Online-only Literature Review for:

Policy Brief – Recommendations for Improving the Treatment of Risk and Uncertainty in Economic Estimates of Climate Impacts in the Sixth IPCC Assessment Report

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Our text points to some limitations of current climate-economy integrated assessment models (IAMs), citing Stern (2016). Many others have pointed to further limitations, including, in rough chronological order: Stern (2013), Pindyck (2013), Wagner and Weitzman (2015), Burke et al. (2016), Millner and McDermott (2016), and Rose et al. (2017). Traditional IAMs rely on numerical solutions. A new class of analytically tractable climate economy models has since emerged that has enabled researchers to calculate analytical carbon pricing rules (e.g. Hassler and Krusell 2012, Golosov et al. 2014).

Large discrepancies between scientific and economic assessments of climate impacts arise for three main reasons: First, the damage function in the Dynamic Integrated Climate-Economy (DICE) model is still calibrated to fit a quadratic functional form first established in Nordhaus (1992). In doing so, the DICE model's damage function relies on a small number of early model-based estimates for the relationship between temperature and economic output (Nordhaus and Sztorc 2013). See the surveys in Nordhaus and Moffat (2017), and earlier in Tol (2009, 2014), as well as Ward (2014a, 2014b). Also see Tol (2018) for a recent survey of some of the literature taking many IAM outputs at face value. Ward (2018), in turn, offers a direct response. See, e.g., Heal (2017) for a more critical take on IAMs. Rose et al (2017) and Howard and Sterner (2017) analyze damage estimates used in current IAMs.

Second, economists have focused their attention on those physical impacts that are more certain, more important in the short run, and, thus, more easily modeled. As a result, the three most widely used IAMs — DICE, the Climate Framework for Uncertainty, Negotiation and Distribution (FUND), and Policy Analysis of the Greenhouse Effect (PAGE) — have mostly abstracted from tipping points in the climate system in their economic assessment. The FUND model has been used to explore the collapse of the West Antarctic ice sheet and the shutdown of the thermohaline circulation (Nicholls et al. 2008, Link and Tol 2011), although these tipping points are not always included in estimates of global economic impacts of climate change. DICE includes a blanket 25% damage increase to account for omitted damage categories such as tipping points (Nordhaus 2017). None of these adjustments, however, has fundamentally altered the predictive power beyond a range of around 3°C. (For lists of potential 'tipping points' considered, see Lenton et al. 2008, Smith et al. 2009, Lenton and Ciscar 2013, Nordhaus 2013, Ciscar et al. 2014, IPCC 2014, Nordhaus 2014, and Kopp et al. 2016.)

Third, the models assume that the growth in economic output is exogenous and positive, and that the damage caused by climate change does not affect the drivers of growth.

A further serious shortcoming of these models is that they fail to take account of broader socio-economic risks not necessarily linked to physical tipping points but amounting to societal ones (e.g., Kopp et al 2016). One example is migration of populations to escape the worst potential impacts of climate change, triggered by increases in the frequency and intensity of extreme weather events.

Estimates of the costs of ‘tipping points’ abound. Whiteman et al. (2013) find that the economic impacts of warming the Arctic ice shelf, and the associated release of methane from the thawing of permafrost beneath the East Siberian Sea alone could lead to damages as large as current global economic output. Kessler (2017) studies the permafrost carbon feedback in DICE and finds that inclusion of this tipping point increases the optimal CO_2 price by between 10 to 220%, depending on the damage function used. Ceronsky et al. (2011) show that incorporating events of low probability and high impact such as a large-scale dissociation of oceanic methane hydrates into the FUND model can increase the modeled CO_2 price by a factor of three. Lemoine and Traeger (2014) take the analysis one step further in considering multiple tipping points in a climate-economy model. They find that optimal climate policy should be more stringent with a warming of 0.5°C below usual goals. More generally, Hof et al. (2012) argue that adequate modelling of dynamic effects increases the benefits of mitigation. In this spirit, Irwin et al. (2016) and Kopp et al. (2016) call for a consideration of potential tipping points for a comprehensive assessment of optimal climate policy. This literature is informative about the general direction of the omissions in the economic climate impact assessment. It shows that physical discontinuities translate into additional economic damages. These damage estimates span enormous ranges, however, and neither are many tipping points nor their interactions sufficiently captured by economic modelling.

All in all, the current literature agrees that pricing uncertainty in climate economics means more stringent climate policy, a point further made by Cai et al. (2015), Jensen and Traeger (2014), and Lontzek et al. (2015). Hjort (2016) is more cautious, arguing that the implications of climate risk for financial markets are not yet sufficiently clear, partly due to wide disagreements among scholars on the probabilities of massive damage (Calel, Stainforth & Dietz. 2015, Millner, Calel, Stainforth & MacKerron, 2012). We would argue that it is precisely these disagreements that ought to be reflected in climate risk estimates.

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