Global Warming and the Carbon Market: an Application of the Cert Model

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Abstract

The economic and industrial anthropogenic activities are increasing the **Greenhouse Gases (GHG)** atmospheric concentration. To solve the global warming was created in 1992 the **United Nations Framework Convention on Climate Change**. The Conference of the Parties held at Kyoto in 1997 created the **Kyoto Protocol** and the **Clean Development Mechanism (CDM)**. To estimate the size of the carbon market the **CERT (Carbon Emission Reduction Trade) Model** was used. In the reference scenarios the best Brazilian participation, through **Certified Emission Reductions (CER)**, was only 3.4% (Scenario 7), selling 14.4 millions tons of carbon, with a revenue of US$ 237 millions and costs of US$ 106.3 millions. The profits of all CDM projects in Brazil were US$ 130,7 millions. In the alternative scenarios the best Brazilian participation was 17.8% (Alternative Scenario 7), selling 32.1 millions tons of carbon, with a revenue of US$ 525.6 millions and costs of US$ 198 millions. In this case the profits of all CDM projects in Brazil was US$ 327.6 millions.

Keywords

Kyoto Protocol, Clean Development Mechanism, Certified Emission Reductions

1. Introduction

The economic and industrial anthropogenic activities are increasing the Green House Gas (GHG) atmospheric concentration. These gases can increase the atmosphere temperature in 1.4 to 5.8°C in the next hundred years (IPCC, 2001a).
To solve this problem was created in 1992 the United Nations Framework Convention on Climate Change (UNFCCC, 2001a). The Conference of the Parties held at Kyoto in 1997 was one of the most important, since it created an international agreement about the GHG emission reductions to the ANNEX B countries. This agreement is called the Kyoto Protocol and it determines that the industrialized countries should decrease the GHG emissions in 5% below the 1990 levels between 2008-2012 (first period commitment) (UNFCCC, 2001b).
The Protocol also created the Clean Development Mechanism (CDM). The idea of the CDM is that each tone of CO_2 that is reduced or sequestered from the atmosphere by a developing country can be negotiated through Certified Emission Reduction (CER).

This work had the main objective of understand the "carbon market", in special the Brazilian participation through the CDM. The specific objective was: determine the size of the global market and the Brazilian participation (through the CDM) in different scenarios.

2. The CERT model (Carbon Emission Reduction Trade)[11]

CERT is a computational framework to present and analyze the GHG offset trading market. It includes various scenarios and switches to give an overview of possible outcomes of the market. CERT is not a new general equilibrium model but a "meta-model" which uses inputs from other models.

2.1. Algorithm Solution

The solution algorithm of the CERT model is designed to find a minimum-cost solution for the global reduction of GHGs. The required emission reductions of Annex B countries / regions, i.e. the total demand of GHG reductions, are calculated by subtracting the "business as usual" (BAU) emissions 2010 from the so-called "assigned amount" (1990 emissions multiplied by the Kyoto target):

$$QR_i = BAU_i - (KT_i\, E_{1990i}) \qquad i = 1,6 \text{ - } \textbf{Equation 1}$$

QR = amount of GHG emissions to be reduc
BAU = "business as usual" emissions in 2010
KT = Kyoto target
E_{1990} = emissions in 1990

The marginal abatement cost functions are used to calculate the amounts and costs of GHG emission reductions. Given a world market price for GHG emission reductions, and assuming perfect competition, each country / region reduces emissions until marginal costs equal the world market price. The integral of the marginal cost function then gives the total costs of emission reduction:

$$MC_i = a_i Q_i^2 + b_i Q_i \qquad i = 1, 12 \text{ - } \textbf{Equation 2}$$
$$MC_i = a_i\, (e^{biQi} - 1) \qquad i = 1, 12 \text{ - } \textbf{Equation 3}$$

MC = marginal costs of emission reduction
Q = emission reduction (Mt of C)

Given a world market price P_k, the amount of emissions reduced in each country / region results as:

$$Q_i = -b_i / 2a_i + ((b_i / 2a_i)^2 + P_k/a_i)^{½} \qquad i = 1, 12 \text{ - } \textbf{Equation 4}$$
$$Q_i = \ln (P_k / a_i + 1) / b_i \qquad i = 1, 12 \text{ - } \textbf{Equation 5}$$

