Working Papers Series

Centre d'Analyse Théorique et de Traitement des données économiques

CATT WP No. 5
October 2013

DOES MEXICO BENEFIT FROM THE CLEAN DEVELOPMENT MECHANISM? A MACROECONOMIC AND ENVIRONMENTAL GENERAL EQUILIBRIUM ANALYSIS

Jean-Marc MONTAUD

Nicolas PECASTAING

CATT-UPPA
UFR Droit, Economie et Gestion
Avenue du Doyen Poplawski - BP 1633
64016 PAU Cedex
Tél. (33) 5 59 40 80 01
Internet : **http://catt.univ-pau.fr/live/**

Does Mexico Benefit from the Clean Development Mechanism? A Macroeconomic and Environmental General Equilibrium Analysis

Jean-Marc Montaud · Nicolas Pécastaing

Abstract:

Since 2000, the Clean Development Mechanism (CDM) under the Kyoto Protocol has included southern countries in the fight against climate change by encouraging northern countries to make environmentally friendly direct investments at the lowest cost in these developing nations. Even if CDM investments have enjoyed great success, the question of how host countries benefit from these investments seems insufficiently explored. Therefore, this article offers a quantitative assessment of the economic and environmental impacts of CDM investments for the specific case of Mexico. We use a computable general equilibrium model that features environmental topics, to simulate the demand and supply effects induced by these investments. Numerical simulations reveal the growth potential and important fund of development that represents the CDM for Mexico, though the environmental impact appears broadly mixed.

KEYWORDS: Clean Development Mechanism, computable general equilibrium, Mexico

JEL CLASSIFICATION: D58, O13, Q56

Jean-Marc Montaud, CATT, University of Pau and Pays de l'Adour, Pau, France. e-mail: jean-marc.montaud@univ-pau.fr

Nicolas Pécastaing, CATT, University of Pau and Pays de l'Adour, Pau, France. e-mail: nicolas.pecastaing@univ-pau.fr

Introduction

Involving southern countries in the fight against climate change, without hindering their development, is a major challenge for the international community. The Clean Development Mechanism (CDM), under the Kyoto Protocol, currently constitutes the primary tool for enabling northern countries (Annex 1 countries) to make environmentally friendly direct investments at lower costs in developing countries (Non-Annex1 countries),[1] through the carbon credit granted in proportion to the greenhouse gas reductions achieved. These CDM investments have enjoyed great success since their introduction in November 2004. As of 01/04/2013, 6600 CDM projects were registered worldwide, for a total investment of

[1] These "non-Annex I" countries must have adopted the Kyoto Protocol and appointed a designed national authority, responsible for validating each project.

approximately US$215.4 billion (Fenhann, 2013; UNFCCC, 2012). Yet the question of how host countries benefit from this additional development funding source seems insufficiently explored by economic literature (for a review, see UNFCCC, 2010) and reveal a lack of a quantitative assessment after ten years of CDM. If early studies adopted prospective quantitative approach (Banuri and Gupta, 2000; Mathy et al., 2001), most research features qualitative multi-criteria analyses (Kolshus et al., 2001; Huq, 2002; Begg et al., 2003; Sutter, 2003; Anagnostopoulos et al., 2004; Olhoff et al., 2004; Olsen, 2007; UNFCCC, 2012) and reflect heterogeneous insights suffering from some weaknesses. Majority appear then focused more on environmental or technical transfer topics, rather than development issues; they tend to assign arbitrary weights to different indicators of development; and in some cases, they depend on criteria specified by the designed national authority of each host country when selecting projects (Olsen, 2007; Olsen and Fenhann, 2008; Boyd et al., 2009; Alexeew et al., 2010; Bumpus and Cole, 2010; Subbarao and Lloyd, 2011). In this context, many authors have emphasized the need to apply an international standard to rate CDM projects, in accordance with their contribution to various development dimensions (Cosbey et al., 2005; Schlup, 2005; Cosbey, 2006; Sutter and Parreno, 2007; Olsen and Fenhann, 2008)[2].

This study seeks to contribute such *ex post* quantitative assessment of CDM on a single host country, using the specific case of Mexico where this mechanism has been a significant funding source for investments since it ratified the Kyoto Protocol in September 2002. At the start of 2013, 215 CDM projects already had been registered or planned in this developing country, equivalent to nearly US$13.2 billion, making it the fifth largest recipient of such funds. In order to simulate numerically the impact of these foreign CDM investments on the Mexican economy, we use a computable general equilibrium (CGE) model in order to reveal the various interdependencies that generate such an exogenous shock on demand, supply, income, and prices in this economy. Moreover, because of the nature of the CDM, we also extend this standard CGE analysis by including an environmental perspective, which can reveal the ecological consequences of these economic changes, in accordance with the conceptual framework of the System of Environmental Accounting used in Mexico. The first section, details the main hypotheses of the CGE model built for Mexico and its economic and environmental databases. The next one presents the numerical simulations and the quantitative results obtained.

---

[2] Olsen and Fenhann (2008) show for example that the potential benefits of CDM projects may concern five criteria: job creation, growth, air quality, access to energy, and well-being of the people.

