The cost of climate change mitigation: uncertainties and metrics matter

Julie Rozenberg, Céline Guivarch

What is the cost of climate mitigation? Economists have been looking for an answer to this overarching question since the discipline started to look into the climate change issue. More broadly, answering this question contributes to finding the right balance between the costs of actions to slow climate change and the benefits of reducing future damages from climate change (Nordhaus, 1992).

But when addressing this issue, one stumbles over the pervasive uncertainties that surround future socio-economic and climate systems. This difficulty was acknowledged since early studies, and the topic has recently received increasing interest (e.g. Haurie et al., 2012), following the recognition that some uncertainties may be irreducible.

On the damages side (and thus mitigation benefits), it has been recognized that the consequences of a given greenhouse gases level in the atmosphere cannot be precisely assessed because of uncertainties on carbon cycle mechanisms, climate sensitivity and climate change damages (e.g. Heal and Millner, 2013).

Here, we propose to explore uncertainties on the mitigation cost side. We adopt a cost-efficiency approach and disregard the uncertainties on the climate system. We open the box of future socio-economic developments and consider uncertainties on factors influencing energy demand, including – in addition to technological uncertainties previously explored in Clarke et al. (2009) – growth drivers (demography and productivity increase), behaviors and lifestyle evolutions and availability of unconventional fuels. We also consider the design of the climate mitigation instrument, and more precisely the recycling of carbon pricing revenues, as an uncertain parameter.

We use an economy-energy-environment (E3) model that endogenizes economic growth and the evolutions in energy demand and represents the links between technical systems, behaviors and economic growth (Waisman et al., 2012). We build a large number of scenarios (432) to explore the uncertain parameters that determine these links and assess mitigation costs across this database.

We first focus on the two most commonly reported cost metrics: the carbon price and the GDP losses between a policy scenario and the corresponding baseline, i.e. scenario with no climate policy. The IPCC chose to present the evaluations of GDP losses in its last report summary for policy makers (IPCC, 2007) while carbon prices are prominent in other studies (e.g. Rogelj et al., 2013) and policy debates.

Both metrics are policy-relevant: the carbon price directly influences firms production costs and investment choices, and it is important for households whose budget might be constrained by their energy bill; GDP losses indicate the overall macroeconomic implications of the policy. These metrics are however conceptually different (Paltsev and Capros, 2013): the carbon price measures the marginal abatement cost, whereas the GDP losses measure the macroeconomic cost of the policy. Yet, in cost assessments, the choice of the metric is sometimes constrained by the model (e.g. partial equilibrium models cannot assess GDP losses and thus focus on carbon prices or technical costs), and results often focus on a single metric, such that it is impossible to quantitatively appreciate the links and differences between the two metrics.

We bridge this gap here, and quantitatively explore the links between the carbon price and macroeconomic losses across a large number of scenarios.

We show that socioeconomic uncertainties in one E3-model are large enough to generate wide range of cost estimates for different metrics. We also show that across our large number of scenarios, the different metrics commonly used to evaluate the performance of a climate mitigation policy are not good proxies for one another: they are not necessarily correlated nor share the same drivers.

We identify two theoretical results from the double dividend literature (Goulder, 1995; Bovenberg, 1999), and show they are quantitatively significant: the recycling of carbon tax revenues through a reduction of pre-existing distortive taxes reduces the macroeconomic cost of the climate policy, but increases the carbon tax.

We also show that the way carbon tax revenues are recycled modifies the correlation between the macroeconomic cost and the carbon tax, as well as the costs drivers. If tax revenues are transfered to households, the macroeconomic cost and the tax are strongly correlated and both cost metrics strongly depend on the availability of low carbon technologies. Conversely, when the carbon tax revenues are used to reduce pre-existing taxes, the two metrics are very weakly correlated and macroeconomic losses no longer depend on technologies. Instead, they depend on the availability of unconventional fossil fuels, which increase per-capita GDP in baseline scenarios.

In a second step, acknowledging that GDP losses are not a suitable cost metric in a cost-efficiency framework in which the baseline GDP varies due to the socio-economic uncertainties considered, we analyze the results in terms of absolute GDP per capita in the policy scenarios. We show that this new metric and GDP losses are not good proxies for one another: they are weakly correlated and do not share the same drivers.

Furthermore, the analysis of the discriminating drivers of absolute GDP per capita in policy scenarios highlights two drivers that would not stand out if the focus was only on the macroeconomic cost: energy efficiency and consumption behaviors. The importance of behaviors and energy efficiency for the cost-efficiency of mitigation policies is a remarkable result, given that most mitigation studies focus on technologies and policy design, and disregard the uncertainty surrounding future consumption behaviors.

The framing of the problem therefore matters: (i) socio-economic uncertainties are important for the evaluation of mitigation costs, and (ii) the cost metric used changes the results. If an answer to the 'what is the cost?' question is out of reach, owing to irreducible uncertainties and multiple cost measures, we show that our approach can give insights to the reframed questions 'what drives the costs?', 'what policy design can reduce the costs?' and 'where are the trade-offs?'.

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