerobic facility and existing aerobic facility	
Renewable energy		1,750
Examples:	Grid-connected electricity generation from renewable sources (not biomass-fired power plants)	
	Consolidated methodology for electricity and heat generation from biomass	
	Grid connected renewable electricity generation (typically biomass)	
Fuel switch		8
Examples:	Partial substitution of fossil fuels in cement or quicklime manufacture	
	Consolidated baseline and monitoring methodology for fuel switching from coal or petroleum fuel to natural gas	
	Recovery and utilization of gas from oil fields that would otherwise be flared or vented	
Energy efficiency		132
Examples:	Consolidated methodology for waste gas and/or heat for power generation	
	Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects	
	Greenhouse gas reductions through waste heat recovery and utilization for power generation at cement plants	
Feedstock switch		2
Example:	Use of noncarbonated calcium sources in the raw mix for cement processing	
GHG emission avoidance		31
Examples:	Alternative waste treatment processes	
	Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting	
	Avoidance of methane emissions through composting	
Low carbon electricity		26
Example:	Grid-connected electricity generation plants using natural gas	
Afforestation and Reforestation		4
Examples	Afforestation and reforestation of degraded land	
	Reforestation of degraded land	
	Afforestation and reforestation of degraded land through tree planting, assisted natural regeneration, and control of animal grazing	

* Codes were developed based upon categories from the United Nations CDM Methodology Booklet (CDM Executive Board 2010).

TABLE 3

CDM Projects by Host Country and Year

Year	Brazil	China	India	Indonesia	Malaysia	Mexico	Peru	Thailand	Total
2005	0	2	2	0	0	0	0	0	**4**
2006	16	22	18	1	0	1	0	0	**58**
2007	2	87	51	2	8	2	1	3	**156**
2008	5	179	51	2	4	1	4	1	**247**
2009	2	340	44	5	6	4	5	6	**412**
2010	2	495	70	9	4	3	2	9	**594**
2011	4	210	121	10	5	5	2	16	**373**
2012	5	46	126	10	2	12	15	7	**223**
Total	**40**	**1,381**	**483**	**39**	**29**	**28**	**29**	**42**	**2,067**

TABLE 4

Summary Statistics

Panel A: Project-Level Variables

Variable	Obs.	Mean	Median	Std. Dev.	Min.	Max.
IRR	2,067	7.634	7.12	2.619	0.130	21.300
IRRDIFF	2,067	5.214	3.70	5.911	0.310	82.580
BENCHMARK	2,067	10.725	10.00	2.969	4.610	25.300
BARRIER	2,067	0.456	0	0.498	0	1
DOEACCT	2,067	0.013	0	0.111	0	1
DOEBAD	2,067	0.126	0	0.332	0	1

Panel B: Country-Level Variables

Variable	Obs.	Mean	Median	Std. Dev.	Min.	Max.
GDP	64	5.21	4.63	3.12	0.74	12.58
HDI	64	87.57	89.00	23.89	48.00	123.00
CO_2	64	3.51	3.05	2.07	1.20	7.80

IRR is the applying firm's reported rate of return. *IRRDIFF* is the incremental internal rate of return stemming from the CERs. *BENCHMARK* is the reported benchmark IRR. *BARRIER* is 1 if the host firm reports a barrier analysis, 0 otherwise. *DOEACCT* is 1 if DOE is affiliated with a Big Four audit firm, 0 otherwise. *DOEBAD* is 1 for the year if DOE was sanctioned, 0 if the DOE was never sanctioned or the years following reinstatement for sanctioned DOEs. *GDP* is Gross Domestic Product per capita in $thousands; *HDI* is the rank of the Human Development Index (inverted so that higher is more-developed); *CO_2* is carbon emissions per capita.