1. CGE Model

Model equations

The model, as detailed in the Appendix, encompasses nine productive activities (agriculture, mining, electricity, energy, construction, industry, transport, services and informal sector) and four institutions (households, government, firms and rest of the world).

The equations linking economic variables follow an internal logic that is fairly standard to CGE modelling in developing countries (for an overview, see Bourguignon et al., 1989). On the supply side, formal activities maximize profit by combining fixed capital with labour factors (Eq. 1–3). The products may be sold locally or to the rest of the world (Eq. 6–9) and are imperfectly substitutable with imported products (Eq. 10–13). Primary incomes are distributed to different agents on the basis of their factor endowments and access to transfer and foreign incomes (Eq. 14–28). On the demand side, household consumption should be a linear expenditure system function; nominal demand from the government is assumed to be exogenous (Eq. 29–31). Intermediate consumption is driven by a fixed technical coefficient in each production process. The volume of investment demand (CDM and others) is assumed to be exogenous (Eq. 32–34). Prices, nominal investments, and row saving ensure the closure mechanisms for product markets, the capital market, and the external accounts market, respectively (Eq. 37–40). The closure rule for the labour market reflects the dualistic nature of the Mexican economy, as is characteristic of this developing country. Because labour supply is fixed in volume and real wages are rigid, the labour market balance can be achieved only through the informal sector, which serves as a shelter for workers excluded from formal employment and unprotected by an efficient social insurance system (Eq. 35–36). In that context, workers who are not employed in formal activities create individual, non-capitalistic microenterprises (Eq. 4–5), whose products sell only in domestic markets for final household consumption (Eq. 30).

Some additional equations link previous economics variables to some environmental variables. Their logic follows the conceptual framework of the international System of Environmental and Economic Accounting (SEEA).[3] Two environmental costs are then be associated with the production of each activity: *Depletion costs* represent the monetary

[3] In 2012, the United Nations decided to adopt an integrated SEEA as an initial version of an international standard for Environmental and Economic Accounting (European Commission et al., 2012).

valuation of the depreciation of natural resources used in the production process,[4] whereas *degradation costs* are monetary assessments of the restoration of the environmental damages caused by each economic activity.[5] Each cost is assumed to be proportional to the volume of production of each activity (Eq. 45–46). Subtracted from the value added of each activity, these two types of environmental costs indicate the ecological gross domestic product or Green GDP (Boyd, 2007) of the Mexican economy (Eq. 43–44).

Model databases

Most of parameters in the economic equations and the initial level of the variables were calibrated from Mexico's 2004 Social Accounting Matrix (2004-SAM), as built by Barboza-Carrasco et al. (2009). This 2004-SAM was previously adjusted to the needs and objectives of our analysis. First, the number of activities was reduced, to fit those used in the SEEA environmental accounting. Second, considering the nature of the CDM projects, an energy sector (*Energy*) was isolated to specify fossil energies (gas, oil, coal) responsible for emissions of greenhouse gas, which are the main target of CDM projects in Mexico. Third, because of the closure rule on the labour market in the model, an informal sector was included in the SAM using data from Mexican employment surveys (INEGI, 2006), to support the estimation of informal activities' contributions to employment and value added.[6]

The initial levels for the environmental variables and parameters came from the Mexican Environmental Accounts System (INEGI, 2010). For Mexico, the depletion costs mainly refer to hydrocarbons, forest resources, and underground water; degradation costs involve the pollution of water, air, and soil. For 2005–2009, these costs accounted for an average of 8% of Mexico's GDP: 6% for degradation costs and 2% for depletion costs (INEGI, 2010).

[4] This valuation relies on a market value approach, which covers only natural assets with economic value. These assets are connected with actual or potential market transactions (United Nations, 2000). Various methods exist to estimate the market value of the stocks of scarce natural resources (e.g., net present value of natural resources, net price method, user cost allowance).

[5] This more difficult valuation relies mainly on the maintenance cost valuation method (i.e., estimate of the costs of restoration of an environmental asset to its original or a tolerable level of degradation) and the contingent valuation method of environmental services.

[6] We use here a restricted definition of informal employment, corresponding to individual entrepreneurs and suppose that these informal microentrepreneurs receive the full value added that they generate.

2. Baseline scenarios of the impact of CDM Investments in Mexico

Exogenous foreign CDM investments ($\overline{CDMQ_i}$) constituted the main variables for our simulations. We predict two impacts on the Mexican economy. First, they generate a demand shock for the activities which produce the fixed capital goods required for their implementation. Second, they generate a supply shock that changes the nature of the production process of some activities. We deduced the nature and the level of these shocks from the data of each Project Design Document (PDD) [7] detailed in the CDM pipeline (Fenhann, 2013), supplemented by data from the UNFCCC (2012) about the type, location, amount, and stage of completion of each project. These data confirm the importance of CDM investments in Mexico since 2005 (Table 1).

