Why the wide range of cost estimates for fulfilling the NDC pledges?- A meta-analysis

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Overview

Against the background of the Nationally Determined Contributions (NDC) climate targets, the Energy Modelling Forum (EMF) organized a cross-model comparison study in 2019. The EMF-36 round on the theme 'Climate Policies after Paris' was jointly organized by the Kiel Institute for the World Economy and University of Oldenburg (Böhringer et al. 2020). In this round there was harmonization across models in terms of baselines and policy targets yet models showed large variations in the marginal abatement costs (MACs) that would be needed to achieve the NDC targets in 2030. In this study we use meta-regression analysis (MRA) to identify the extent to which choice of model and policy variables influence the resulting MACs.

in our study we contribute to the meta-analysis literature by considering a new group of Computable Generable Equilibrium (CGE) models, majority of which have not been part of the previous meta-studies . These new generation of models are based on updated databases, apply updated modelling techniques and model new and diverse portfolio of energy technologies. Therefore, our study delivers a key resource in understanding which model and policy characteristics are significant in determining the MACs.

Methods

The database used in this article is based on the results provided by 15 multi-regional CGE models. In the EMF-36 study each model was calibrated to two baselines called – IEO and WEO. These two baselines were created using forecasts of GDP and CO2 emissions from two different projections: World Energy Outlook 2018 (WEO 2018) and International Energy Outlook 2017 (IEO 2017). Next, the ambition levels of the climate policy were calculated based on the initial Nationally Determined Contributions (NDC) that were submitted by countries subsequently after signing the Paris Agreement in 2015. Three ambition targets for emission reduction were defined – NDC, NDC+, NDC2-degree. The NDC target corresponds to the unconditional NDCs, NDC+ to the conditional NDC pledges and NDC-2 degree to the scaled up NDC+ pledges that would be needed to reach the 2-degree temperature goal. Naturally, NDC2-degree is the stricter target, followed by NDC+ and NDC respectively. Details on how these targets were calculated for each model region are described in Böhringer et al. (2021). Finally, five different cooperation scenarios are defined for each ambition level.

- ref: each region reaches its reduction target unilaterally without ETS
- partial: ETS across all regions in EITE and power sectors
- eurchn: ETS between Europe and China in EITE and power sectors
- asia: ETS between China, Japan and South Korea in EITE and power sectors
- global: ETS across all regions and sectors

Each of the five scenarios represent varying degrees of cooperation between regions and sectors. On the one hand, ref represents a stylized scenario of no cooperation while on the other hand global assumes complete cooperation and, the rest of the three scenarios deliver intermediate cooperation.

We estimate the regression using the 450 observations. Since some models might structurally produce higher MACs than others we cluster errors at model level using a robust variance estimator. We include a total of nine independent variables (see Table 1) which are further categorized into model and policy variables.

Table 1: Independent variables with description

Model	Description
region	(log of) total number of regions
energy	(log of) total number of energy sectors
unemp	= 1 if unemployment is characterised, 0 otherwise
dyn	= 1 if model is dynamic, 0 otherwise
endotech	= 1 if model has endogenous technological change, 0 otherwise
eletyp	= 1 if electricity if model differentiated between fossil and renewable (including nuclear) electricity types, 0 otherwise
armel	= 1 if model strictly uses GTAP Armington elasticities, 0 otherwise
Policy	Description
climtarg	Categorical variable for emission reduction targets

	=0 if NDC, =1 if NDC+, =2 if NDC-2degree
coop	Categorical variable for cooperation between regions and sectors =0 if *ref*, =1 if *asia*, =2 if *eurchn*, =3 if *partial*, =4 if *global*

Results

The combination of model variables and policy variables is able to explain about 80% of the variance in MAC. Larger number of regions and differentiation of fossil and renewable electricity in a model increase MAC etstimates. Similarly, a dynamic model increases MAC compared to static and models which strictly use the GTAP-9 armington elasticties produce significantly higher MACs. Decrease in MAC are associated with inclusion of unemployment in models and that of endogenous technological change. As we expect, stricter climate targets increase MACs while only glbal and asia cooperation scenarios provide statistically significant decrease in MACs.

Conclusions

CGE models remain important tools in conducting ex-ante policy analysis and informing policymakers. However, diverging results of the same policy from different models can confound decision makers. Through this study, we shed light on which model characteristics are important and statistically significant determiners of the MAC resulting from CGE models. These results would be of interest to policy makers who often question the robustness of results from CGE models.

Additionally because of the inclusion of policy variables results provide insights into which coaltions lead to statistically significant reductions in global MACs. A completely global coalition between all regions and sectors can reduce global MAC by 45% in 2030. All of the three sub-global coalition decreases the global MAC however only a coalition between China, Japan and South Korea between power and energy intensive sectors has significant reduction in global MAC.

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