Clean development mechanism: leverage for development?

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Abstract

The objective of this paper is to show that the investments through the clean development mechanisms (CDM) can exert a leverage effect to (i) make attractive to developing countries non-binding commitments and the adoption of national policies and measures; this comes as a guarantee of non-conditionally of the mechanisms to strictly environmental concerns and (ii) create a flow of additional investments and technological transfer from Annex B countries to non-Annex B countries.

The Indian power sector has been chosen as an example of a sector where institutional barriers, market imperfections and tariff distortions create a great space for Pareto improvements and leave an important potential for no-regret measures: technological transfer, air conditioned systems, transport infrastructures and removal of subsidies on consumption.

This paper presents a micro-economic formalisation on (i) the evolution of profitability of current emitting technologies used in the power sector under the adoption of national policies and measures and (ii) the impact on renewable energy technologies competitiveness of emission credits in the context of CDM. This formalisation has been developed to enable quantitative simulation. A first exercise using the Markal model (used in 77 countries) on the electric sector in India enabled us to simulate the leverage effect of emission credits on additional incomes taken as a proxy for development. © 2001. Published by Elsevier Science Ltd.

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2. Harmonisation space between flexibility and development policies

It is often overlooked that a CDM project can be defined purely as an abatement project in only a few cases such as sequestration in non-occupied areas. In most of the cases, these investments cannot be analysed in isolation from the investment in energy, agriculture or transportation to which it is attached and from the externalities it generates. Three types of benefits should be considered jointly: the carbon benefit due to the gap between the international value of carbon and the unit cost of the CER yielded by the project, the commercial benefit, and the social benefit due the local positive environmental externalities or to the economic spill-over which may be considered by the public authorities of the host countries. One of the most repeated arguments against the CDM is that both of these side-effects may be negative (large scale dams, for example) and that the risk of generating social costs rather than benefits is high because of the asymmetry of negotiation power between investors and most of host countries. We will come back to this argument only in conclusion and consider, for the time being, that even though a lower
access to expertise prevents the host country from getting the biggest share of the rents associated with the project, the Protocol guarantees host state sovereignty in that it may define what type of CDM project it is ready to accept and what type of project will be rejected because of negative social costs.

The co-existence of these three types of benefits is critically important; should a CDM project only yield a carbon benefit, the potential for a net development benefit for the host country would be weak. Indeed there would be no direct net surplus, if the foreign investment recovers the total cost of the abatement and all the CERs accrue to the investor; the only benefit would be then an upgrading of technical know-how.

To demonstrate the mechanisms potential leverage on development we will start from a conventional macro-economic representation of the income $j(I)$ generated by a level of investment $I$ in an economy under given technical and institutional constraints. The curve $j(I)$ describes the income generated by an amount $I$ of cumulated investment if the individual investments are ranked by decreasing profitability order. The slope of the curve ($f''(I) > 0, f''(I) < 0$) represents the profitability of each marginal project and the last investment made in a country is represented at the point where the slope of the curve equals the prevailing discount rate. A higher level of income can be then generated either through lowering the discount rate or through an upward move of $f(I)$ due to access to a new production frontier (Fig. 1).

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Fig. 1. Income generated by investment.
The domestic discount rate is determined by the availability of capital in the economy and its level of indebtedness. In most of non-Annex B economies, this rate \( r_{\text{real, South}} \) is higher than the optimal social discount rate \( r_{\text{opt, South}} \) that would prevail in a perfect capital market, which would equalise the discount rates all over the world. Indeed, these countries have to confront higher interest rates if they want to mobilise capital because the real interest rates on the capital markets increase with the external debt and are perceived as presenting a ‘country risk’ higher than investments in OECD countries. The resulting level of investment is \( r_{\text{real, South}} < r_{\text{opt, South}} \) yielding a lower net income.