TABLE 1. CDM projects: Investments (in million USD) and installed electrical capacity (MW)

	Registered			**At Validation**			**Total**		
	Number of Projects	Investment	Installed Electric Capacity	Number of Projects	Investment	Installed Electric Capacity	Number of Projects	Investment	Installed Electric Capacity
Type									
Biomass energy	6	30.9	0.3	9	45.8	100.0	15	76.7	100.3
Coal bed/Mine methane	-	-	-	1	12.3	7.0	1	12.3	7.0
EE industry	4	1.8	36.2	2	1.4	-	6	3.2	36.2
EE own generation	1	43.9	-	1	3.2	-	2	47.1	-
Fossil fuel switch	-	-	-	1	-	-	1	-	-
Fugitive	1	14.5	-	-	-	-	1	14.5	-
Geothermal	-	-	-	1	98.9	50.0	1	98.9	50.0
HFCs	1	-	-	-	-	-	1	-	-
Hydro	5	141.1	92.8	6	849.8	1071.0	11	990.9	1163.8
Landfill gas	23	90.8	69.2	10	43.5	30.3	33	134.3	99.5
Methane avoidance	98	21.5	5.9	5	59.0	3.7	103	80.5	9.6
N2O	1	0.3	-	2	-	-	3	0.3	-
Transport	5	3713.3	-	1	22.2	-	6	3735.5	-
Wind	26	7474.0	3937.9	5	874.8	495.8	31	8348.8	4433.7
Total	**171**	**11532.1**	**4142.3**	**44**	**2010.9**	**1757.8**	**215**	**13543.0**	**5900.1**

Notes: At Validation projects include those waiting for validation and those that have requested registration already. EE = energy efficiency. MW = megawatts of electric capacity.
Source: CDM pipeline 04/2013

[7] Any submission of a CDM project requires such PDD, which provides information about the project's legislative aspects, implementation, baseline scenarios adopted, funding sources, and involved local political operators.

A first group of 171 projects "*registered*", such that they already have been validated by the Executive Board supervising the Kyoto Protocol's CDM, represent US$11532.1 million (or nearly 1.25% of Mexico's GDP). A second group of 44 projects still "*at validation stage*", such that they are waiting to be validated, account for US$2010.9 million, or nearly 0.22% of Mexico's GDP. Projects involving *methane avoidance* are the most numerous, but the data also reveal a preponderance of *wind*, *hydro* and *transport* projects—that is, 98.2% of registered and 87% of *at validation* investments. These projects, and renewable energy projects more generally (e.g., wind, hydro), appear to offer a sustainable alternative to the highly polluting thermal generation of electricity, which currently accounts for nearly 71% of installed electricity capacity in Mexico (SENER, 2010).

In this context, we consider two main scenarios for our simulations, either involving just registered projects or including projects that remain to be validated. We first apply these two scenarios to all types of CDM projects in Mexico, then, second, we consider only the renewable energy projects, which are critical for overall CDM investments. The four numerical simulations performed with our CGE model are summarized in Table 2.

TABLE 2. Nature of simulations

	All CDM Projects		***Only Renewable Energy CDM Projects***	
	Scenario 1 ***Registered projects***	***Scenario 2*** ***Registered and At Validation projects***	***Scenario 1*** ***Registered projects***	***Scenario 2*** ***Registered and At Validation projects***
Demand shock for activities (million USD)				
Industry	+ 6808,5	+ 7777,9	+ 4821,5	+ 5674,1
Transport	+ 390,2	+ 493,2	+ 235,5	+ 332,7
Construction	+ 3217,1	+ 3948,6	+ 1868,5	+ 2552,6
Services	+ 1116,6	+ 1323,3	+ 689,6	+ 879,2
Total	**+ 11532,1**	**+ 13543,0**	**+ 7615,1**	**+ 9438,6**
Supply shock $ica_{ener,elec}$	**- 8,1%**	**- 11,5%**	**- 7,9%**	**- 11,0%**
Environmental shock θ_{elec}	**- 8,1%**	**- 11,5%**	**- 7,9%**	**- 11,0%**

Source: Own calculations, based on CDM pipeline 04/2013.

The simulations differ by the magnitudes of the shocks experienced by the Mexican economy. On the demand side, we can determine this shock by analysing the PDD of each project and thereby uncovering the average distribution of fixed capital demand addressed to each activity. Wind, hydro, and transport[8] projects largely determine this allocation. For example, for a wind project, 64% of investments go to *industry* (e.g., purchase of wind turbines), 24% to *construction* (engineering and electrical installations), 9% to *services* (e.g., legal fees, project engineering, control systems, financial and import costs), and 3% to *transport* (transportation costs). On the supply side, because of the type of investments in CDM projects, we assume that the production of energy and electricity would be the main concerns. The CDM pipeline shows that the additional production of electricity expected from all registered CDM projects would be nearly 8.1% (4142 MW) of the 2004 total production (EIA, 2004),[9] whereas that expectation would increase to 11.5% (5881 MW) if we included at validation stage projects too. For solely renewable energy projects, the additional production obtained through registered projects would be 7.9% (4040MW), and that of the combined registered and at validation stage projects would be 11.0% (5625 MW). Relying on the principle of additionality from the Kyoto Protocol,[10] we assume the generation of this clean electricity will replace the use of fossil fuels and reduce the demand for intermediate consumption of electricity activity in the production of energy. The effect of this environmentally friendly technology therefore needs to be included in each simulation, as a reduction of the technical coefficient $ica_{ener,elec}$ for the electricity activity (Eqs. 3 and 32). It also should appear in the environmental equations, as a reduction of the same magnitude in the parameters linking depletion costs (θp_{elec}) and degradation costs (θg_{elec}) to the volume of production of electricity activity (Eqs. 45–46).