P = world market price of GHG offsets

The costs of emission reductions result from the integration of the marginal cost functions:

$$C_i = 1 / 3\, a_i\, Q_i^{\,3} + 1 / 2\, b_i\, Q_i^{\,2} \qquad i = 1, 12 \text{ - } \textbf{Equation 6}$$
$$C_i = (a_i / b_i)\, e^{\,biQi} - a_i Q_i - (a_i / b_i) \qquad i = 1, 12 \text{ - } \textbf{Equation 7}$$

C = costs of emission reduction ($/t C)

[11] Based on Grutter (2001)

The market equilibrium is achieved if total emissions to be reduced equal total emission reduction. Under the condition of perfect competition the world market equilibrium price of GHG emission reductions results as:

$$TQR = ? \ QR_i \qquad i = 1,6;\ QR_i > 0$$ **- Equation 8**

TQR = total emissions to be reduced
QR = emissions to be reduced

$$TQ = ? \ Q_i \qquad i = 1,12$$ **- Equation 9**

TQ = total emission reduction

$$P^* = P \text{ for } TQR = TQ$$ **Equation 10**

P* = equilibrium price for GHG reductions

The worldwide costs of GHG emission reduction are:

$$TC = ? \ C_i \qquad i = 1, 12$$ **- Equation 11**

TC = total costs of emission reduction

The Kyoto target could also be achieved without trade of emission reductions among countries and regions. In this "autarkic" solution each Annex B country / region would reduce GHG emissions to its "Assigned Amount", i.e. QR_i would equal Q_i for each Annex B country / region with $QR_i > 0$.

Total costs for the autarkic solution are given by:

$$C_{Ai} = 1 / 3\ a_i\ Q_{Ai}^{\ 3} + 1 / 2\ b_i\ Q_{Ai}^{\ 2} \qquad i = 1, 6;\ QR_i > 0$$ **- Equation 12**

$$C_{Ai} = (a_i / b_i)\ e^{b_i Q_{Ai}} - a_i Q_{Ai} - (a_i / b_i) \qquad i = 1, 6;\ QR_i > 0$$ **- Equation 13**

$$TC_A = ? \ C_{Ai} \qquad i = 1, 6;\ QR_i > 0$$ **- Equation 14**

C_{Ai} = autarkic costs of emission reduction
Q_{Ai} = autarkic emission reduction
TC_A = total costs of autarkic emission reduction

Total savings or benefits from international trade of emission reductions (relative to the autarkic solution) then result as:

$$TS = (TC - TC_A) / TC_A \qquad \text{Equation 15}$$

TS = savings from trade of emission reductions in relative terms
TC = total costs of emission reduction with trade
TC_A = total costs of autarkic emission reduction

2.2. Marginal Abatement Cost Curves

Marginal Abatement Cost Curves (MACs) represent the marginal cost of reducing carbon emissions by different amounts within an economy. MACs are either derived with a top-down or a bottom-up approach.

2.3. Reference scenarios

The CERT reference scenarios are:

1 Medium growth, EPPA MACs, only CO_2
2 Low growth, EPPA MACs, only CO_2
3 High growth, EPPA MACs, only CO_2
4 Medium growth, GTEM MACs, only CO_2
5 Low growth, GTEM MACs, only CO_2
6 High growth, TEM MACs, only CO_2
7 GTEM all GHG
8 Medium growth, GTEM bottom-up MACs CO_2

All scenarios assumes 100% implementation of CDM projects; 100% of "hot air" trade; zero transaction costs; 2% tax over CER trade for the Adaptation Fund; no LULUCF projects; and 100% participation of USA.

