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Is the Clean Development Mechanism Promoting Sustainable Development?

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Abstract

One of the dual objectives of the Clean Development Mechanism (CDM) of the Kyoto Protocol is to promote sustainable development in the host countries. With different CDM indicators for 58 CDM host countries over 2005-10, this paper empirically assesses whether CDM project development fulfils this objective of sustainable development. Using a unique dynamic panel data method based on long-differences of the model, this research provides evidence in support of significant contribution to sustainable development of CDM projects in the host countries. It sheds light on the role of CDM projects in the process of sustainable development with clear policy implications for developing countries and the wider world.

Keywords: clean development mechanism, sustainable development, dynamic panel data model, long-differencing

JEL classification: O19, Q54, Q56

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1 Introduction

As an important step towards a long-term international climate change protocol, the Durban climate change conference managed to extend the current Kyoto Protocol with another five-year commitment period, which effectively avoids the much-feared scenario of having no legal-binding international agreement at all after 2012. However, this achievement is overshadowed by the worries and criticisms that the current Kyoto Protocol is fundamentally flawed and, more specifically, its flexibility mechanisms such as the Clean Development Mechanism (CDM) do not live up to its twin objectives of emission reductions and sustainable development. Against this background, it is high time to examine the effectiveness of Kyoto mechanisms to deepen our understandings of how the global efforts should proceed to pave the way for the formation of the all-party-inclusive climate treaty by 2015 as agreed in Durban.

As the only market-based mechanism that engages both Annex I countries (mainly developed countries) and non-Annex I countries (mainly developing countries) in carbon dioxide emission abatement activities, CDM attracts special attention and focus. As specified in Article 12 of the Kyoto Protocol, CDM was set up with two major aims, which are equally important: one is to mitigate GHG emissions in a cost-effective manner and the other is to boost sustainable development in the host countries. The dual objectives of the CDM serve as important driver for both the developing countries and developed countries to engage in the CDM projects.

However, one central issue high on the agenda of recent discussions, among both practitioners and scholars, is whether CDM promotes the host countries' sustainable development. So far the existing literature on this topic has been vastly divided in opinions. Some research argues that CDM has brought about considerable sustainable development benefits to the host countries (Austin et al. 1999; UNFCCC 2011). Others claim that CDM projects have not benefited the host country in its sustainable development (e.g. Olsen 2007) but rather in some cases reduce the emissions at the expense of the host countries' sustainable development (e.g. Paulsson 2009). Ellis et al. (2007) observe that the small-scale projects that are believed to have more sustainable development benefits are less popular for the investors than the large-scale projects with few sustainable development benefits but great impacts on emission reductions for the investors. Also, CDM projects such as projects on energy efficiency, renewables and sustainable farms that achieve the synergies between CDM's two goals but not necessarily offering the cheapest options for GHG abatement do not occupy a big share of the current CDM market (Ellis et al. 2007).

Sustainable development calls for a balance between the three pillars of economic development, social equity and environmental protection.[1] This concept has gained widespread endorsement from governments, private sector and civil society as a significant guiding principle. Given the importance of this issue and the contrasting views in the literature related to CDM development, it is of great value for this paper to

1 The most widely accepted definition of the concept of sustainable development is: 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987: 43).

investigate whether in reality CDM projects have produced sustainable development benefits in the host countries.

This paper makes use of the human development indicators to measure sustainability and four CDM indicators based on new data on CDM credits and investments for 58 countries over 2005-10. To deal with highly persistent data in the dynamic panel data model, this paper employs a unique method of long-difference instrumental variable estimation method, aiming to provide new evidence and insights into this crucial issue.

This paper finds that CDM project development, measured by CDM credits per capita, CDM contribution to the economy, CDM actual emission reductions and CDM investment capability, could induce sustainable development in the host countries. This paper not only deepens our understanding of the debatable issue on CDM's sustainability impacts but also enriches the current methodology of assessing CDM's effects. The finding has important implications for both research and practice.

The remainder of the paper proceeds in Section 2 to review the literature. Section 3 describes the model and variables. Section 4 outlines the methodology employed. Section 5 conducts estimation and presents results. Section 6 concludes.

2 Literature review

The adoption of the Kyoto Protocol in 1997 marked a milestone in the global efforts of curbing GHG emissions and boosting sustainable development. Under the Kyoto Protocol, there are three market-based mechanisms, namely, Emissions Trading (ET), Joint Implementation (JI) and CDM. This paper discusses the CDM exclusively.

CDM embodies the principle of the 'common but differentiated responsibilities'. CDM is the only flexibility mechanism which involves developing countries in the world's GHG abatement activities and incorporates sustainable development objective into emission reduction efforts. This mechanism itself is an innovation which contributes to carbon pricing and commodification process and achieves the synergies between global emission reduction targets and local sustainable development objectives (Olhoff et al. 2004). More specifically, it is the first global environmental offset instrument of its kind, providing financial incentives for the developed countries to invest in low-carbon projects in the developing countries which help to induce the host countries onto a low-carbon development path, and contribute to the stabilization of the global atmospheric GHG emissions.

To ensure that the registered CDM projects bring about sustainable development benefits to the host countries, it is required in the Marrakesh Accords that 'it is the host Party's prerogative to confirm whether a clean development mechanism project activity assists it in achieving sustainable development' (UNFCCC 2001). In recent years there has been increasing attention to the crucial issue of whether CDM has fulfilled its sustainable development objective.[2] Opinions differ widely in the existing literature.

