SENSITIVITY OF CLIMATE ABATEMENT COSTS ESTIMATES TO TECHNOLOGICAL AND REGIONAL DETAILS: A CASE STUDY OF THE EUROPEAN UNION

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Overview

Model differences in technological and geographical scales are common, but their contributions to uncertainties have not been systematically quantified in the climate policy literature. Computable General Equilibrium (CGE) modeling has been a popular tool for analyzing the economic impacts of national carbon mitigation policies. The modeling approach captures the interactions between supply, demand, prices, labor, capital and trade; and it therefore provides a rigorous and consistent evaluation framework to quantify the socioeconomic impacts of government policies on energy production and consumption as well as other related economic activities. CGE models can help policy makers gain a broad view of the consequences of their decisions. However, results from CGE models vary greatly, and they are sometimes contradictory, even for a common scenario. For instance, five recent studies suggest that for the EU27 countries to achieve a 20% emission reduction target by 2020 from the 1990 level, the carbon price can range from 19 €/tCO2 to 70 €/tCO2 (Bohringer et al., 2009; Durand-Lasserve et al., 2010; Peterson et al., 2011; Bosello et al., 2013; Orecchia and Parrado, 2013). These results indicate that there could be gross domestic product (GDP) gains of around 0.1% or losses of up to 2%.

Great variations in modeling results are not surprising, and numerous modeling comparison efforts have been conducted since the 1970s to explore the underlying factors contributing to the differences and to gain insights. Most of the differences in modelling results can be attributed to differences in (1) modeling mechanisms (e.g. macroeconomic “top-down” model vs. “bottom-up” technology detailed optimization model, (2) the scale and scope of the model (e.g. the boundary and resolution of the analysis), (3) assumptions about baseline scenarios, and (4) assumptions on policy constraints, and market responses. Among these factors, the model differences in technological and geographical details are particularly noticeable. For example, studies examining the 20% emission reduction target by 2020 in EU27 show different levels of sophistication in representing the electrical sector and country-level details. The ICES model (Bosello et al., 2013; Orecchia and Parrado, 2013) has four electricity technologies, including hydro, solar,wind and others,whereas the models used in other studies have only one electricity sector without further technological details. Peterson et al. (2011) considers EU27 as a single economic unit, while the models in other studies account for each major country separately. In our previous modelling exercise for Italy, we find that the estimation for carbon price and the economic cost of a de-carbonization pathway by means of a model with technological and sub-national regional details can be lower than a model without such details by up to 40%. Additionally, the effect of representing regional details appears to be far more important than the effect of representing the details of electricity technology in both the estimated carbon prices and the estimated economic impacts. We also found significant “interaction effects” between regional and technological disaggreagations.

There are many remaining questions in the previous case study that can be more fully explored using the European Union as a case study. Specifically:

- Are our findings for Italy robust when applied to other regions?
- Would regions with smaller/larger regional differences lead to smaller/larger difference in economic costs estimates?
- Does there exist a limit to the impacts of the technological and geographical details on CGE models? For example, does going deeper in the spatial resolution likely result in smaller spatial asymmetries and smaller reductions in economic costs?

In addition, when disaggregating the Italian regions, we have used the same parameterization across the regions to estimate the trade flows. Economic literature and good sense suggest that this parametrization should be more flexible across the sub-national regions. A good example is the flexibility of labor movement. What are the other important parameters that are different across regions and can influence our findings? Using EU case study can reduce the uncertainty in estimating many of the parameters and improve our ability to better validate our results.

Methods

Follow the methods developed in Standardi et al. (2017), this paper carries out a systematic assessment on the sensitivity of CGE models to technological and geographical scales in evaluating the economic impacts of carbon mitigation policies. In particular, we examine the impacts of regional details and technological details of power generation on the estimate of carbon price and economic cost. We have carried out an experiment consisting in achieving a 20% CO_2 emission reduction target in EU27 by a uniform carbon tax. No permits trade takes place between the European countries.