TABLE 5

Correlation Matrix for Primary Variables Included in Regression Analyses

	IRR	*IRRDIFF*	*BENCHMARK*	*BARRIER*	*MONITOR*	*DOEBAD*
IRR	1.0000					
IRRDIFF	-0.2354	1.0000				
	0.0000					
BENCHMARK	0.6947	0.1440	1.0000			
	0.0000	*0.0000*				
BARRIER	0.2734	0.1118	0.4075	1.0000		
	0.0000	*0.0000*	*0.0000*			
MONITOR	-0.4017	0.1051	-0.4222	-0.3766	1.0000	
	0.0000	*0.0000*	*0.0000*	*0.0000*		
DOEBAD	0.1040	0.0236	0.1427	0.0919	-0.1393	1.0000
	0.0000	*0.2835*	*0.0000*	*0.0000*	*0.0000*	
DOEACCT	-0.0113	-0.0193	-0.0510	-0.0337	0.0717	-0.0428
	0.6450	*0.3816*	*0.0205*	*0.1261*	*0.0011*	*0.0516*

MONITOR is the factor score from the first principal component of the country-level variables for *HDI_RANK* (Human Development Index rank), CO_2 emissions per capita, and Gross Domestic Product (*GDP).* Remaining variables are as described in Table 4. The table includes Pearson's correlation coefficients, with significance shown in *italics*.

TABLE 6

Robust Regression of Factors Affecting Reported IRR, for Positive IRR Projects

	Predicted Sign	*IRR_RES* Coefficient	P-value	*IRR_RES* Coefficient	P-value
BENCHMARK	+	**0.7231**	**0.000**	**0.7186**	**0.000**
BARRIER	+	**0.0010**	**0.095**	**0.0010**	**0.084**
IRRDIFF	-	**-0.2453**	**0.000**	**-0.2306**	**0.012**
MONITOR	+	**0.0076**	**0.004**	**0.0068**	**0.073**
*MONITOR*IRRDIFF*	+			**0.0352**	**0.000**
DOEBAD	-	-0.0002	0.857	**0.0034**	**0.005**
*DOEBAD*IRRDIFF*	-			**-0.1076**	**0.000**
DOEACCT	+	**0.0045**	**0.047**	-0.0003	0.968
*DOEACCT*IRRDIFF*	+			0.1122	0.481
Intercept		**-0.0702**	**0.000**	**-0.5647**	**0.000**
Year fixed effects		Yes		Yes	
Mitigation type fixed effects		Yes		Yes	
Country fixed effects		Yes		Yes	
Registration status fixed effects		Yes		Yes	
N		2,066		2,066	
F		**165.90**	**0.000**	**158.81**	**0.000**

Two-tailed *p* values are reported. *IRR_RES* is the residual from the regression model where the reported internal project rate of returns (excluding CER benefits) is regressed on project mitigation type, registration status, country, and year. Remaining variables are as described in tables 4 and 5. One outlier was deleted from the regression by STATA's robust regression routine. Bold values indicate statistical significance at the 0.10 level.

Robust Regression of Factors Affecting Reported IRR, pre- and post-2008

		2005-2007		2008-2012	
		IRR		*IRR*	
	Predicted Sign	Coefficient	P-value	Coefficient	P-value
BENCHMARK	+	**0.7634**	**0.000**	**0.7359**	**0.000**
BARRIER	+	-0.0023	0.245	**0.0011**	**0.089**
IRRDIFF	-	**-0.2851**	**0.000**	**-0.2437**	**0.000**
MONITOR	+	-0.1003	0.109	**0.0105**	**0.004**
DOEBAD	-	-0.0023	0.242	0.0014	0.239
DOEACCT	+	N/A		**0.0043**	**0.050**
Intercept		**0.0476**	**0.004**	0.0081	0.128
Year fixed effects		Yes		Yes	
Mitigation type fixed effects		Yes		Yes	
Country fixed effects		Yes		Yes	
Registration status fixed effects		Yes		Yes	
N		217		1,849	
F		**88.69**	**0.000**	**347.87**	**0.000**

Variables are described in Tables 4 and 5. Two-tailed *p* values are reported. One outlier was deleted from the regression by STATA's robust regression routine. Bold values indicate statistical significance at the 0.10 level.