2 Its sister paper, Huang et al. (2012), deals with CDM effectiveness for emission reductions.

At one end of the spectrum are the positive views on CDM's sustainability benefits. Based on the case studies of the effects of more than 40 CDM projects on sustainable development in Brazil, India and China, Austin et al. (1999) point out that in many cases the CDM projects chosen for the GHG emission reduction benefits are also likely to bring about considerable beneficial effects on sustainable development.[3] Their research demonstrates that GHG abatement and sustainable development targets can be pursued at the same time, and the identified CDM sustainable benefits include improved water availability, decreased soil erosion, biodiversity conservation, creation of job opportunities, raised income and improved energy self-sufficiency.[4] By analysing the claims made by CDM project participants in the project design documents of 2,250 projects registered before July 2011, UNFCCC (2011) shows that most examined CDM projects made positive claims about sustainable development benefits and CDM projects have made real contributions to sustainable development on top of GHG abatement benefits in the host countries.[5]

At the other end of the spectrum, however, such an optimistic view of CDM's sustainability benefits is not echoed by others. It is argued that the mechanism's focus on low-cost GHG emission reductions projects might to some degree compromise the host countries' sustainability development since sustainable development is not integrated into the market aspect of the mechanism and there is no financial incentive for the project developers to pursue the CDM projects which merely boost sustainable development (Ellis et al. 2007; Olsen 2007; Paulsson 2009). It is also argued that a trade-off favouring the low-cost GHG emission abatement is very likely due to intense competition and the lack of global sustainable development criteria.[6] Based on an assessment of 16 officially registered CDM projects using the methodology of Multi-Attributive Assessment of CDM, Sutter and Parreño (2007) found that although 72 per cent of the examined CDM projects are likely to bring about real and measurable

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3 More specifically, in Brazil, the case studies were conducted in the forestry and energy sectors and the researchers evaluated the effects of the potential CDM projects against 12 national development criteria with findings lending support to the positive impacts of CDM on its national development priorities. In India, researchers carried out case studies of 20 potential CDM projects in 5 sectors and found that of all the reviewed projects, there exist strong synergies between emission abatement and sustainable development. In China, a similar methodology was employed and the results demonstrate that there exists considerable overlap between projects with most emission reduction impacts and projects with most sustainable development benefits.

4 Similarly, Olhoff et al. (2004) show a wide range of sustainable development benefits of CDM, including enhanced energy efficiency, technology diffusion, improved local environment, boosted employment rate, improved health conditions and increased living standards.

5 In this research, 15 indicators covering the three pillars of sustainable development (economic development, social equity, and environmental protection) were employed to assess the projects. The analysis demonstrates that employment creation is the most frequently claimed sustainability benefit, together with other benefits inclusive of the reduction in noise and pollution, the protection of natural resources, promotion of renewable energy, investment in local infrastructure, financial benefit for the economy, technology diffusion, promotion of education, health and safety, poverty alleviation, and labour condition improvement.

6 Olsen (2007) and Sutter and Parreño (2007) argue that, although developing countries can set the sustainable development requirements of the CDM projects to be carried out in their countries as specified in the Marrakech Accords, the competition among non-Annex I nations to attract CDM investment actually create an incentive for the host countries to lower their sustainable development standards to invite more projects with low-emission reduction cost. On top of the intense competition among the developing nations for CDM projects, the lack of global sustainable development criteria is another reason that gives rise to a trade-off favouring the emissions reduction goal.

emission reductions, less than 1 per cent of the total assessed portfolio is likely to make significant contributions to the host country's sustainable development. Likewise, based on desktop analysis and case study of 500 registered CDM projects, the work by Subbarao and Lloyd (2011) demonstrates that the CDM has failed to deliver its sustainable development goals for host nations' rural communities.

As summarized by the UNFCCC (2011), most of the existing research which evaluate the CDM's sustainable development impacts are project-based analyses. The existing research usually uses a list of quantitative or qualitative sustainable development indicators against which a CDM project is examined to score the project, and then aggregates the obtained scores from each indicator into an overall score to measure the project's impacts on sustainable development (Sutter and Parreño 2007, Olsen and Fenhann 2008). As noted by Schneider (2007), the actual effects of CDM projects on the host countries' sustainable development at the national level are difficult to evaluate. Actually, research on CDM's sustainable development impacts at the national level has been lacking. To fill the gap, this research aims to provide cross-country evidence on the effectiveness of CDM in promoting sustainable development in the host countries.

3 Model and variables

This section sets up the model and discusses the variables involved.

In recent years, considerable research has suggested that a number of variables, such as per capita GDP growth rate, gross national income per capita, life expectance and age dependency, are closely related to the level of sustainable development (UNECE 2009). To assess the impacts of CDM projects on sustainable development process in the host countries, the following model is used in this context:

$$\begin{aligned}\mathrm{HDI}_{it} = {} & \gamma_i + \alpha\mathrm{HDI}_{i,t-1} + \beta_1\mathrm{CDM}_{i,t-1} + \beta_2\mathrm{GR}_{i,t-1} + \beta_3\mathrm{GNIPC}_{i,t-1} \\ & + \beta_4\mathrm{LIFE}_{i,t-1} + \beta_5\mathrm{AGE}_{i,t-1} + \beta_6\mathrm{TRADE}_{i,t-1} + \\ & \beta_7\mathrm{WGI}_{i,t-1} + \varrho_{it}\end{aligned} \quad (1)$$

i = 1, 2…, 58 and t=2, 3..., 6

The dependent variable is the Human Development Index (HDI).[7] The HDI index is the standard measure for life expectancy, literacy, education and standards of living. It can be used to distinguish whether the country is developed, developing or under-developed and has been widely used to gauge the level of sustainable development for a country.[8] Data on HDI are taken from the UNDP Human Development Report (2011).

7 There is a lack of common standards for sustainable development. Olsen and Fenhann (2008) suggest creating an international standard for evaluating the sustainability benefits from CDM projects. However, Paulsson (2009) worries that such a suggestion might not be politically and practically feasible given the context-specific nature of the concept of sustainable development for different hosting nations. The HDI could be so far the most appropriate one.