The EPPA scenarios use quadratic functions to represent Brazil MAC:

$C = 0.5612\ q^2 + 8.4974q$ – "top-down", only for CO_2 - **Equation 16**

The GTEM scenarios uses exponential functions to represent Brazil MAC:

$C = 136.04\ (\exp^{0,05531723\ q} - 1)$ - "top-down", only for CO_2 **- Equation 17**
$C = 18.62\ (\exp^{0,0407115\ q} - 1)$ - "top-down", for all GHG **- Equation 18**
$C = 17.62\ (\exp^{0,1081202\ q} - 1)$ - "bottom-up", only for CO_2 - **Equation 19**

2.4. CERT Options

The CERT model allows for choosing various options:

- **Trade of "hot air":** The model user can specify the percentage share of "hot air" that may be traded. Since the COP 7 unlimited trade of "hot air" is allowed. The "default" is 100%.
- **Supplementarity:** The model user can specify the share of GHG emission reductions that Annex B countries may import, either as percentage of their assigned amount or as percentage of the required emission reduction. COP 7 decided to not establish a quantitative supplementarity limit.
- **Adaptation fund:** The model user can specify a percentage share of proceeds on the CDM project activities that will be allocated to the adaptation fund. At COP 7 it was decided to finance that fund with a premium of 2% on the proceeds from CER sales.
- **Transaction cost:** The model user can specify transaction costs in US$ per ton of carbon, which result in an upward shift of the MACs of Non-Annex B countries.
- **Implementation rate of CDM projects:** The model user can specify implementation rates (in percent) for Non-Annex B countries. Implementation rates below 100 % assume that Non-Annex B countries do not fully implement all projects as reflected in

their MACs. Implementation rates below 100 % increase the gradient of the respective MACs.

- **Introduction of MACs functions for "sinks" (LULUCFs):** exponential or quadratic

2.5. Alternative scenarios

The following options were made in the alternative scenarios:

- **Implementation rate of CDM projects:** Brazil (38%); China (41%); India (36%); Rest of the world (36%)
- **Trade of "hot air"**: 41%
- **Transaction cost:** Brazil (US$ 1,73); China (US$ 1,33); India (US$ 1,40); Rest of the world (US$ 1,75)
- **USA participation:** 32%

2.5.1. LULUCF MAC for Brrazil

In the alterntative scenarios, Brazil can offer LULUCF projects using the following MAC:

$C = 0.0021\ q^2 + 0{,}0805\ q$ – "top-down", only for CO_2 – **Equation 20**
$C = 67.17\ (\exp^{0{,}00905099\ q} - 1)$ – "top-down", only for CO_2 – **Equation 21**
$C = 18.24\ (\exp^{0{,}007666301\ q} - 1)$ - "top-down", all GHG **- Equation 22**
$C = 17.29\ (\exp^{0{,}02034329\ q} - 1)$ - "bottom-up", only for CO_2 **- Equation 23**

3. Results

3.1 Reference scenarios

In the reference scenarios the best Brazilian participation, through the CER, was only 3.4% (Scenario 7), selling 14.4 millions tons of carbon, with a revenue of US$ 237 millions and costs of US$ 106.3 millions. The profits of all CDM projects in Brazil were US$ 130,7 millions.

3.2 Alternative scenarios

In the alternative scenarios the best Brazilian participation was 17.8% (Alternative Scenario 7), selling 32.1 millions tons of carbon, with a revenue of US$ 525.6 millions and costs of US$ 198 millions. In this case the profits of all CDM projects in Brazil was US$ 327.6 millions.

4. Conclusions

A new market is being formed: the carbon market. This market will sell and buy **Certified Emission Reductions (CER)**, from **Clean Development Mechanism (CDM)**. To determine the size of the global market and the Brazilian participation (through the CDM) in different scenarios, the CERT model (Carbon Emission Reduction Trade) was used.
In the reference scenarios the best Brazilian participation, through the CER, was only 3.4% (Scenario 7), selling 14.4 millions tons of carbon, with a revenue of US$ 237 millions and costs of US$ 106.3 millions. The profits of all CDM projects in Brazil were US$ 130,7

millions. In this scenario the market equilibrium occurs with the trade of 860 Mt of C at $ 16,8 per ton. The Brazilian participation is small compare to China (54,89%), India (10,10%) and the rest of the world (31,64%), due to the fact that: I) the Brazilian MAC are too high; II) the scenarios don't take into consideration LULUCF projects.
In the alternative scenarios the best Brazilian participation was 17.8% (Alternative Scenario 7), selling 32.1 millions tons of carbon, with a revenue of US$ 525.6 millions and costs of US$ 198 millions. In this case the profits of all CDM projects in Brazil was US$ 327.6 millions. The Brazilian participation increase due LULUCF projects: 17.8% (China, 49.71%, India 7.94% and 24.58% Rest of the world).

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