We consider two different levels of technology details:

- The CTAP model considers the electricity sector as characterized by a unique technology. This technology is a Leontief function between power generation and non-fuel intermediates inputs involved in the O&M and distribution activities. Imposing a carbon price will result in a shift toward higher share costs of labor and capital, and less oil, coal and gas, mimicking the transition toward cleaner technologies.
- The CTEM model features disaggregated modeling of the electricity sector into a bundle of 13 generation technologies (Coal, Oil, Gas, Nuclear, Hydro, Wind, Solar, Biomass, Waste, Geothermal, Coal plus CCS, Oil plus CCS, Gas plus CCS).

We use four different geographical aggregations:

- one region, without and with technological details [CTAP-EU1 and CTEM-EU1],
- three regions, North, South and East without and with technological detail [CTAP-EU3 and CTEM-EU3],
- seventeen geographical areas, without and with technological detail [CTAP-EU17 and CTEM-EU17],
- Every country is considered, without and with technological detail [CTAP-EU27 and CTEM-EU27],

Results

In Tables 1 and 2 below we report the results for estimated carbon price and GDP according to the four different aggregations of Europe:

Table 1: Carbon price to achieve a 20% CO2 emission reduction in EU27 and the estimated effects of disaggregating countries and electric technologies

	$ per ton of CO2	Effect of regional disaggregation	Effect of tech disaggregation	Effect of both regional and tech disaggregation
CTAP-EU1	278			
CTEM-EU1	159		-42.81%	
CTAP-EU3	249	-10.43%		
CTEM-EU3	149		-40.2%	-46.4%
CTAP-EU17	231	-16.91%		
CTEM-EU17	144		-37.7%	-48.2%
CTAP-EU27	227	-18.34%		
CTEM-EU27	144		-36.6%	-48.2%

Table 2: Mitigation cost to achieve a 20% CO2 emission reduction in EU27 and the estimated effects of disaggregating regions and electric technologies

	GDP loss (billion 2007US$)	Effect of regional disaggregation	Effect of tech disaggregation	Effect of both regional and tech disaggregation
CTAP-EU1	260.74			
CTEM-EU1	153.03		-41.3%	
CTAP-EU3	237.52	-8.9%		
CTEM-EU3	148.28		-37.6%	-43.1%
CTAP-EU17	220.24	-15.5%		
CTEM-EU17	154.61		-29.8%	-40.7%
CTAP-EU27	219.03	-16.0%		
CTEM-EU27	156.40		-28.6%	-40.0%

These results are consistent with those of the Italian sub-national modeling exercise (Standardi et al., 2017). Comparing the most and the least aggregated models (CTAP-EU1 and CTEM-EU27), GDP losses are around 40% smaller using the model with the most aggregated spatial and technological details.

However, there are also substantial differences with respect to the sub-national specification. In this EU27 experiment the technological details appear to be more important than the geographical details in affecting the estimates of carbon prices and GDP losses. Secondly, the impacts of regional disaggregation diminish as more regions are added. There also seems to be interactive effects between regional and technological disaggreagations: the effects of technological disaggragation becomes smaller as more regions are included. These results are preliminary. More work is needed to fully answer the list of questions proposed the the overview.

References

Standardi, G., Y. Cai and S. Yeh (2017). "Sensitivity of modeling results to technological and regional details: The case of Italy's carbon mitigation policy." Energy Economics **63**: 116-128.

Bohringer, C., Rutherford, T., Tol, R., 2009. The EU 20/20/20 targets: an overview of the EMF22. Energy Econ. 31, 268–273.

Durand-Lasserve, O., Pierreu, A., Smeers, Y., 2010. Uncertain Long-run Emissions Targets, CO2 Price and Global Energy Transition: A General Equilibrium Approach. CORE Discussion Paper No 2010.27, June 2010.

Orecchia, C., Parrado, R., 2013. A Quantitative Assessment of the Implications of Including Non-CO2 Emissions in the European ETS. Working Papers 2013.100. Fondazione EniEnrico Mattei.

Peterson, E.B., Schleich, J., Duscha, V., 2011. Environmental and economic effects of the Copenhagen pledges and more ambitious emission reduction targets. Energy Policy 39, 3697–3708.

Bosello, F., Campagnolo, L., Carraro, C., Eboli, F., Parrado, R., Portale, E., 2013. Macroeconomic Impacts of the EU 30% GHG Mitigation Target. Working Papers 2013.28. Fondazione Eni Enrico Mattei.