A general equilibrium model for climate change policy analysis: An application to Uruguay

Francisco Rosas
Universidad ORT Uruguay & Centro de Investigaciones Económicas
Uruguay
rosas@ort.edu.uy

Luis Miguel Galindo
Universidad Nacional Autónoma de México
gapaliza@unam.mx

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Francisco Rosas[1] and Luis Miguel Galindo[2]

[1]Universidad ORT Uruguay & Center for Economic Research (CINVE) [2]Universidad Nacional Autónoma de México

1 – Overview and Motivation

- The Climate Change Long Term Strategy (LTS) is the compromise of a country (against UNFCCC) of constructing and presenting a low carbon long-term development strategy.

  1. The LTS must be consistent with global and national objectives of mitigation and adaptation, such as those in the NDC and NAP.
  2. LTSs usually have 2 scenarios:

- The Trend scenario projects variables driving CO_2 emissions with current trends
- The CO_2-neutral scenario comprises changes in key sectors that at 2050 yield a CO_2-neutral economy:
  - i. Fossil Fuels:
  - ii. Electricity:
  - iii. Forestry:
  - iv. Livestock output

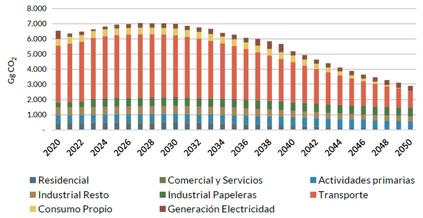

Figura 19: Proyección de emisiones de CO_2, del escenario aspiracional a 2050

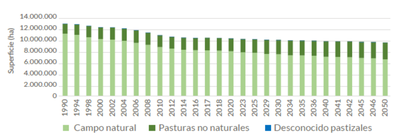

Figura 54: Evolución de área de pastizales escenario Fmad (ha).

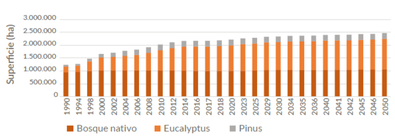

Figura 55: Evolución de área de tierras forestales escenario Fmad (ha).

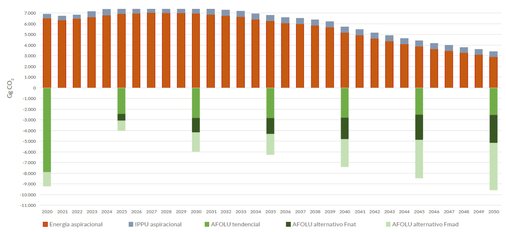

Figura 24. Trayectoria de emisiones / remociones de CO_2, período 2020-2050

- We use a simple GE model based on Fullerton and Ta (2019) to analyze the impacts of the CO2-neutral scenario on key macroeconomic variables.
- Our model can be solved analytically for a set of macroeconomic solution variables (GDP, prices and qty of inputs and outputs, by sector and aggregated, labor market, and CO2 emissions).
- Fullerton and Ta (2019) show that for the US economy, this simple model generates comparable results to those of a large CGE model.
- We extend their model and implement a calibration for the case of Uruguay.

2 – The Model

Households problem: Maximize utility function

$$U = X^a E_H^b F_H^c L_H^{1-a-b-c}$$

subject to budget restriction. Solutions are the optimal demands of:
- Electricity
- Fossil fuels
- Composite good
- Leisure or work at home

Fossil Fuels sector: Maximize profits with production function:

$$F = F_E + F_T + F_X + F_H = GL_F$$

Solution is the optimal demand of Labor

Electricity sector: Maximize profits with production function:

$$E = E_X + E_H = B_E K_E^{\alpha_1} L_E^{\alpha_2} F_E^{1-\alpha_1-\alpha_2}$$

Solution are the optimal demands of:
- Capital, Labor
- Fossil fuels

Timber sector: Maximize profits with production function:

$$T = T_X = B_T K_T^{\beta_1} L_T^{\beta_2} A_T^{\beta_3} F_T^{1-\beta_1-\beta_2-\beta_3}$$

Solution are the optimal demands of:
- Capital, Labor, Ag land
- Fossil fuels

Composite good sector: Maximize profits with production function:

$$X = B_X K_X^{\gamma_1} L_X^{\gamma_2} A_X^{\gamma_3} E_X^{\gamma_4} T_X^{\gamma_5} F_X^{1-\gamma_1-\gamma_2-\gamma_3-\gamma_4-\gamma_5}$$

Solution are the optimal demands of:
- Capital, Labor, Ag land
- Electricity, Timber, Fossil fuels

Government Budget Restriction:

$$R = \rho\tau_C F + \tau_E P_E E + \tau_L P_L L + \sigma\tau_A A_T$$

Household Budget Restriction:

$$\begin{aligned} I &= P_K\bar{K} + P_L\bar{L} + P_A\bar{A} + R \\ &= P_X X + P_E(1+\tau_E)E_H + (P_F + \rho\tau_C)F_H + P_L L_H \end{aligned}$$

Emissions by sector: Fossil fuels and Forestry land

$$\begin{aligned} C_F &= \rho F \\ C_A &= \sigma A_T \end{aligned}$$

General equilibrium conditions
- Income balance: HH and Government, income = expenditures
- Zero profit: All sectors, revenues = costs
- Market clearing conditions:
  - ✓ F, E, T sectors: supply = demands
  - ✓ Endowments of K, L, A: endowments = demands

3 – Model Calibration

Uruguay LTS Scenarios: The 2050 CO2-neutral scenario comprises the following changes with respect to current values:
- i. Fossil Fuels, reduction in demand: -50%
- ii. Electricity, increase in demand: 80%
- iii. Forestry, moderate increase in forestry area: 14%
- iv. Livestock output, moderate increase in productivity: 8%

Objective:
We seek to analyze the impacts on aggregate variables (GDP, inputs and outputs by sector, prices, labor markets.

Implementation:
Scenarios are implemented through exogenous shocks on model parameters, calibrated to be consistent with these required changes.
- i. Fossil fuels: Carbon tax of 280 USD/ton (τC)
- ii. Ag land in Timber (τ_A)
- iii. Electricity: Price subsidy (τ_E) of −48%
- iv. Livestock output: shock of 0,35% on TFP of X (B_X).

4 – Preliminary Results

Our preliminary results show that:

- The cumulative impact until 2050 on GDP level is non-negative
- When we transform this cumulative impact to annual GDP growth (assuming it is equally distributed over time), it implies an annual GDP growth rate that is almost equal to the BAU scenario.
- In sum, we find:
  - Mild impacts (but non-negative) on overall GDP of the LTS
  - Mixed impacts on output by sector and households

5 – References

Fullerton, D. y C.L. Ta (2019) “Environmental policy on the back of the envelopment: A Cobb-Douglas model is not just a teaching tool” *Energy Economics*, 84, 104477.

URU–SNRCC (2022) “Estrategia climática de largo plazo. Para un desarrollo bajo en emisiones de gases de efecto invernadero y resiliente al clima – Uruguay (LT-LEDS).” Available in: https://unfccc.int/documents/424113

Authors

[1] Francisco Rosas is a Professor and Chair in Econometrics and Statistics at Universidad ORT Uruguay, and Research Fellow at the Center for Economics Research (www.cinve.org.uy)

[2] Luis Miguel Galindo is a Professor at Universidad Nacional Autónoma de México

Contact information: Francisco Rosas, rosas@ort.edu.uy Luis Miguel Galindo, gapaliza@unam.mx