FLEXIBILITY IN PETROLEUM PRODUCT MIX UNDERMINES GREENHOUSE GAS BENEFITS FROM BIOFUEL POLICIES

I. Daniel Posen, University of Toronto, 416-978-6101, daniel.posen@utoronto.ca
Richard J. Pevin, University of California, Berkeley, plevin@berkeley.edu
Inês L. Azevedo, Carnegie Mellon University, iazevedo@cmu.edu
Paulina Jaramillo, Carnegie Mellon University, pjaramil@andrew.cmu.edu
W. Michael Griffin Carnegie Mellon University, wmichaelgriffin@cmu.edu

Overview

Dozens of jurisdictions around the world have implemented policies to reduce oil consumption and greenhouse gas (GHG) emissions by promoting increased use of low-carbon alternatives, like biofuels. A basic assumption underlying many of these transportation fuel policies is that the use of a lower-carbon alternative to, say, gasoline, avoids the use of an equivalent quantity of gasoline. This assumption is embedded in the conventional attributional life cycle assessment approach, which calculates the cradle-to-grave GHG emissions from different fuels and compares the results. In contrast, a growing literature has shown that biofuel policies lead to a variety of consequential, market-mediated effects (e.g., indirect land use change (ILUC) [1] and the indirect fuel use effect (IFUE) [2, 3]) that can undermine desired greenhouse gas (GHG) reductions. This work models the previously unquantified GHG impact that results from petroleum refineries changing their product slate in response to market conditions (petroleum product mix change, PPMC).

Methods

We use a set of dynamic regression models on monthly data for relative yields of different petroleum products from U.S. oil refineries. Gasoline and distillate yields respond to their own and each other's prices, with absolute elasticities ranging from 0.2 to 0.5. We use these estimates in a stochastic partial equilibrium model of the global petroleum fuels market (based on Rajagopal and Plevin, 2013 [4]) to account for how the petroleum product mix changes in response to market prices. The model is a two region depiction of global petroleum and biofuel markets: a home region, calibrated to represent the U.S., and a Rest of World region. Through a set of simultaneous equations, the model compares GHG emissions in a world without any biofuel policy to worlds with three different representative biofuel policies applied within the home region: a 15% biofuel share mandate, a transportation fuel emission standard that requires a 10% reduction in GHG emission intensity, and a \$20/tonne carbon tax. The model uses Monte Carlo simulation to model uncertainty among emissions factors and elasticities of supply and demand.

Results

The model suggests that biofuel share mandates and emission standards induce refiners to shift toward greater distillate production. This shift increases GHG emissions both by increasing the proportion of combusted products from each processed barrel (e.g., more distillate and less asphalt) and through increased upstream (crude oil extraction and refining) emissions, which correlate positively with distillate yields. As a result, share mandates and emission standards can induce a net increase in GHG emissions, making them ineffective strategies for climate mitigation. In contrast, a carbon tax, which suppresses demand for all refined fuels, provides robust emissions reductions.

When considering only process-related life-cycle emissions, the share mandate and emission standard appear to *reduce* GHG emissions by ~50-100 Mt CO2e/year and ~100-300 Mt CO2e/year, respectively. However, when accounting for different market-mediated effects (ILUC, IFUE and PPMC), our model suggests that these policies actually *increase* GHG emissions, by ~50-200 Mt CO2e/year, and ~0-500 Mt CO2e/year, respectively. The carbon tax largely avoids these indirect effects, and reliably reduces emissions by ~50 Mt CO2e/year.

For the share mandate and emission standard, our result suggests that PPMC is responsible for greater GHG emissions than the more classic IFUE and ILUC.

Conclusions

While the simple model presented here cannot give definitive numerical results, it suggests that PPMC strongly increases the likelihood that biofuel share mandates or emission standards result in a net increase in GHG emissions. A carbon tax is the only policy for which the model predicts reliable reductions in GHG emissions, reinforcing existing economic wisdom favoring environmental taxation. Together, the various market-mediated effects (ILUC, IFUE, PPMC) play a critical role in the success or failure of biofuel policies: leaving these out of analyses of policy outcomes can create a false impression of climate change mitigation benefits when the opposite may be occurring.

References

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