The production frontier \( f(I) \) results from technical endowments and institutional constraints including domestic market imperfections and tariff distortions in the public sector. In principle a government can move \( f(I) \) upwards by adopting domestic reforms among which those yielding the co-benefits of carbon saving projects. Those of these policies that lead to lower GHGs emissions levels are typically ‘no-regret’ policies that should be adopted regardless of climate concerns (for instance reducing coal subsidies induces efficiency improvements in coal-based thermal power stations that reduce local pollution). In the presence of such ‘no-regret’ policies, some projects that were formerly unprofitable do become economically viable while the profitability of others decreases, but the balance of the two effects is by definition positive. With the same discount rate, the level of investment moves to \( I_{\text{measure, South}} > I_{\text{opt, South}} \).

The inflow of foreign investment has two related impacts: (a) it relaxes the capital constraint, lowers the domestic discount rate if the interest rate demanded by the foreign investor (including a risk premium) is \( r_{\text{N}} < r_{\text{real, South}} \); the volume of investment increases until \( r(I) = r_{\text{N}} \) and the output until \( I_{\text{opt, North}} > I_{\text{measure, South}} \); (b) by providing more efficient technologies through technology transfer, the production frontier moves up from \( f_{\text{measure}}(I) \) to \( f_{\text{measure+transfer}}(I) \). This results in a new level of investment at \( I_{\text{transfer, North}} > I_{\text{opt, North}} \).

Note that the improvement of the net situation compared with the initial \( f(I_{\text{real, South}}) \) is unrelated to the value of carbon. Typically, there are ‘no-regret’ policies, based on the relationship between national policies and capital inflows that should be implemented regardless of climate change concerns (IPCC, 1993, 1995). Obviously, the very fact that they have not been implemented so far demonstrate the existence of transaction and political costs inhibiting the removal of market barriers and institutional bias. The obstacles to the adoption of “Pareto improving policies” pointed out by Stiglitz (1998) do operate in this field because of the asymmetric mobilisation capacities of the losers and the winners (Jaffe and Stavins, 1994). The CDM can have a leverage effect on development by triggering the exploitation of potential no-regret policies that might otherwise remain frozen. It can do so through two interrelated channels: (a) technically, the creation and sharing of a carbon benefit through the CDM inflates the profitability of investments and moves up the curve to \( I_{\text{transfer+credit, North}} > I_{\text{transfer, North}} \); (b) this additional benefit provides an incentive to public authorities for confronting the transaction costs of Pareto improving policies since, it yields revenues to compensate the losers of such policies.

3. Micro-economic and macro-economic assessment of the leverage effect

In this section we will try and disentangle the main drivers of the mechanisms sketched in the previous paragraphs. We will first concentrate on how project profitability is impacted by a public policy (a tax on fossil energies) and by the revenues from emission reduction credits for foreign investors. In a second step, we will generalise the results obtained for one project to a set of projects and a portfolio of investments. In a last step, we will examine the macro-economic impacts of the new allocation of investments.
The domestic discount rate is determined by the availability of capital in the economy and its level of indebtedness. In most non-Annex B countries, this rate $i_{\text{real South}}$ is higher than the optimal social discount rate $i_{\text{opt South}}$ that would prevail in a perfect capital market, which would equalise the discount rates all over the world. Indeed, these countries have to confront higher interest rates if they want to mobilise capital because they are indebted (the real interest rates on the capital markets increase with the external debt) and are perceived as presenting a 'country risk' higher than investments in OECD countries. The resulting level of investment is $I_{\text{real South}} < I_{\text{opt South}}$ yielding a lower net income.

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The inflow of foreign investment has two related impacts: (a) it relaxes the capital constraint, lowers the domestic discount rate if the interest rate demanded by the foreign investor (including a risk premium) is $i_N < i_{\text{real South}}$; the volume of investment increases until $r(I) = i_N$ and the output until $I_{\text{North}} > I_{\text{measure South}}$; (b) by providing more efficient technologies through technology transfer, the production frontier moves up from $f_{\text{measured}}(I)$ to $f_{\text{measured+transfer}}(I)$. This results in a new level of investment at $I_{\text{transfer North}} > I_{\text{North}}$.