Robust Regression of Factors Affecting Reported IRR, pre-2008 and 2008 and after

	Predicted Sign	IRR Coefficient	P-value	IRR Coefficient	P-value
BENCHMARK	+	**0.7217**	**0.000**	**0.7236**	**0.000**
Pre2008		**0.0428**	**0.000**	**0.0401**	**0.000**
BARRIER	+	**0.0009**	**0.095**	**0.0013**	**0.048**
*BARRIER*Pre2008*				-0.0025	0.166
IRRDIFF	-	**-0.2453**	**0.000**	**-0.2376**	**0.000**
*IRRDIFF*Pre2008*		**-0.1306**	**0.000**	**-0.1152**	**0.000**
MONITOR	+	**0.0083**	**0.002**	**0.0057**	**0.067**
MONITOR Pre2008*				**-0.0034**	**0.055**
DOEBAD	-	-0.0001	0.908	0.0012	0.321
DOEBAD Pre2008*				**-0.0020**	**0.084**
DOEACCT	+	**0.0044**	**0.045**	**0.0044**	**0.046**
DOEACCT Pre2008*				*	*
Intercept		**0.0121**	**0.014**	**0.0141**	**0.010**
Year fixed effects		Yes		Yes	
Mitigation type fixed effects		Yes		Yes	
Country fixed effects		Yes		Yes	
Registration status fixed effects		Yes		Yes	
N		2,066		2,066	
F		**377.98**	**0.000**	**342.04**	**0.000**

Pre2008 takes value 1 for observations in years 2005-2008, 0 otherwise. Remaining variables are as described in Tables 4 and 5. Two-tailed *p* values are reported. One outlier was deleted from the regression by STATA's robust regression routine. Bold values indicate statistical significance at the 0.10 level. *Note that there accounting firm DOEs are not represented in our sample until after 2008.

TABLE 8

Robust Regression of Factors Related to Incremental Internal Rate of Return from CERs

	Predicted Value	IRRDIFF Coefficient	P-value	IRRDIFF Coefficient	P-value
BENCHMARK	?	**0.1334**	**0.000**	**0.1365**	**0.000**
BARRIER	?	**0.0037**	**0.000**	**0.0036**	**0.000**
REDUCTION	+			**0.0000**	**0.033**
MONITOR	-	**-0.0161**	**0.000**	**-0.0159**	**0.000**
DOEBAD	?	-0.0013	0.326	-0.0014	0.293
DOEACCT	?	0.0049	0.104	0.0045	0.132
Intercept		**0.1058**	**0.000**	**0.004**	**0.013**
Year fixed effects		Yes		Yes	
Mitigation type fixed effects		Yes		Yes	
Country fixed effects		Yes		Yes	
Registration status fixed effects		Yes		Yes	
N		2,067		2,067	
F		**229.03**	**0.000**	**218.39**	**0.000**

REDUCTION is the residual from a regression of the annual expected carbon reduction on dummy variables for each mitigation method. Remaining variables are described in tables 4 and 5. Two-tailed *p* values are reported. Bold values indicate statistical significance at the 0.10 level.

TABLE 9

Robust Regression of Factors Affecting Reported IRR, Using Components of MONITOR

	Predicted Sign	IRR Coefficient	P-value	IRR Coefficient	P-value	IRR Coefficient	P-value
BENCHMARK	+	**0.7256**	**0.000**	**0.7221**	**0.000**	**0.7298**	**0.000**
BARRIER	+	0.0008	0.161	**0.0012**	**0.046**	0.0008	0.200
IRRDIFF	-	**-0.2449**	**0.000**	**-0.2468**	**0.000**	**-0.2454**	**0.000**
GDP	+	**0.0011**	**0.065**				
HDI_RANK	+			**0.0005**	**0.000**		
CO2	+					0.0014	0.212
DOEBAD	-	-0.0000	0.968	-0.0004	0.700	-0.0000	0.972
DOEACCT	+	**0.0046**	**0.042**	**0.0044**	**0.051**	**0.0046**	**0.043**
Intercept		**0.0292**	**0.001**	-0.0112	0.429	**0.0356**	**0.000**
Year fixed effects		Yes		Yes		Yes	
Mitigation type fixed effects		Yes		Yes		Yes	
Country fixed effects		Yes		Yes		Yes	
Registration status fixed effects		Yes		Yes		Yes	
N		2,066		2,066		2,066	
F		**371.61**	**0.000**	**378.34**	**0.000**	**374.08**	**0.000**

Variables are described in tables 4 and 5. Two-tailed *p* values are reported. One outlier was deleted from the regression by STATA's robust regression routine. Bold values indicate statistical significance at the 0.10 level.

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