8 Actually, the HDI is a measure of human well-being, saying little about environmental degradation. This paper focuses more on the economic and social dimension of sustainability whereas its sister paper, Huang et al. (2012), examine the impacts of CDM on environment and climate specifically.

The key independent variable is the CDM project development (CDM), which could be any of the following four indicators:[9]

(1) CDM credits per capita (CER_POP), the ratio of total CDM credits (kCERs) over total population in a given country;[10]

(2) CDM Contribution to the Economy (CER_GDP), the ratio of total CDM credits (kCERs) over total GDP.[11] It measures the economic revenue coming from the CDM projects compared to the countries' GDP. It is a direct indicator of the relative importance of CDM projects to the host country's economy or the prominence of CDM activities relative to other economic activities;

(3) CDM Actual Emissions Reductions (CER_CO2), the ratio of total CDM credits (kCERs) over a country's actual carbon emissions.[12] It is the expected emission reductions achieved through CDM projects compared to a country's actual carbon emissions. It gives a rough idea of the domestic emission reductions efforts via CDM and how much the CDM projects can contribute to national emission reductions efforts in a given country;

(4) CDM Investment Capability (INV_GDP), the ratio of total investments in CDM projects over total GDP.[13] It is an immediate indicator of green FDI via CDM projects relative to GDP, capturing the ability of a country to attract external financing for emission reductions.

Data on total CDM credits (kCERs to 2040) and total investments (million US$) at project validation are from the UNFCCC.[14] Data on total CO_2 emissions from fuel combustion by sectoral approach ($MtCO_2$) are from the Enerdata's Global Energy Market Data (2012). Data on total GDP (ppp in constant 2005 international $) and population are from the World Bank World Development Indicators Database (2012).

A number of control variables are used in this analysis, including per capita GDP growth (GR), gross national income per capita (GNIPC), Life Expectancy Ratio (LIFE), Age Dependency Ratio (AGE), Trade (TRADE) and World Governance Indicator (WGI). Trade share is to control for the extent of trade openness while World Governance Indicator measures the institutional quality in a given country. Data for per capita GDP growth rate, gross national income per capita, life expectance ratio, age dependence ratio, and trade share are from the World Bank World Development Indicators Database (2012). The WGI measure from Kaufmann et al. (2011) is a widely-

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9 Based on the total number of CDM projects and total CDM credits (CERs), Lütken (2011) proposes four indicators: Project Generation Ability, CDM Contribution to the Economy, Investment Capacity and Actual Emissions Reductions. Since the size of CDM projects varies considerably across countries, this analysis focuses on CDM credits (CERs) and actual investments (Million US$) instead. It gives up the indicator of Project Generation Ability and uses the ratio of investment, rather than the number of projects, over GDP for the indicator of Investment Capacity.

10 The indicator is adjusted by a multiplication factor of 1,000 so that it is CERs per capita.

11 A multiplication factor of 1,000,000 is applied, so it is CERs per 1000 units of GDP.

12 The CERs per tCO_2 emissions (sectoral approach) is used.

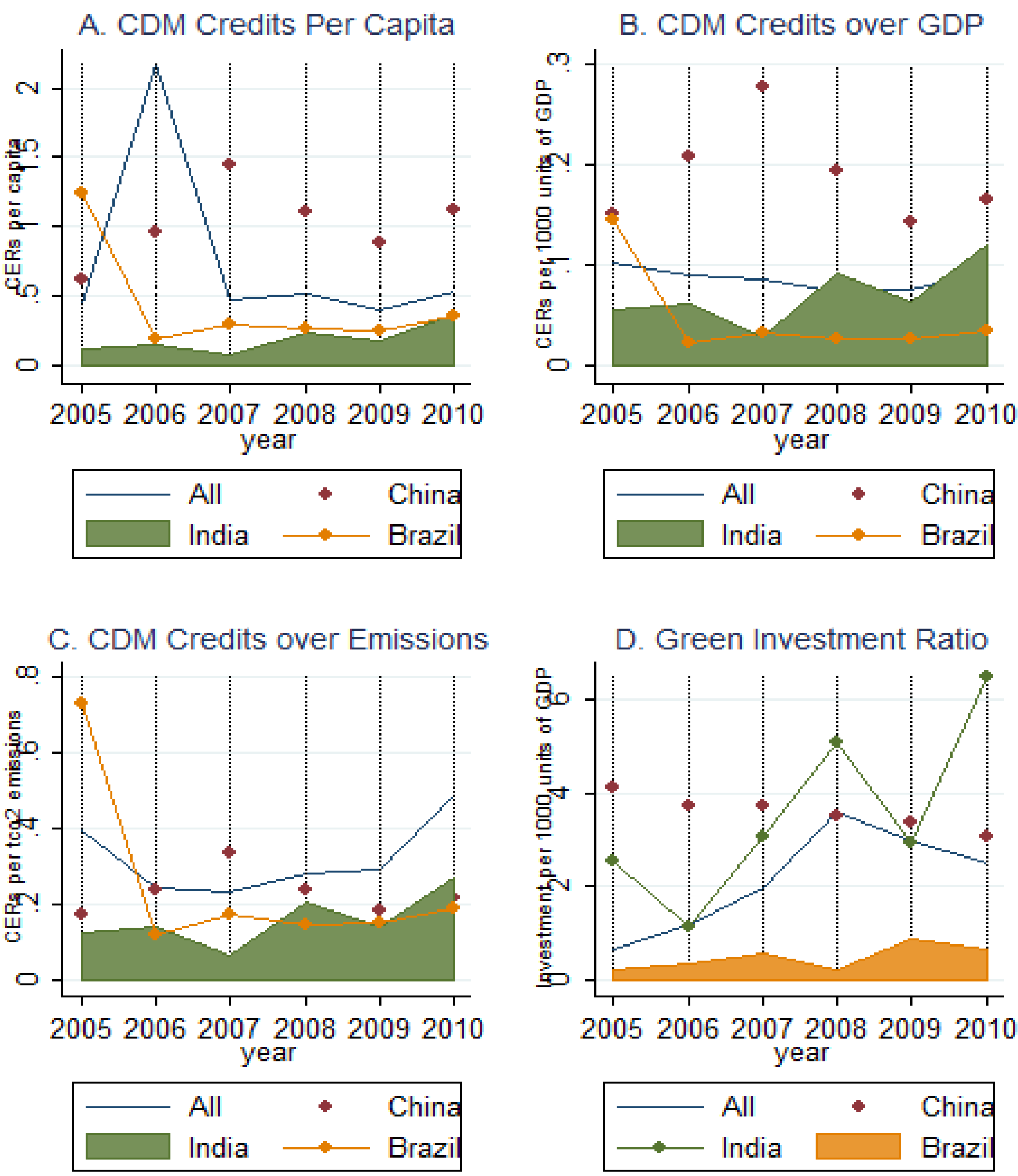
13 It is adjusted by a multiplication factor of 1,000,000,000 so that it is investment per 1000 units of GDP.