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3.1. Impact of the CDM on micro-economic choices

Let \( S(t) \) be the demand for an energy service for a period of \( N \) years. This demand can be satisfied either by a carbon intensive technology (coal plant), or by a carbon free technology (wind power plant for instance). Though in the real world the criteria for decision making are more complex, for simplicity we will retain here the internal rate of return \( \rho(\text{IRR}) \) to model the investment behaviour: a project with an IRR lower than the discount rate observed in the country will not be realised and the same applies to choices of technology within a project. We have to examine how this IRR will be modified by rational policies on one hand, and by the credits from the CDM yielded by foreign investments on the other.

3.1.1. Impact of a tax on the profitability of carbon intensive technologies

A tax on fossil energies is used here as an illustrative example of domestic policies. This tax is applied to the energy producer. The increase of taxation induced by this new carbon tax is denoted by \( d\rho \); the volume of carbon intensive energy being charged \( E_c \); it flows immediately that the additional energy expenditure \( E_c d\rho \).

In theory, the first response of an investor would be to respond to the tax burden on consumers by increasing the price of energy. To keep the demonstration simple without altering the substance of the conclusion, we will assume here that the energy prices are unchanged at this stage: in general, part of the burden of a tax falls on the producer in case of elastic demand and in a large subset of developing countries public authorities regulate energy prices and are reluctant to reflect tax increases in energy prices for equity and political reasons. As a result, demand can be considered unchanged.

The producer, if he does not abandon his project, will have a lower IRR as follows:

\[
\rho(T) = \frac{1}{(1/(\rho_0 + 1)) + (E_c/T)(T - T_0)} - 1
\]

with \( \rho_0 \) as the internal rate of return with a tax level of \( T_0 \), before the tax increase.

This equation shows that for a given tax, the higher the carbon intensity of the investment \( (E_c/I) \), the greater is the importance of the decrease of the internal rate of return.

For the rest of this demonstration, we will assume that faced with a decline of the internal rate of return, a producer will nevertheless respond to the anticipated level of demand and will not reduce his investment, because the tax is not high enough to incentives a switch in investment to another sector (see Appendix A).

3.1.2. Impact of the credits on the adoption of carbon saving technologies

Imagine the case of an Annex B investor. We assume that he controls an Annex B technology that is a perfect substitute to the technology locally available and otherwise employed by the national investor. Let \( \rho' \) be the internal rate of return of the carbon saving project.

In each period the amount of carbon is reduced by this technology is \( E_c C \) (where \( C \) is the decline in carbon content compared to the carbon intensive energy and \( E_c \) the amount of energy which would have been consumed by the carbon intensive technology). If the value of credits is \( V \), each year, receipts rise by \( E_c CV \).

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\(^1\) In India, energy consumption has long been considered as a public service. Consumption tariffs are far from reflecting production costs. Residential and agricultural tariffs are very low and will, as a result of equity considerations, remain low. Produced electricity is sold at a minimum price to state entities that in their turn distribute the electricity to customers at a specific price set in order to respect equity concerns. These prices are not high enough to cover production costs; but the government does not want to increase prices.
If $\rho_0$ is the internal rate of return of the carbon saving project without remuneration from emission credits, the value of the internal rate of return with a value $V$ for the credits is

$$
\rho'(V) = \frac{1}{(1/(1 + \rho_0)) - (CE_c/V)} - 1
$$

(2)

These equations show that the internal rates of return of two technologies will get closer to one another. As the tax increases, $\rho$ decreases and as $V$ increases, $\rho'$ rises. They show also that the more carbon intensive the baseline technology is, the more attractive the credit remuneration will be for the northern investor.