3. Simulations results

Table 3 describes the contribution of each industry to GDP and Green GDP, as well as to each environmental cost, at the initial equilibrium.

[8] Branch allocation for transport projects is more difficult to estimate, because of the importance of the Metro Line 12 (Mexico City) and Metrobus 2-1 projects, which together account for an estimated total investment of US$3.4 billion.
[9] We used the 2004 Mexican electricity sector data for two reasons: to maintain consistency with SAM-2004 and to avoid double counting of the impact of CDM in this sector during 2004–2012.
[10] This principle states that the projects would not have happened in the absence of the CDM and that the new power capacity related to CDM projects substitutes for fossil fuels (greenhouse gas reduction).

TABLE 3. Economic and environmental contributions of each activity at initial equilibrium (share in %)

		GDP	Depletion Costs	Degradation Costs	Green GDP	Total Costs/GDP
Initial equilibrium	*Agriculture*	4.0	26.9	18.9	2.5	38.8
	Mining	3.6	71.4	0.2	1.9	44.2
	Industry	17.2	1.0	2.9	16.8	1.0
	Electricity	1.3	-	1.4	1.2	5.4
	Construction	5.2	0.2	0.2	5.4	0.2
	Transport	8.3	-	49.9	6.1	30.6
	Services	59.8	0.6	26.4	65.4	5.5
	Energy	0.6	0.0	0.2	0.6	1.5
	Total economy	**100.0**	**100.0**	**100.0**	**100.0**	**7.3**

Source: Own calculations, based on INEGI (2010).

Nearly 60% of the Mexican national value added is generated by the service sector, and 17% by industry. Depletion costs come mainly from agriculture and mining, whereas the degradation costs are generated by the transportation sector, services, and agriculture. Globally, these environmental costs represent 7.3% of GDP.

In turn, Table 4 indicates the impact of Mexican CDM projects on each sector. Panel a (Panel b) details the impact of all type of projects (only renewable energy projects) for each scenario. According to these simulations, CDM investments contribute significantly to Mexican economic growth, mainly through a demand effect for activities. With all registered projects, GDP increases by 0.5%, an effect that gets logically amplified when we include validation projects too (0.7%). Renewable energy projects contribute to 0.4% of the growth in the first scenario and 0.5% in the second. In addition, the overall environmental impact of this economic growth appears negative or, at best, neutral, regardless of the simulations considered. When we take all types of projects into account, Green GDP grows at a slower pace than economic growth in both the first (0.4% vs. 0.5%) and the second (0.7%) scenarios. This negative impact reflects that growth is accompanied by parallel increases of depletion costs (3.0% in the first scenario, 4.0% in the second) and degradation costs (0.5% in both scenarios). Ultimately, the share of GDP represented by these environmental costs increases by 0.8% for both scenarios. These trends are confirmed in the data involving only renewable energy projects, though the magnitude of changes is less. In this case, Green GDP increases by 0.3% in the first scenario and 0.4% in the second. The depletion costs increase by 1.9%

(2.6%) in the first (second) scenario, while the degradation costs increase by 0.2% (0.3%), and their total share of the GDP increases to 0.4% (0.5%).

These global effects hide the sectoral changes that CDM investments generate for the economy though. With its close links with other sectors and the nature of its related projects, the electricity sector is logically the one most affected by the shocks. . When we take all types of projects into account, its value added grows by 9.7% in the first scenario (38.3% in the second). At this stage, the supply effects in the model (i.e., reduced use of fossil fuels and associated effects on the degradation costs generated by electricity activity) exert a substantial influence. Despite increasing production, environmental costs decrease by -5.7% in scenario 1 and increase only slightly by 1.3% in scenario 2. The share of environmental costs from the electricity sector, as a proportion of total GDP, decreases by -14.1% (-26.7%) in the first (second) scenario. These results are confirmed by the analysis of renewable energy projects, in which case the contribution to GDP of the electricity sector rises by 18.9% (26.6%) in the first (second) scenario and generates lower degradation costs of -1.0% (-2.0%). Finally, we find a decrease in the share of environmental degradation in GDP from the electric sector (-16.8% and -22.6%).