14 Grant A. Kirkman and Mathew Wilkins at UNFCCC have generously shared the data with us.

used indicator of the quality of a given government in a broader sense, derived by averaging six measures of the government quality: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption.

γ_i are the country-specific unobserved fixed effects. α and β_1-β_7 are coefficients to be estimated for variables explained above. The autoregressive coefficient α is assumed to lie inside the unit circle, $|\alpha|<1$, to ensure the model stability. ϱ_{it} are the idiosyncratic errors, which are assumed to be uncorrelated with the individual effects and independently distributed with zero mean and finite variance.

Figure 1: Trend in CDM Development



Note: 58 countries, 2005-2010. Variables and data are described in text.

Source: Authors' calculations.

We assume that GR_{it}, $GNIPC_{it}$, $LIFE_{it}$, AGE_{it}, $TRADE_{it}$, and WGI_{it} are predetermined with respect to ϱ_{it} in the sense that these variables may be correlated with $\varrho_{i,t-1}$ and earlier shocks, but is uncorrelated with ϱ_{it} and subsequent shocks. The assumption on these explanatory variables being predetermined rules out a potential endogeneity bias.

The whole sample includes 58 CDM host countries over 2005-10, as listed in the Appendix Table 1. We exclude any countries which have less than 2 annual observations for dependent variable or CDM credits.

Descriptive statistics of all variables can be found in Appendix Table 2 while correlations among variables are presented in Appendix Table 3.

In four separate charts with one chart one CDM indicator mentioned above, Figure 1 presents the comparisons for all countries (average) against three largest CDM host countries: China, India and Brazil. In terms of CDM credits per capita, CDM credits over GDP and CDM credits over emissions, China in general remains at the relatively higher levels compared to India and Brazil. In terms of green investment ratio, India's ratios are comparatively high and volatile while the investments in China and Brazil are relatively stable.

4 Methodology

This section outlines the estimation methods used for the dynamic panel data model with fixed effects in this context. This research basically applies the methods using the long-differencing estimator due to Hahn et al. (2007), in comparison to the traditional within group estimator and system-GMM estimator due to Blundell and Bond (1998), which are employed widely.

A number of methods have been proposed to estimate the dynamic panel data models with a short time dimension, in which within transformation or first-differencing can be used to eliminate the individual effects. Below is Equation (1) in first differences:

$$\Delta HDI_{it} = \alpha\Delta HDI_{i,t-1} + \beta_1\Delta CDM_{i,t-1} + \beta_2\Delta GR_{i,t-1} + \beta_3\Delta GNIPC_{i,t-1} + \beta_4\Delta LIFE_{i,t-1} + \beta_5\Delta AGE_{i,t-1} + \beta_6\Delta TRADE_{i,t-1} + \beta_7\Delta WGI_{i,t-1} + \Delta\varrho_{it} \quad (2)$$

i = 1, 2, ..., 58 and t=3, ..., 6

where $\Delta HDI_{it} = HDI_{it} - HDI_{i,t-1}$. $\Delta CDM_{i,t-1} = CDM_{i,t-1} - CDM_{i,t-2}$, which also applies to $\Delta GR_{i,t-1}$, $\Delta GNIPC_{i,t-1}$, $\Delta LIFE_{i,t-1}$, $\Delta AGE_{i,t-1}$, $\Delta TRADE_{i,t-1}$, and $\Delta WGI_{i,t-1}$. $\Delta\varrho_{it} = \varrho_{it} - \varrho_{i,t-1}$.

For simplicity, let y_{it} denote the dependent variable, HDI_{it}, and $x_{i,t-1}$ denote a k×1 (k=7) vector of the independent variables, $x_{i,t-1}=(CDM_{i,t-1}, GR_{i,t-1}, GNIPC_{i,t-1}, LIFE_{i,t-1}, AGE_{i,t-1}, TRADE_{i,t-1}, WGI_{i,t-1})'$. β_i is a vector of heterogeneous slope coefficients that reflect the existence and direction of any specific effects on HDI_{it}, $\beta_i=(\beta_1,\beta_2,...,\beta_7)'$. Equation (1) and its first-differenced equation (2) can be simplified as:

$$y_{it}= \gamma_i+\alpha y_{i,t-1}+ \beta_i' x_{i,t-1}+\varrho_{it} \quad (3)$$
$$\Delta y_{it}= \Delta\alpha y_{i,t-1}+ \beta_i' \Delta x_{i,t-1}+\Delta\varrho_{it} \quad (4)$$

Arellano and Bond (1991) propose the first-differenced GMM estimator, which uses all lagged values of dependent variable and independent variables dated from *t*-2 and earlier as suitable instruments for the differenced values of the original regressors.