These two results, which are valid for a single project, also apply to a program of substitution projects if $\rho$ is interpreted as a global mean rate of return of the programme (see Appendix A).

3.2. Assessment of the leverage effect

3.2.1. Components of the leverage effect

The increase in tax on fossil fuels will lower the profitability of carbon intensive projects and will at the same time increase the profitability of projects using carbon saving technologies. Thus, some projects that would have been realised by domestic investors in the reference scenario will be replaced by CDM projects. This substitution is not the only one to be considered. Indeed, CDM projects are realised with a northern contribution, and will come to substitute projects that would otherwise have been realised by southern investors. On the assumption that electricity demand is fixed as a public objective of the country, the global economic effect of the substitution between domestic and foreign investors makes domestic capital available for other investment opportunities. It is well known that since energy is a highly capital-intensive sector, it crowds out investment in other industrial development priorities. This is demonstrated where a large part of the indebtedness of certain developing countries (Brazil) is due to the investment in the energy sector. At the macro-economic level, the leverage in developing countries is produced by this higher availability of capital. One can refer here to some kind of Keynesian investment multiplier. Every period, investments increase inducing an increase in production and so an increase in consumption. Evidently, this effect cannot be considered long-term, but rather on a period-by-period basis. To evaluate its magnitude it is necessary to estimate the amount of domestic investments that have been reoriented to non-power sectors by the entry of international investment thanks to the clean development mechanism and at which marginal efficiency.

In the reference scenario (no tax increase and no CDM project), the income generated by investments in the power and non-power sectors is

$$
R(T_0, V = 0) = R_{E, South}^{non-power \ sector} + R(I_{E, South}(T_0)) \text{ power sector}
$$

(3)

Under the policy mix (tax and CDM), the general equilibrium effect of the CDM is then given by

$$
R(T, V) = R_{E, South}^{non-power \ sector} + R_{E, South}(\lambda I_{E, South}(T_0)) + R((1 - \lambda) I_{E, South}(T)) + R(I_{E, North}(V))
$$

$$
+ TE_c(T) - T_0 E_c(T_0) + \frac{JE}{inassexpenses}
$$

(4)

which is composed of four basic components.
• The variation of the income from the power sector is as follows:
  o CDMS investments from northern countries generate the income \( R(I_{E,North}(V)) \).
  o \((1 - \lambda)I_{E,South}\), which is the amount of domestic investments, which remains in the energy sector in
    the CDMS scenario. Important for the mechanics of the leverage is the fact that, because of the tax,
    the least profitable projects are no more funded by domestic investments and the remaining domestic
    investments in the power sector have a higher internal rate of return.
  • The variation of the income of the non-power sector: this share of domestic investment made available
    by the inflow of foreign investments is supposed to be realised under a uniform internal rate of return
    equal to the rate of interest used in the country. A part \( \lambda \) of initial domestic investments is transferred
    to other sectors and induce the income \( R_Q(T_0) \).
  • Recycling of tax in the economy captures the potential for no-regret measures and legitimates the
    adoption of the tax for public authorities.
  • The co-benefits: the decline in CO2 emissions reduces local negative externalities (NOx, particles,
    sulphur emissions) which lower the impact on health and the need for some public expenditure to
    offset these externalities.

The estimate of public expenditures is a very sensitive matter because they generate ancillary benefits
that are not easy to quantify (benefits linked with the decrease of pollutants which affect local populations
for instance). Since the evaluation of such ancillary benefits is controversial (Krapnick, 1998) these
benefits will not be considered here even if they may be of big importance in countries like China or
India. Calculation of the leverage effect quantifies the additional income of one unit of credits, like a
multiplier effect of credits on additional income:

\[
l = \frac{R_2(T, V) - R_1(T_0, V = 0)}{E_r CV}
\]

(5)