TABLE 4. Economic and environmental impacts of CDM investments in Mexico

a. All CDM projects (variation in %)

		GDP	**Depletion Costs**	**Degradation Costs**	**Green GDP**	**Total Costs/GDP**
Scenario 1: *Registered projects*	*Agriculture*	1.0	0.9	0.9	1.1	-0.1
	Mining	4.3	3.9	3.9	4.6	-0.4
	Industry	0.8	0.6	0.6	0.8	-0.1
	Electricity	9.7	-	-5.7	10.6	-14.1
	Construction	-3.3	-3.0	-3.0	-3.3	0.3
	Transport	0.8	-	0.7	0.8	-0.1
	Services	0.3	0.3	0.3	0.3	0.0
	Energy	-1.7	1.5	1.5	-1.8	3.3
	Total economy	**0.5**	**3.0**	**0.5**	**0.4**	**0.8**
Scenario 2: *Registered and At validation projects*	*Agriculture*	-0.2	0.0	0.0	-0.4	0.2
	Mining	6.1	5.6	5.6	6.6	-0.5
	Industry	1.0	0.7	0.7	1.0	-0.3
	Electricity	38.3	-	1.3	40.4	-26.7
	Construction	-4.8	-4.6	-4.6	-4.8	0.2
	Transport	0.8	-	0.7	0.8	-0.1
	Services	0.0	0.2	0.2	0.1	0.2
	Energy	-1.2	2.7	2.7	-1.2	3.9
	Total economy	**0.7**	**4.0**	**0.5**	**0.6**	**0.8**

b. Only Renewable energy CDM projects (variation of initial shares in %)

		GDP	Depletion Costs	Degradation Costs	Green GDP	Total Costs/GDP
Scenario 1: ***Registered projects***	*Agriculture*	-0.2	0.0	0.0	-0.2	0.1
	Mining	3.0	2.7	2.7	3.2	-0.3
	Industry	0.6	0.4	0.4	0.6	-0.2
	Electricity	18.9	-	-1.0	20.1	-16.8
	Construction	-2.5	-2.4	-2.4	-2.5	0.1
	Transport	0.4	-	0.3	0.4	0.0
	Services	0.0	0.1	0.1	0.1	0.1
	Energy	-0.3	1.6	1.6	-0.3	1.9
	Total economy	**0.4**	**1.9**	**0.2**	**0.3**	**0.4**
Scenario 2: ***Registered and At validation projects***	*Agriculture*	-0.2	0.0	0.0	-0.3	0.2
	Mining	4.0	3.6	3.6	4.2	-0.3
	Industry	0.7	0.5	0.5	0.7	-0.2
	Electricity	26.6	-	-2.0	28.2	-22.6
	Construction	-3.3	-3.2	-3.2	-3.3	0.2
	Transport	0.5	-	0.5	0.6	-0.1
	Services	0.0	0.2	0.2	0.1	0.1
	Energy	-0.8	1.9	1.9	-0.8	2.6
	Total economy	**0.5**	**2.6**	**0.3**	**0.4**	**0.5**

Source: Own calculations, using GAMS software.

With regard to other activities, our results show that the variations of sectoral production induced by CDM investments modify their respective contributions to the environment. They help slightly reduce the environmental impacts generated by mining, transportation, and industry, across the various simulations performed. In contrast, construction, services, and energy sectors exert a stronger environmental impact.

4. Conclusion

This study has explored the ex-post quantitative impact of CDM investments on the Mexican economy since 2004, using a CGE model that includes environmental topics as well. The numerical simulations show that these investments partially meet their development and environmental objectives. They also reveal the growth potential and the important fund for development represented by the CDM. However, its environmental impact appears broadly mixed, even though some sectors benefit from these “clean” investment flows—including electricity, the main target of CDM projects in Mexico.

In terms of our methodological perspective, these results require added nuance, because of the global approach we adopted, yet the nature of the data we used and the constraints imposed by current environmental accounting tools suggest that they offer a viable alternative to existing assessments of the effects of CDM on host countries. Further research could pursue an even more integrated approach, combining simultaneously a genuine sectoral analysis of the production processes affected by CDM investments together with global macroeconomic and environmental approaches.

References

Alexeew, J., L. Bergset, K. Meyer, J. Petersen, L. Schneider, and C. Unger (2010), 'An analysis of the relationship between the additionality of CDM projects and their contribution to sustainable development', International Environmental Agreements: Politics, Law and Economics 10(3): 233-248. doi:10.1007/s10784-010-9121-y

Anagnostopoulos, K., A. Flamos, A.G. Kagiannas, and J. Psarras (2004), 'The impact of clean development mechanism in achieving sustainable development', International Journal of Environmental Pollution 21 (1): 1–23

Banuri, T. and S. Gupta (2000), 'The clean development mechanism and sustainable development: an economic analysis', in Manila GP (ed.), Implementation of the Kyoto Protocol, Asian Development Bank.

Barboza-Carrasco I., J.M.P. Vázquez-Alvarado, and J.A. Matus-Gardea, (2009), 'Mexico's Social Accounting Matrix 2004', Agrociencia 43 (5): 551-558.

Begg, K., S. Parkinson, D.V.D. Horst, R. Wilkinson, D. Theuri, S. Gitonga, M. Mathenga, H. Amissah-Arthur, S. Atugba, S. Ackon, S. Ageby, H. Meena, S. Mwakifwamba, and S. Mwakasonde (2003), 'Encouraging CDM energy projects to aid poverty alleviation', final report of project R8037 under the DFID KAR programme, Centre for Environmental Strategy, University of Surrey, 1–113.

Bourguignon, F., W. Branson, and J. De Melo (1989), Macroeconomic adjustment and income distribution: a macro-micro simulation model, Organisation for Economic Cooperation and Development.