When data are highly persistent, the weak instruments problem associated with the first-differenced GMM estimator has been widely recognized. To address this issue, Blundell and Bond (1998) develop a 'system GMM' estimator, by considering a mean stationarity assumption on initial conditions, which enables the lagged first-differences of the series (y_{it} , x_{it}) dated *t*-1 as instruments for the untransformed equations in levels.[15] More specifically, in addition to the moments for errors in differences (5) shown below on which the first-differenced GMM estimator is based, the system GMM estimator, denoted by SYS-GMM estimator, also uses the moments for errors in levels (6) as follows:

$$E\left[\begin{pmatrix} y_i^{t-2} \\ x_i^{t-2} \end{pmatrix}(\Delta\varrho_{it})\right] = 0 \quad (5)$$
$$t = 3,\ldots, 6$$

$$E\left[\begin{pmatrix} \Delta y_{i,t-1} \\ \Delta x_{i,t-1} \end{pmatrix}(\gamma_i+\varrho_{it})\right] = 0 \quad (6)$$
$$t = 3,\ldots, 6$$

where y_i^{t-2}=(y_{i1},y_{i2},...., $y_{i,t-2}$)' and x_i^{t-2} = (x_{i1},x_{i2},...., $x_{i,t-2}$)'. For highly persistent data series in a dynamic panel model with a short time dimension, Hahn et al. (2007) propose another estimation approach, called the long-differencing estimator denoted by LD estimator. More specifically, Hahn et al. (2007) suggest taking a multi-year difference of the model rather than a one-year difference. The *k*-year differenced equation of Equation (3) can be written as:

$$y_{it}-y_{i,t-k}=\alpha\,(y_{i,t-1}- y_{i,t-k-1}) + \beta_i'(x_{i,t-1} - y_{i,t-k-1})+ \varrho_{it}- \varrho_{i,t-k} \quad (7)$$

or

$$\Delta y_{it,t-k}=\alpha\Delta y_{it-1,t-k-1}+ \beta_i'\Delta x_{it-1,t-k-1}+\Delta\varrho_{it,t-k} \quad (8)$$

The estimation strategy of the LD estimator due to Hahn et al. (2007) usually includes three iterations. In the first iteration, they propose to use $y_{i,t-k-1}$and $x_{i,t-k-1}$ as valid instruments for $\Delta y_{it-1,t-k-1}$ and $\Delta x_{it-1,t-k-1}$, respectively, to estimate Equation (7) with two-stage least squares (2SLS). With the estimated coefficients $\widehat{\alpha}$ and $\widehat{\beta_i'}$, they suggest that the residuals $y_{i,t-1}$-$\widehat{\alpha}y_{i,t-2}$+$\widehat{\beta_i'}x_{i,t-2}$,..., and $y_{i,t-k}$- $\widehat{\alpha}y_{i,t-k-1}$+ $\widehat{\beta_i'}x_{i,t-k-1}$ are also valid instruments to be included. The model is estimated again with 2SLS using

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15 Blundell and Bond (1998) argue that, combining the first-differenced equations (with suitably lagged levels as instruments), with levels equations (with suitably lagged first-differences as instruments), the system GMM estimator has much smaller finite sample bias and greater precision than first-differenced GMM estimator in the presence of persistent data.

$y_{i,t-k-1}$and $x_{i,t-k-1}$ together with the residuals as valid instruments for $\Delta y_{it-1,t-k-1}$ and $\Delta x_{it-1,t-k-1}$. We then need to further iterate the estimation to the third iteration.

Hahn et al. (2007) argue that long differences will increase the explanatory power of the instruments so that the new estimator has significant reductions in finite sample bias and mean squared error. Their Monte Carlo studies show that the LD estimator using a reduced set of instruments is much less biased than the SYS-GMM estimator, even for high positive values of the lagged dependent variable.[16]

5 Econometric evidence

This section presents the empirical evidence for the effectiveness of CDM project development for the process of sustainable development in 58 CDM host countries over 2005-10. Four CDM indicators explained in Section 3 are examined, with the results reported in Tables 1 to 4, respectively.

Each table compares the within group (WG) estimates, SYS-GMM estimates and LD estimates. The conventional WG estimates are the OLS estimates of the coefficients of a panel data regression model after removing the fixed effects via within transformation. By using the first-differencing to remove the fixed effects, the SYS-GMM estimates are two-step estimates with heteroskedasticity-consistent standard errors and test statistics; the standard errors are based on the finite sample adjustment due to Windmeijer (2005). The LD estimator uses long-differencing approach to remove the fixed effects. More specifically, in the first iteration, we use y_{i1} and x_{i1} as valid instruments for $y_{i,t-1}$-y_{i1} and $x_{i,t-1}$ -x_{i1}, respectively, to estimate Equation (7) with two-stage least squares (2SLS). With the estimated coefficients $\widehat{\alpha}$ and $\widehat{\beta_i'}$, the model is estimated again with 2SLS using y_{i1} and x_{i1} together with the residuals as valid instruments for $y_{i,t-1}$ -y_{i1} and $x_{i,t-1}$ -x_{i1}. We then proceed to iterate the estimation to the second and third iterations. For each model, the point estimate of the long-run effect of respective CDM variable is calculated with its standard error being approximated by using the delta method (for example Papke and Wooldridge 2005).

Table 1 reports the results when the indicator of CDM credits per capita is considered. Both the WG and SYS-GMM estimates suggest that the lagged dependent variable, Lag HDI, is significantly positive in the model. In particular, the SYS-GMM estimate of Lag HDI is very close to the unit circle.[17] This result highlights that the LD estimation approach is especially appropriate in this context given the data being highly persistent. The LD estimate of Lag HDI is also significantly positive.

The Lag CDM credits per capita (CER_POP) has been found insignificant using the WG or SYS-GMM approach, but significantly positive when the LD estimation approach is applied. This evidence clearly reveals that the more credits generated from

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[16] The simulation study of Hahn et al. (2007) shows that, if the true autoregressive parameter is 0.9, the system GMM estimate is only 0.664 whereas the long differencing estimate is 0.902 with a differencing length of k = 5.