3.2.2. Calculation of northern investments

Northern investors penetrate the market after solving Eq. (2) allowing the transfer of \( \lambda I_{E}(T_0) \). They
satisfy the demand \( \lambda \delta \). Since their technology is supposed to be more productive than technologies
available in the host countries less investment is needed for a constant demand. Let \( \sigma \) be the technical
efficiency improvement. Then the income is given by

\[
R(I_{E,North}(V)) = \sigma \lambda \frac{I_{E,South}(T_0)l}{\sum_i (1/(1 + \rho_{E,North}(V))^i)} \]

(6)

3.2.3. Calculation of domestic investments

3.2.3.1. Power sector: Only a part \( 1 - \lambda \) of former domestic investments in the power sector in the
reference scenario remains in the same sector under the CDMS scenario. Thus, the difference between the
incomes from the two scenarios is

\[
R((1 - \lambda)I_{E,South}(T)) - R(I_{E,South}(T_0))
\]

\[
= I_{E,South}(T_0) \left[ \frac{1 - \lambda}{\sum_i (1/(1 + \rho_{E,South}(T))^i)} - \frac{1}{\sum_i (1/(1 + \rho_0))^i} \right]
\]

(7)
3.2.3.2. Transfer of investments to non-power sectors. A part \( \lambda \) of initial domestic investments in the power sector \( I_0(T_0) \) is reoriented towards other sectors. A uniform internal rate of return \( \rho_{OS} \) (here 12%) is considered for these investments:

\[
R_{\rho_{OS}}(\lambda I_{E\text{South}}) = \lambda \frac{I_{E\text{South}}(T_0)}{\sum_t (1/1.12)^t} \tag{8}
\]

3.2.4. Total additional income generated by the mechanism

Finally the additional income \( R_2 - R_1 = I_E(T_0)\Pi \) is given by Eq. (9) as follows:

\[
\Pi = \frac{1 - \lambda}{\sum_t (1/(1 + \rho_{\text{South}}(T)))^t} - \frac{1}{\sum_t (1/(1 + \rho_{0\text{South}}))^t} + \lambda \left[ \frac{1}{\sum_t (1/(1.12))^t} + \sum_t (1/(1 + \rho_{\text{North}}(V))^t \right] \tag{9}
\]

This literal expression shows the factors influencing the multiplier effect of credits regardless of the tax recycling and of the lower public expenditures to compensate pre-existing local externalities:

- The gap between social marginal profitability of investments before and after tax (gap between \( \rho_{\text{South}}(T) \) and \( \rho_{0\text{South}} \)).
- \( \lambda \) the foreign share of total investments needed to meet the demand: \( \lambda \) has a negative effect on the income derived from domestic investments in the power sector because, assuming a constant demand, the bigger \( \lambda \) is, the smaller domestic investments will be. However, this effect is compensated for by positive variation of foreign investments, and by the transfer of domestic investments to other sectors.
- \( V \) the value of carbon: the higher \( V \) is, the higher the northern investor’s internal return rate \( \rho_{\text{North}}(V) \), and accordingly the bigger the income generated.

This multiplier is not constant and changes each new period, depending on the multiplier of preceding periods.

3.3. Illustration — the case of the Indian power sector

In this exercise, we will try to evaluate to potential for CDM with respect to the leverage on development and the decrease in CO\(_2\) emissions in the context of national policies and measures. This has been tested for the Indian power sector using the Markal model. The Markal model is a linear optimisation model representing the energy system at the level of a country or a region. For a given period (from 1995 to 2035) and a fixed energy demand, the model chooses the less expensive combination of technologies by minimising the discounted sum of the costs for investments, operations and maintenance.

The Indian power sector is characterised by institutional obstacles, as well as political and social barriers commonly found in developing countries. The Indian situation can be considered sub-optimal. There is therefore great potential for policies that could improve the global performance of the system. In co-operation with our Indian colleagues, we selected four kinds of policies and measures currently under discussion in India. This does not mean that all of these measures would be politically acceptable, but at least they are not excluded from the debate.