Boyd, J. (2007), 'Nonmarket benefits of nature: What should be counted in green GDP?' Ecological Economics 61: 716–723

Boyd, E., N. Hultman, J. Roberts, E. Corbera, J. Cole, A. Bozmoski, J. Ebeling, R. Tippman, P. Mann, K. Brown, and D. Liverman (2009), 'Reforming the CDM for sustainable development: lessons learned and policy futures', Environmental Science & Policy 12(7): 820-831. doi:10.1016/j.envsci.2009.06.007

Bumpus, A.G., and J.C. Cole (2010), 'How can the current CDM deliver sustainable development?' Climate Change 1(4): 541-547. doi:10.1002/wcc.57

Cosbey, A. (2006), 'Defining and measuring the development dividend', Meeting of the Expert Task Force of the IISD, International Institute for Sustainable Development, 12

Cosbey, A., J.E. Parry, J. Browne, Y.D. Babu, P. Bhandari, J. Drexhage, and D. Murphy (2005), 'Realizing the development dividend: Making the CDM work for developing countries', Phase 1 Report – Prepublication Version, International Institute for Sustainable Development (IISD), 1–72

EIA (Energy Administration Information), (2004), International Energy Statistics: Mexico. Available from http://www.eia.gov.

European Commission, Food and Agriculture Organisation, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations, World Bank

(2012), System of Environmental-Economic Accounting: Central Framework. White cover publication, pre-edited text subject to official editing. http://unstats.un.org/unsd/envaccounting/White_cover.pdf

Fenhann, J. (2013), UNEP Risø CDM Pipeline 01 April 2013. Available from http://www.CD4CDM.org.

Huq, S. (2002), 'Applying sustainable development criteria to CDM projects: PCF experience', Prototype Carbon Fund, World Bank, 1–37.

Instituto Nacional de Estadística, Geografía e Informática (INEGI) (2006), Cuenta Satélite del Subsector Informal de los Hogares 1998-2003, México.

Instituto Nacional de Estadística, Geografía e Informática (INEGI) (2010), Sistema de Cuentas nacionales de México: Cuentas Económicas y Ecológicas de México 2003-2007, Instituto nacional de Estadísticas y geografía, México. ISBN: 978-607-494-082-4.

Kolshus, H.H., J. Vevatne, A. Torvanger, and K. Aunan (2001), 'Can the clean development mechanism attain both cost-effectiveness and sustainable development objectives?' CICERO Working Paper 2001: 8. Oslo, Norway.

Mathy, S., J-C. Hourcade, and C. De Gouvello C (2001), 'Clean development mechanism: leverage for development?' Climate Policy 1: 251–268

Olhoff, A., A. Markandya, K. Halsnæs, and T. Taylor (2004), 'CDM sustainable development impacts', UNEP Risø Centre, 1–88

Olsen, K.H. (2007), 'The clean development mechanism's contribution to sustainable development: a review of the literature', Climatic Change 84(1): 59-73. doi:10.1007/s10584-007-9267-y.

Olsen, K.H., and J. Fenhann (2008), 'Sustainable development benefits of clean development mechanism projects. A new methodology for sustainability assessment based on text analysis of the project design documents submitted for validation', Energy Policy 36(8): 2819-2830. doi:10.1016/j.enpol.2008.02.039

Schlup, M. (2005), 'The gold standard: linking the CDM to development and poverty reduction, climate or development?' Hamburg Institute of International Economics, Hamburg, Germany.

Secretaría de Energía (SENER) (2010), 'El sector eléctrico mexicano'. Available from www.renovables.gob.mx.

Subbarao, S., and B. Lloyd (2011), 'Can the clean development mechanism (CDM) deliver?' Energy Policy 39(3): 1600-1611. doi:10.1016/j.enpol.2010.12.036

Sutter, C. (2003), 'Sustainability check up for CDM projects. How to assess the sustainability of international projects under the Kyoto Protocol', WVB, Wissenschaftlicher Verlag Berlin. doi:10.3929/ethz-a-004674122.

Sutter, C., and J.C Parreño (2007), 'Does the current clean development mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects', Climatic Change 84(1): 75-90. doi:10.1007/s10584-007-9269-9

United Nations (2000), 'Integrated environmental and economic accounting: An operational manual', Handbook of National Accounting, Studies in Methods Series F, No. 78, ST/ESA/STAT/SER.F/78

UNFCCC (2010), 'The contribution of the clean development mechanism under the Kyoto Protocol to technology transfer', June. Available at https://cdm.unfccc.int/about/CDM_TT/index.html.

UNFCCC (2012), 'Benefits of the clean development mechanism 2012', United Nations Climate Change Secretariat, Bonn, Germany. Available at http://cdm.unfccc.int.