[17] While not reported, the evidence of M1, M2 and Hansen test indicates that the model in the middle column of each table is well-specified and the instruments are valid. In this analysis we only use lagged values of y_{it} and x_{it} from t-2 to t-3 as instruments.

the CDM projects over total population in a given CDM host country, the higher levels of sustainable development can be expected. The LD estimate also indicates that this effect tends to persist into the long run.

Table 1: The impact of CDM on sustainable development – CDM credits per capita

Estimators	WG Estimator	SYS-GMM Estimator	LD Estimator
Data Transformations	**Within Transformation**	**First-differencing**	**Long-differencing**
Lag HDI	0.643***	0.984***	0.981***
	(0.000)	(0.000)	(0.000)
Lag CDM Credicts Per Capita	-0.000	0.000	0.003***
	(0.550)	(0.772)	(0.002)
Lag Per Capita GDP Growth	-0.000	-0.000	0.000***
	(0.912)	(0.273)	(0.002)
Lag Per Capita GNI	-0.001	0.001	0.000
	(0.176)	(0.667)	(0.865)
Lag Life Expectance	0.005	-0.051	0.008
	(0.955)	(0.688)	(0.202)
Lag Age Dependence Ratio	0.073***	-0.037	-0.001
	(0.003)	(0.155)	(0.683)
Lag Trade Openness	0.001	-0.004	-0.002**
	(0.790)	(0.433)	(0.024)
Lag Governance	0.001	-0.000	0.000
	(0.111)	(0.714)	(0.886)
Constant	0.197***	0.074	0.012***
	(0.002)	(0.179)	(0.009)
Number of Countries	47	47	47
Observations	172	172	131
R-squared	0.95		0.99
Long-run Effect	-0.001	0.018	0.167***
Standard Error	[0.00]	[0.08]	[0.06]

Note: The dependent variable is the Human Development Imdices (HDI) for 58 CDM host countries over 2005-2010. This table focuses on the CDM credits per capita. Variables and data sources are described in the text. This table presents the within group (WG) estimates, system GMM (SYS-GMM) estimates and long-differencing (LD) estimates, respectively. M1 and M2 test the null of no first-order and no second-order serial correlation in first-differenced residuals, respectively. The Hansen tests the overidentifying restrictions for GMM estimators, asymptotically χ^2. P-values are reported in the parentheses. All equations include year dummies. *, **, *** significant at 10%, 5%, 1%, respectively.

Source: Authors' calculations.

The model includes four variables, which are the key factors for sustainable development: per capita GDP growth (GR), per capita GNI (GNIPC), life expectance (LIFE), and age dependence (AGE). Via the LD approach, significant evidence has been provided in terms of the positive effect of Lag per capita GDP growth on sustainable development. As suggested by LD estimates, Lag GNIPC and Lag LIFE have been found positively while Lag AGE negatively associated with sustainable development, but the effects are not significant.

We also include trade openness (TRADE) and world governance indicator (WGI) to control for the extent of open trade policy and institutional quality in a given country. The lagged trade openness has been observed to have significantly negative impacts on sustainable development. This is consistent with the existing literature such as Frankel and Rose (2005) that more open trade is more likely to lead to increased CO_2 emissions; therefore more open trade could prevent sustainable development. The Lag Governance is likely to have positive impacts on sustainable development, supported by the WG estimate at 11 per cent significance level.

Table 2: The impact of CDM on sustainable development – CDM contribution to the economy

Estimators	WG Estimator	SYS-GMM Estimator	LD Estimator
Data Transformations	**Within Transformation**	**First-differencing**	**Long-differencing**
Lag HDI	0.668***	0.934***	0.984***
	(0.000)	(0.000)	(0.000)
Lag CDM Contribution to the Economy	-0.000	0.008	0.025***
	(0.977)	(0.218)	(0.002)
Lag Per Capita GDP Growth	-0.000	-0.000	0.000**
	(0.524)	(0.485)	(0.034)
Lag Per Capita GNI	-0.001	0.001	0.000
	(0.174)	(0.777)	(0.283)
Lag Life Expectance	-0.000	-0.007	0.007
	(0.996)	(0.949)	(0.218)
Lag Age Dependence Ratio	0.076***	-0.033	-0.000
	(0.002)	(0.416)	(0.844)
Lag Trade Openness	0.001	-0.004	-0.001**
	(0.698)	(0.666)	(0.013)
Lag Governance	0.001	0.001	0.000
	(0.129)	(0.574)	(0.436)
Constant	0.183***	0.074	0.010**
	(0.005)	(0.250)	(0.016)
Number of Countries	46	46	46
Observations	170	170	131
R-squared	0.95		0.99
Long-run Effect	0.000	0.129	1.527***
Standard Error	[0.00]	[0.20]	[0.55]

Note: This table focuses on the indicator of CDM contribution to the economy, the ratio of CDM credits over GDP. See Table 1 for more notes.

Source: Authors' calculations.

Table 2 examines the impacts on sustainable development of CDM Contribution to the Economy (CER_GDP), the ratio of CDM credits over total GDP. The WG estimate, SYS-GMM estimate and LD estimate of Lag HDI are all significantly positive in the models. In terms of the Lag CDM Contribution to the Economy, LD estimate shows a positive effect at 1 per cent significance level, but not for WG and SYS-GMM estimates. This highlights that the more important CDM projects are for the economy, the more chances a given host country is likely to achieve sustainable development. This effect has been observed via LD approach to be not only in the short-run but also in the long run. The significant evidence of lagged per capita GDP growth and lagged trade openness has been confirmed, as suggested by the LD estimates.

