Searching for the weak spot – A comprehensive investigation of climate change and macroeconomic growth

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Motivation

A central gap in the latest Fifth Assessment Report of the International Panel on Climate Change is a quantification of the benefits of different mitigation pathways as well as remaining damages at a given level of global warming. This is due to the lack of plausible estimates of the economic damages. The largest economic effects would be expected if climate change affects long-term economic growth. Such links between climate conditions and economic indicators are increasingly established in the empirical literature (e.g. Dell et al. 2014, Burke et al. 2015). However the traditional aggregate damage function approach used to model economic impacts of climate change, which only affects output, is not suited to study these effects. Instead, impacts on the individual drivers of growth need to be assessed (Figure 1). While a number of recent papers investigate pieces of the puzzle (e.g. Moore & Diaz 2015, Dietz & Stern 2015, Weisbach et al. 2013, Fankhauser & Tol 2005), we are conducting a systematic and comprehensive investigation of the effects with the goal to directly link individual damage channels to corresponding impact sectors.

Approach

We use the integrated assessment model DIceans (Nordhaus 2013) and explore damages on all components of its standard Cobb-Douglas production function: damage on the capital stock K, on labour L, on total factor productivity TFP and on output Y (the standard channel). By treating damages as individual shocks we can calibrate them to ensure comparability between the different damage channels – a prerequisite for understanding the importance of the different channels. In addition, we investigate how capital adjustment costs and endogenous growth affect the magnitude of the resulting damages.

Single shock experiments

For a first impression of the effects of the different damage channels we apply a single shock of a 15% GDP loss in 2050 in all channels (Figure 2, solid lines). While there are dynamic long-term effects beyond the direct shock in all channels, there are large differences in their strength. It is largest for the labour and TFP shocks. Contrary to capital, their growth is exogenous, preventing fast recovery. The dashed lines show the results where TFP growth is endogenous, driven by investment (following Dietz & Stern 2015: A_t = (1 - δ) A_{t-1} + β(ΔG) where β,γ are constants). Endogenous growth increases long-term damage effects as a reduced output translates into reduced investments, now affecting TFP directly.

Continuous damages

We now apply the standard DICE damage function specified as \( Q = 0.00267T^2 \) in the various damage channels. The damage acting at a given time step is still treated as a shock and therefore comparable across the channels, but now damages accumulate over time (Figure 3). This leads to significant effects in particular in the labour and TFP channels. Interestingly, an exogenous, fixed savings rate (dashed lines) reduces damages, even though often it is argued that an adjustment in savings behaviour in response to damages is an adaptation mechanism. The explanation is found in a strong initial reduction in the investment share when saving is endogenous. This reflects an attempt to increase present-day consumption in the face of large expected future losses. Later on this is reversed, with TFP channel investment shares even above the baseline case, leading to similar long-term damages as with a fixed savings rate. As in the single shock case, endogenous growth increases damages (Figure 4). Capital adjustment costs turned out to only be a baseline effect.

Conclusions and outlook

While GDP growth rates are negatively affected by the damages in all channels, only TFP damages lead to a reversal of long-term growth. Of course, the whole aggregate damage function would never act through only one channel. Therefore, we plan to use the shock approach to establish direct links to empirically derived sectoral damages acting through the different channels, e.g. hurricanes on capital assets. Furthermore, we plan to extend our model by using a CES production function with factor-specific, endogenous productivity growth. This could result in competition for investment, leading to effects on factor income shares.

References