APPENDIX: CGE Model

Formal activities or products: *i or j = Agriculture, Mining, Electricity, Energy, Construction, Industry, Transport, Services*

Informal activities or products: *inf= Informal sector*

Institutions: *H=Households, G=Government, R = Rest of the World, F=Firms*

Production Block

Formal production process

1. $QX_i = A_i^p.\left[\alpha_i^p.LD_i^{-\mu_i^p} + \left(1-\alpha_i^p\right)\overline{K_i}^{-\mu_i^p}\right]^{-\frac{1}{\mu_i^p}}$

2. $LD_i = QX_i.\left[\frac{\alpha_i^p.PVA_i}{\left(A_i^p\right)^{\mu_i^p}.w_i}\right]^{\sigma_i}$

3. $PVA_i = PX_i - \sum_j PQ_j.ica_{j,i} - tx_i$

Informal production process

4. $QD_{\inf}^r = \gamma_{\inf}.LD_{\inf}$

5. $PVA_{\inf} = PD_{\inf} - \sum_j PQ_j.ica_{j,\inf}$

Trade Block

Exports and domestic sales (CET specification)

6. $QX_i = A_i^t.\left[\alpha_i^t.QE_i^{-\mu_i^t} + \left(1-\alpha_i^t\right)QD_i^{-\mu_i^t}\right]^{-\frac{1}{\mu_i^t}}$

7. $\frac{QD_i}{QE_i} = \left[\frac{\alpha_i^t}{\left(1-\alpha_i^t\right)}\right]^{\sigma_i^t}.\left[\frac{PD_i}{PE_i}\right]^{\sigma_i^t}$

8. $PX_i = \frac{PD_i.QD_i + PE_i.QE_i}{QX_i}$

9. $PE_i = EXR.\overline{PWE_i}$

Imports and domestic sales (Armington specification)

10. $Q_i = A_i^m.\left[\alpha_i^m.QD_i^{-\mu_i^m} + \left(1-\alpha_i^m\right)QM_i^{-\mu_i^m}\right]^{-\frac{1}{\mu_i^m}}$

11. $\frac{QM_i}{QD_i} = \left[\frac{\alpha_i^m}{\left(1-\alpha_i^m\right)}\right]^{\sigma_i^m}.\left[\frac{PD_i}{PM_i}\right]^{\sigma_i^m}$

12. $PQ_i = \frac{PD_i.QD_i + PM_i.QM_i}{(1-tq_i).QQ_i}$

13. $PM_i = EXR.\overline{PWM_i}$

Incomes and savings Block

Factors

14. $RL = RL_{for} + RL_{\inf} + \overline{RL_R}$

15. $RL_{for} = \sum_i LD_i.w_i$

16. $RL_{\inf} = PVA_{\inf}.QX_{\inf}$

17. $RK = \sum_i \left(PVA_i.QX_i - LD_i.w_i\right) + \overline{RK_R}$

Households

18. $YH = \lambda_l^H.RL + \lambda_k^H.RK + \overline{DivF} + \overline{Trsf_H^G} + \overline{Trsf_H^R}$

19. $YDH = (1-t_y^H).YH$

20. $SH = mps.YDH$

21. $CFMH = YDH - SH$

Firms

22. $YF = \lambda_k^F.RK + \overline{Subv_F^G}$

23. $SF = (1-t_y^F).YF - \overline{DivF}$

Administration

24. $YG = TAXY + TAXS + TAXX + \lambda_k^G.RK + \overline{Trsf_G^R}$

25. $TAXY = t_y^H.YH + t_y^F.YF$

26. $TAXS = \sum_i tva_i.PQ_i.QQ_i$

27. $TAXX = \sum_i tx_i.PX_i.QX_i$

28. $SG = YG - \overline{CFMG} - \overline{Trsf_H^G} - \overline{Subv_F^G}$

Demand Block

Final Consumption

29. $PQ_i.CFQH_i = C\min_i.PQ_i + pmc_i.\left[CFMH - \sum_{j\neq i} c\min_j.PQ_j - PD_{\inf}.CFQH_{\inf}\right]$

30. $PD_{\inf}.CFQH_{\inf} = C\min_{\inf}.PD_{\inf} + pmc_{\inf}.\left[CFMH - \sum_i c\min_j.PQ_j\right]$

31. $PQ_i.CFQG_i = \varphi_i.\overline{CFMG}$

Intermediate consumption

32. $DIQ_i = \sum_j ica_{j,i}.QX_j + .ica_{i,\inf}.QD_{\inf}$

Investment

33. $IT = \sum_i \overline{INVQ_i}.PQ_i + CDM$

34. $CDM = \sum_i \overline{CDMQ_i}.PQ_i$

Closure rules

Labor market

35. $\overline{LDS^S} = \sum_i LD_i + LD_{\inf}$

36. $w_i = \overline{w}$

Commodities

37. $QQ_i = CFQH_i + CFQG_i + DIQ_i + \overline{INVQ_i} + \overline{CDMQ_i}$

38. $QD_{\inf} = CFQH_{\inf}$

Foreign account

39. $\sum_i EXR.\overline{PWM_i}.QM_i = \sum_i EXR.\overline{PWE_i}.QE_i + \overline{RL_R} + \overline{RK_R} + \overline{Trsf_G^R} + \overline{Trsf_H^R} + Srow$