Table 3 examines whether the higher probabilities of CDM actual emission reductions (CER_CO_2) could lead to higher levels of sustainable development in the host countries. The CDM actual emission reductions measure the expected emissions reduced through CDM projects compared to a country's actual carbon emissions. The pattern of the results in this table is quite similar to those in the previous two tables. The LD estimate indicates that the lagged CDM actual emission reduction has a positive impact on the process of sustainable development, in both the short run and the long run. It is clear that the more domestic emission reductions efforts such as CDM project development have been devoted to in a given country; this country is more likely to embark on a sustainable development path. As suggested by LD estimates, apart from the significant evidence for the lagged per capita GDP growth and lagged trade openness observed above, lagged age dependence ratio and lagged per capita GNI (at 12 per cent significance level) could also be important factors for the process of sustainable development.

Table 3: The impacts of CDM on sustainable development - CDM actual emission reductions

Estimators	WG Estimator	SYS-GMM Estimator	LD Estimator
Data Transformations	**Within Transformation**	**First-differencing**	**Long-differencing**
Lag HDI	0.646***	0.972***	0.981***
	(0.000)	(0.000)	(0.000)
Lag CDM Actual Emission Reductions	-0.000	0.002	0.006***
	(0.821)	(0.588)	(0.006)
Lag Per Capita GDP Growth	-0.000	-0.000	0.000***
	(0.876)	(0.340)	(0.007)
Lag Per Capita GNI	-0.001	0.000	0.000
	(0.170)	(0.963)	(0.119)
Lag Life Expectance	0.005	-0.100	0.005
	(0.951)	(0.497)	(0.349)
Lag Age Dependence Ratio	0.072***	-0.057*	-0.005*
	(0.004)	(0.073)	(0.088)
Lag Trade Openness	0.001	-0.005	-0.001
	(0.767)	(0.424)	(0.101)
Lag Governance	0.001	0.001	0.000
	(0.130)	(0.736)	(0.753)
Constant	0.194***	0.131*	0.016***
	(0.003)	(0.081)	(0.001)
Number of Countries	47	47	47
Observations	172	172	131
R-squared	0.95		0.99
Long-run Effect	0.000	0.063	0.303***
Standard Error	[0.00]	[0.27]	[0.10]

Note: This table focuses on the indicator of CDM Actual Emission Reductions, the ratio of CDM credits over total emissions. See Table 1 for more notes.

Source: Authors' calculations.

Table 4 focuses on the amount of investment put into the CDM projects, rather than the CDM credits generated. It presents evidence on whether more investment in CDM projects is associated with higher levels of sustainable development in the host countries. All of the WG, SYS-GMM and LD estimates show that Lag HDI enters the model significantly and positively. Regarding the lagged CDM investment capability, the SYS-GMM estimate suggests a positive but not significant parameter, but not significant. This positive effect has been observed significant at 1 per cent level when the long-differencing approach is applied, but its long-run effect is less precisely estimated. This finding sheds light on the national CDM development policy that the more investment put into the environmental-friendly CDM projects or the more foreign investment/green FDI a host country can attract from Annex I countries, the more likely this country can achieve its sustainable development objectives. The evidence on the control variables is similar to that observed in the previous tables, although lagged per capita GDP growth is insignificant in the model.

In sum, by adopting different CDM indicators, this research produces significant evidence that CDM project development can contribute to sustainable development efforts in a given host country. It finds that higher CDM credits per capita, higher ratios of CDM credits over both the economy and total emissions, and higher investment ratios are all expected to promote sustainable development. The findings of this analysis have important policy implications in terms of encouraging developing countries to engage themselves more in CDM projects for low-carbon development. It also presents interesting evidence for per capita GDP growth and per capita GNI being contributing

Table 4: The impacts of CDM on sustainable development – CDM investment capability

Estimators	WG Estimator	SYS-GMM Estimator	LD Estimator
Data Transformations	**Within Transformation**	**First-differencing**	**Long-differencing**
Lag HDI	0.631***	0.971***	0.995***
	(0.000)	(0.000)	(0.000)
Lag CDM Investment Capability	-0.000	0.000	0.001***
	(0.224)	(0.506)	(0.003)
Lag Per Capita GDP Growth	0.000	-0.000*	0.000
	(0.700)	(0.066)	(0.700)
Lag Per Capita GNI	-0.001	0.001	0.000
	(0.151)	(0.690)	(0.920)
Lag Life Expectance	0.143	-0.046	0.004
	(0.331)	(0.426)	(0.433)
Lag Age Dependence Ratio	0.081**	-0.032	-0.006**
	(0.017)	(0.250)	(0.030)
Lag Trade Openness	0.002	-0.004	-0.001***
	(0.524)	(0.516)	(0.002)
Lag Governance	0.001	0.000	-0.000
	(0.226)	(0.667)	(0.446)
Constant	0.104	0.080*	0.008**
	(0.330)	(0.083)	(0.024)
Number of Countries	47	47	47
Observations	155	155	120
R-squared	0.94		0.99
Long-run Effect	0.000	0.002	0.199
Standard Error	[0.00]	[0.01]	[0.25]

Note: This table focuses on the indicator of CDM investment capability, the ratio of CDM investment over total GDP. See Table 1 for more notes.

Source: Authors' calculations.

factors whereas age dependence ratio and trade openness being detrimental factors for sustainable development. The results are not due to unobserved heterogeneity and reverse causality, and in general robust to the use of different CDM indicators, which capture different dimensions of the importance of CDM in a given country.

6 Conclusion

With new data and a unique econometric method, this research conducts a comprehensive and renewed study to examine the CDM's sustainability objective in the host countries. This research finds evidence that higher CDM credits per capita, higher ratios of CDM credits over both the economy and total emissions, and higher investment ratios are all conducive to sustainable development in 58 CDM host countries. It lends support to the effectiveness of CDM in boosting global sustainability and contributes to the heated discussions and debates on the role of CDM in the post-Kyoto climate regime.

