MODELING THE SOCIO-ECONOMIC IMPLICATIONS OF MITIGATION ACTIONS IN COLOMBIA.

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Overview

Climate change requires worldwide efforts in order to reach greenhouse gases abatement. Despite the fact that some developing countries are not considerable emitters, some of these countries are implementing measures to deviate its emission patterns. In this paper, a methodological approach to assess the socio-economic implications of some of these potential measures is proposed and implemented to evaluate the Colombian case. The most frequent way used to assess these implications have been the use of either sectorial models or General Equilibrium Models. The methodology proposed consists on the linkage of these two kinds of models in order to assess the impacts in both the sectorial activities and the economic wide parameters. A set of mitigation actions were evaluated. These mitigation actions included: renewable portfolios for power generation; carbon taxes with and without recycler mechanisms; and mandatory limits on emissions. The results shows the abatement potentials, the costs that the energy sector must face and the macroeconomic impacts of this class of measures. This paper focuses on measures on the energy sector and the impacts in the economic growth of the country. The main finding is that a carbon tax does not affect significantly the macroeconomic indicators and yet reached important abatements, especially if low oil prices are considered as baseline.

Methods

To reach the paper goal –to assess relevant mitigation actions and its expected impacts in the whole Colombian economy– we use a set of modeling tools that may enable us to evaluate these measures. The energy sector is one of the most relevant GHG emitter in the Colombian economy. By this reason, a sectorial bottom up model was used to find out the impacts of carbon tax and mitigation actions in its activities. The selected model was the Colombian version of MARKAL. On the other hand, a top down modeling approach were used to assess the macroeconomic impacts of such kind of measures. This model is called MEG4C and is based on the GREEN model. An intermediate endogenous growth model –M– was formulated and used in the linking procedure.

The model linking approach proposed here consists on three stages in the following sequence. First, the endogenous growth model –M– provides the CGE –MEG4C– with GDP projections. Second, MEG4C produces sectorial GDP, used as energy demand drivers in MARKAL. Third, MARKAL optimizes the energy sector and provides M with new annual total energy costs. The idea behind the three model approach is that GDP growth is inversely related to the cost of energy: higher energy costs mean less money available for either consumption or investment; this translates into less investment on productive capital and lower GDP growth. In turn, lower GDP growth leads to lower energy demand, and lower energy costs, which raise GDP. Concerning the carbon tax, it is placed in MARKAL. MARKAL total energy cost will raise causing investment and GDP growth to decline in the other models. The recycling mechanism considered was direct transfer to households and this transfer was implemented in model M.

Results

Results with and without recycler mechanism are similar, with a slightly trend to reduce more emissions in absence of the recycle, especially in the last periods. In total, a $50 carbon tax can reduce Colombian energy related cumulative emissions by 33% until 2045; it is up to 10.4% of the emissions in the considered sectors. If a smaller tax is considered, the total abatement is less than 1% of the national emissions for a $10 tax and less than 1.5% for a $20 tax.

Regarding to the limit on the emissions, despite the fact that the total abatement is equivalent, the abatement path is different. In the limit on emissions, the investments and changes are postponed to the last periods. This behavior can be explained by the assumption of decreasing costs of new technologies in time. The responses of the energy sector to the evaluated measures are: increase on the penetration of electric vehicles; increase in the penetration of non conventional renewable sources for the power generation; and, in the case of the industries, there is a small substitution of coal towards natural gas. The remaining final consumption sectors are not able to substitute fuels or to incorporate more efficient technologies since they are already included in the baseline.

Two energy programs were assessed. The first one consisted on a renewable portfolio for power generation. The second evaluated measure in this group was the substitution of fossil fuels in the industry by electricity. The modeled substitution was devoted to fulfill a share of the heat and steam requirements. These programs, in terms of abatement, obtain results comparable with the carbon tax of $20 per CO2 ton. However, the abatement keeps a growing path, while in the tax and in the cap measures the size of the abatement varies between periods. The total abatement of these measures is 0.64% and 1.56% of the emissions in the baseline until 2045 for the renewable portfolio and for the use of electricity in the industry, respectively.

A sensitivity analysis to international price of oil was performed, so there are results for two oil price scenarios.

Regarding to the macroeconomic impacts there are four main ideas concerning the results: first, imposing a carbon tax lowers GDP. In fact, in 2020 GDP decreased with respect to BAU by 0.58% for a USD $10 carbon tax; 0.56%, for a USD $20; 0.77%, for $50. However, we have reasons to consider that this result is biased –it's smaller in magnitude that it should be. One reason is that the model is only taxing the energy sector –which represent a third of total GHG emissions–. The other reason is that we are ignoring the costs of enforcing the tax.

Second, implementing a recycling mechanism can reduce the GDP impact of a carbon tax in the long run. Imposing a $10 carbon tax without recycling reduced GDP by -0.31% and with transfer by -0.25%; a $20, -0.45% and -0.22%; and a $50, -0.79% and -0.36%. This means that the potential side effect of a carbon tax can be reduced by transferring the collected money to the households. Nevertheless, carbon tax with transfer still has a negative effect on GDP, this means "there is no free lunch" in mitigation actions.

Third, GDP reduction due to carbon cap result very similar to carbon tax with transfer to the households. In fact, except for carbon cap 10$ scenario the others differ very little with they counterparts. Yet, our analysis ignores the mechanism of how GHG emissions are allocated. This is, in our model MARKAL works like a central planner allocating resources to minimize cost, but in real life we ignore how emissions will be distributed among people and firms. This, in turn, can rise energy costs, so cost may be underestimated.

Fourth, both the Renewable Portfolio and the Electricity for Industry scenarios had the same negative impact on the economy. Difference in energy costs where very small between both scenarios, so the GDP projection was practically the same –in other words, the difference between GDP growth in both was below our convergence criterion. Table 3 shows that imposing this scenarios led to a reduction in GDP with respect to BAU. This reduction is, in magnitude, very similar to the impact of a $10 carbon tax without recycling, to a $20 carbon tax with recycling and to a $20 carbon cap equivalent.

Conclusions

It was observed that a $50 carbon tax can reduce Colombian energy related cumulative emissions by 33% until 2045. In all the evaluated measures, the mitigation could be obtained from changes in the transportation sector (use of electric vehicles and metro systems) and in the power sector by the increase of non conventional renewable energies as primary sources (geothermal, wind and solar). In this exercise we did not considered the use of nuclear as source for electricity production (during the discussions of the mitigation action for the power sector, this option were rejected). Penetration of electricity in the transportation sector would be part of the least cost energy mix (baseline) if the oil price does not decline from its current level (near 100 US dollars per barrel by mid 2014): it would be too expensive otherwise. Part of the coal used currently in industries might be substituted by natural gas in presence of a carbon tax. With the evaluated measures, there is always a share of the industrial energy requirements that are met by using coal. The energy mix in commerce and households is not likely to change in the presence of the evaluated measures. It was observed that recycling mechanism have not significant results neither in the abatement potential nor in the resulting energy mix. Results are similar among the different taxes with and without recycling mechanisms.

Concerning the results of the model, there are two main conclusions of imposing a carbon tax . First, a carbon tax reduces GDP with respect to the business as usual scenario. The mechanism through which this tax reduces GDP is that as energy cost rise, the economy as a whole will have less money to spend on either consumption or investment, lower investment translates into a smaller capital stock, and less GDP growth. Second, the carbon tax impact on GDP can be reduced by transferring the collected money to the households. Yet, carbon tax with transfers still has a negative effect on GDP. In other words, "there is no free lunch" in mitigating GHG emissions with a carbon tax.