Capital

40. $IT = SF + SH + SG + Srow$

Price index and numerar

41. $Pindex = \sum_i \pi_i.PQ_i$

42. $EXR = 1$

Environmental topics

43. $GDP = \sum_i PVA_i.QX_i$

44 $GreenGDP = PIB - \sum_i DEGC_i - \sum_i DEPC_i$

45 $DEGC_i = \theta g_i.QX_i$

46 $DEPC_i = \theta p_i.QX_i$

Simulations impacts on parameters

$\theta_i = \overline{\theta_i^0} \quad \forall i \neq élec$

$\theta_{elec} = (1 - cdm_{effect}).\overline{\theta_{elec}^0}$

$ica_{j,i} = \overline{ica0_{j,i}} \quad \forall i \neq elec$

$ica_{Ener,Elec} = (1 - cdm_{effect}).\overline{ica0_{Ener,Elec}}$

Simulation of the impact of All type of CDM projects

$Sc.1: \quad cdm_{effect} = 0.081$

$Sc.2: \quad cdm_{effect} = 0.115$

Simulation of the impact of renewable Energy CDM projects

$Sc.1: \quad cdm_{effect} = 0.079$

$Sc.2: \quad cdm_{effect} = 0.11$

Endogenous variables

PVA_i	Value-added activity price
$PVA_{\inf}$	Informal value-added activity price
PX_i	Aggregate producer commodities price
PD_i	Domestic commodities price
$PD_{\inf}$	Informal commodities price
PE_i	Export commodities price
PM_i	Import commodities price
PQ_i	Composite commodities price
$Pindex$	Consumer price index
EXR	Exchange rate
QX_i	Quantity of aggregate commodity i output
QD_i	Quantity of domestic supply of commodity i
$QD_{\inf}$	Quantity of supply of informal commodity
QE_i	Quantity of commodity i exports
QM_i	Quantity of commodity i imports
QQ_i	Quantity of composite commodity i
$CFQH_i$	Quantity of consumption of composite commodity i by households
$CFQH_{\inf}$	Quantity of consumption of informal commodity by households
$CFQG$	Quantity of consumption of composite commodity i by Government
DIQ_i	Quantity of intermediate demand for composite commodity i
RL	Labour incomes
RL_{for}	Labour incomes from formal activities
$RL_{\inf}$	Labour incomes from informal activities
RK	Capital incomes

YH Households' income
YDH Households' disposable income
SH Households' savings
$CFMH$ Households' consumption expenditures
YF Firms' income
SF Firms' savings
YG Government's income
$TAXY$ Income tax
$TAXS$ Sale tax
SG Government's savings
$Srow$ Foreign savings

CDM Nominal CDM investment
IT Nominal investment
LD_i Quantity of labour in activity i
LD_{inf} Quantity of informal labour
w_i Labour wage rate in activity i
GDP Gross domestic product
$GreenGDP$ Green gross domestic product
$DEGC_i$ Degradation costs from activity i
$DEPC_i$ Depletion costs from activity i

Exogenous variables

$\overline{CFG}$ Government consumption expenditures
$\overline{Trsf_H^G}$ Transfers from government to households
$\overline{Subv_F^G}$ Transfers from government to firms
$\overline{DivF}$ Dividends from firms to households
$\overline{Trsf_H^R}$ Transfers from rest of the world to households
$\overline{PWE_i}$ Foreign export commodities price
$\overline{PWM_i}$ Foreign import price
$\overline{K_i}$ Quantity of capital factor in activity i
$\overline{w}$ labour wage rate

$\overline{INVQ_i}$ Quantity of investment demand for composite commodity i
$\overline{CDMQ_i}$ Quantity of CDM investment demand for composite commodity i
$\overline{RL_R}$ Labour income from rest of the world
$\overline{RK_R}$ Capital income from rest of the world
$\overline{LDS^S}$ Quantity supplied of labour factor
$\overline{CQNMG_c}$ Quantity of government consumption of non marketed commodities
$\overline{Subv_{Healthg}^h}$ Price subvention of public health commodities

Parameters

A_i^p Production function efficiency parameter for commodity i
α_i^p Production function share parameter for commodity i
μ_i^p Production function exponent for commodity i
σ_i^p Production function substitution parameter for commodity i
$ica_{i,j}$ Quantity of intermediate input i per unit of product j
A_i^m Armington function shift parameter for commodity i
α_i^m Armington function share parameter for commodity i
μ_i^m Armington function exponent for commodity i
σ_i^m Armington function substitution parameter for commodity i
A_i^t CET domestic-export function shift parameter for commodity i
α_i^t CET domestic-export function share parameter for commodity i
μ_i^t CET domestic-export function exponent for commodity i

σ_i^t CET domestic-export function substitution parameter for commodity i
tva_i Sales tax rate for commodity i
tx_i Production tax rate for commodity i
t_y^H Direct tax rate on households
t_y^F Direct tax rate on Firms
$c\min_i$ Subsistence consumption of commodity i for households
$c\min_{inf}$ Subsistence consumption of informal commodity for households
pmc_i Marginal share of consumption of spending on commodity i for households
pmc_{inf} Marginal share of consumption spending on informal commodity for households
φ_c Share of commodity i in total government consumption
mps Marginal propensity to save for households
π_i Weight of commodity i in the consumer price index