Although nearly every nation on the planet realizes the necessity and urgency of combating climate change, to commit to emission reduction efforts not only requires conscience but also, more importantly, financial incentives. As wisely pointed out by Barrett and Toman (2010), for any international climate regime to be successful, there needs to be financial incentives for the parties to join in, in other words ‘every country should gain individually from an agreement’. It is fair to say that finance is at the root of all the world’s climate change problems. And CDM is just that kind of mechanism that provides such financial gains for the involving parties thanks to its innovative market-based mode of governance.

Despite its shortcomings and limitations, CDM is the only existing climate change mechanism that effectively deals with this issue and offers an innovative solution to the challenge of how to incorporate sustainable development considerations into emission mitigation activities. By attracting foreign financial and technological resources to help address the host nations’ development concerns, CDM plays a very positive role in encouraging developing countries to participate in the world’s GHG abatement efforts. Although there is still a lot of room for improvement, CDM should have its well-deserved place in any future post-Kyoto climate regime.

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Appendix Table 1: The list of sample countries (58)

Country Code	Country Name	Country Code	Country Name
ALB	Albania	MAR	Morocco
ARE	United Arab Emirates	MDA	Moldova
ARG	Argentina	MEX	Mexico
ARM	Armenia	MKD	Macedonia, FYR
BGD	Bangladesh	MNG	Mongolia
BOL	Bolivia	MUS	Mauritius
BRA	Brazil	MYS	Malaysia
CHL	Chile	NGA	Nigeria
CHN	China	NIC	Nicaragua
CMR	Cameroon	NPL	Nepal
COL	Colombia	PAK	Pakistan
CRI	Costa Rica	PAN	Panama
CUB	Cuba	PER	Peru
CYP	Cyprus	PHL	Philippines
DOM	Dominican Republic	PNG	Papua New Guinea
ECU	Ecuador	QAT	Qatar
EGY	Egypt, Arab Rep.	RWA	Rwanda
FJI	Fiji	SEN	Senegal
GEO	Georgia	SGP	Singapore
GTM	Guatemala	SLV	El Salvador
HND	Honduras	SYR	Syrian Arab Republic
IDN	Indonesia	THA	Thailand
IND	India	TUN	Tunisia
IRN	Iran, Islamic Rep.	TZA	Tanzania
ISR	Israel	UGA	Uganda
JOR	Jordan	URY	Uruguay
KEN	Kenya	UZB	Uzbekistan
KHM	Cambodia	VNM	Vietnam
LKA	Sri Lanka	ZAF	South Africa

Note: This table lists the country codes and country names for 58 CDM host countries considered in this analysis.

Source: Authors' calculations.

Appendix Table 2: Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
HDI	overall	0.643	0.121	0.376	0.886	N = 348
	between		0.121	0.404	0.881	n = 58
	within		0.010	0.612	0.666	T = 6
CER_POP	overall	0.712	3.640	0.001	56.210	N = 241
	between		3.656	0.013	28.146	n = 58
	within		2.598	-27.351	28.776	T-bar = 4.15517
CER_GDP	overall	0.087	0.116	0.000	0.854	N = 237
	between		0.126	0.003	0.812	n = 57
	within		0.080	-0.186	0.649	T-bar = 4.15789
CER_CO2	overall	0.328	0.600	0.001	7.608	N = 241
	between		0.309	0.010	1.745	n = 58
	within		0.512	-1.349	6.190	T-bar = 4.15517
INV_GDP	overall	2.214	6.073	0.004	59.915	N = 207
	between		8.486	0.034	59.915	n = 56
	within		3.527	-19.929	24.357	T-bar = 3.69643
LIFE	overall	0.698	0.079	0.490	0.816	N = 348
	between		0.080	0.501	0.809	n = 58
	within		0.005	0.678	0.718	T = 6
AGE	overall	0.582	0.164	0.170	1.053	N = 348
	between		0.164	0.216	1.047	n = 58
	within		0.017	0.534	0.658	T = 6
GR	overall	3.534	3.822	-14.314	13.742	N = 346
	between		2.546	-8.188	10.640	n = 58
	within		2.868	-16.558	12.732	T = 5.96552
GNIPC	overall	3.529	5.191	0.299	33.100	N = 285
	between		5.231	0.340	30.852	n = 49
	within		0.315	1.784	5.777	T = 5.81633
TRADE	overall	0.875	0.570	0.223	4.459	N = 343
	between		0.565	0.251	4.152	n = 58
	within		0.085	0.485	1.183	T = 5.91379
WGI	overall	-1.636	3.500	-9.258	9.186	N = 348
	between		3.493	-8.094	8.824	n = 58
	within		0.475	-4.177	0.400	T = 6

Note: See text for the description of each variable.
Source: Authors' calculations.

Appendix Table 3: Correlations among variables

	HDI	CER_POP	CER_GDP	CER_CO2	INV_GDP	LIFE	AGE	GR	GNIPC	TRADE	WGI
HDI	1.000										
CER_POP	0.162	1.000									
CER_GDP	-0.024	0.495	1.000								
CER_CO2	-0.157	0.161	0.650	1.000							
INV_GDP	0.031	0.067	0.034	0.046	1.000						
LIFE	0.845	0.113	-0.010	-0.163	0.043	1.000					
AGE	-0.729	-0.166	0.003	0.292	-0.045	-0.681	1.000				
GR	-0.105	-0.065	0.082	-0.020	0.030	-0.021	0.039	1.000			
GNIPC	0.652	0.211	-0.134	-0.097	-0.075	0.461	-0.342	-0.058	1.000		
TRADE	0.310	0.031	0.033	-0.054	0.034	0.275	-0.304	-0.058	0.624	1.000	
WGI	0.666	0.135	-0.059	-0.055	-0.006	0.473	-0.458	-0.152	0.734	0.461	1.000

Note: See text for the description of each variable.

Source: Authors' calculations.