Climate-economy feedbacks under growth, low-growth, and no-growth scenarios

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Human economic activity over the last 200 years has brought fundamental changes to the complex relationship between humans and climate. For most part of human history, this relationship was dominated by an influence of climate on the developpment of human societies, while human activity affected climate only on local scale. Economic growth and the burning of fossil fuels, however, extended the influence of human activity on climate to the global scale, and projected climate change will most likely lead to severe global economic and social consequences.

Despite intensive research over the last decades, there is little agreement among economists about the optimal strategy of dealing with climate change. Much of this disagreement is rooted in uncertainty about the incorporation of climate change in economic models, in particular uncertainty concerning the formulation of a social welfare function and the representation of the effects of climate change on economy and society [6, 4]. Different ways to cope with this uncertainty cause the respective recommendations to range from an immediate stop of all emissions [9] to comparably low mitigation measures [3, 5].

While most climate economists agree on the objective of sustainable or green economic growth, more fundamental transformations have recently once more come into focus [7, 1]. Economic models of scenarios of non-growing economies could indeed show how such transformations might work [8]. Yet also under low- or non-growth scenarios, many of the uncertainties concerning the economic modeling of climate change remain.

In this work we use conceptual mathematical models to explore the role of feedbacks in the coupled climate-economy system under different economic scenarios. These feedbacks are usually modeled as a reduction of economic production proportional to the increase of temperature [6]. Assumptions about the strength of the feedbacks range from a linear [2], quadratic [3] to even an exponential [9] relationship between the reduction of economic production and an increase in global mean temperature.

We combine different representations of the climate-economy feedback with three scenarios for the global economy: unconstrained background economic growth with slow decoupling of economic production from carbon emissions, economic growth with competition between a high-carbon-intensive and a low-carbon-intensive economy, and the transition to a steady-state economy with a final globally equal distribution of economic production.

For the high growth scenario we apply the model of Kellie-Smith and Cox (2011) [2]. This model embraces three variables, economic production represented by CO_2 emissions, atmospheric concentration of greenhouse gases, and global mean temperature. In this model, exogeneous economic growth increases economic production, which produces carbon emissions that lead to an increase of global mean temperature. An increase of global mean temperature in turn reduces economic growth. This closed feedback loop allows for possible oscillatory behaviour. Results from this simple conceptual

model show that potentially devastating oscillations can be avoided by either a sufficiently low carbon intensity of production or a sufficiently low background economic growth [2].

The model of the low growth scenario divides the economy into two parts that differ with respect to their carbon intensity and background economic growth. Depending on the economic success of the two parts, their fraction of the global economy dynamically changes. Different policies such as subsidies and constant and increasing carbon tax rates are evaluated with respect to their effect on which of the two economic strategies prevails.

Under the no-growth scenario, the global economy is split up into a rich and a poorer part. Both parts of the economy are constrained by the same fixed maximal level of economic production, but differ in model parameters such as initial consumption rate, carbon intensity of consumption, and background economic growth. By simulating the transition to a global equal level of production we explore the implications on climate of such transition, how it is affected by different representations of the climate-economy feedback, and under which conditions such transition might keep climate change within acceptable limits.

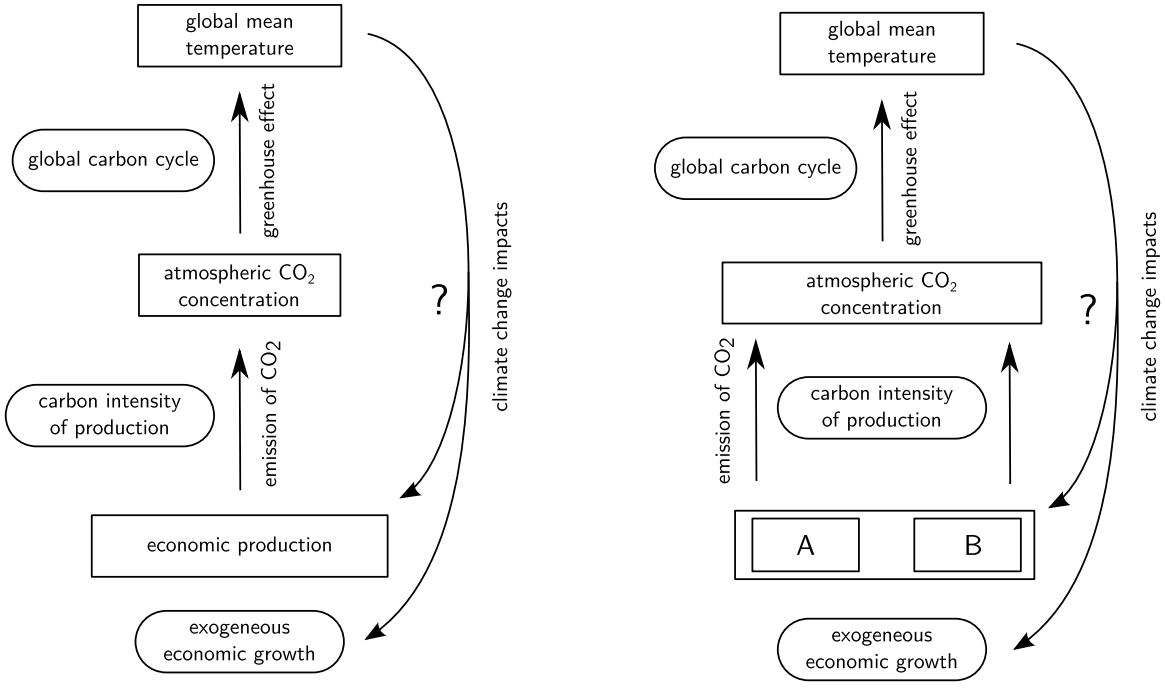

Figure 1: Conceptual models of climate-economy feedbacks; while in (left) a globally homogeneous economy is assumed, (right) divides the economy (A, B) in either its rich and poor (and hence at some point not-growing/growing) parts

Although the urgent need to reduce global carbon emissions is widely acknowledged, climate change mitigation policies have been predominantly uneffective to date. As the implementation of efficient climate policies endangers short-term economic growth, it seems unclear how this might change in the near future. Transformations to low- or non-growing economies show a way out of this dilemma, while at the same time providing the fundament of a long-term sustainable future. Yet economic models of such scenarios only sparsely exist, and their application to the climate problem faces the same uncertainties as growth-based economic models. In this work, we use conceptual mathematical models

to explore the consequences of different representations of climate-economy feedbacks under growth, low-growth and no-growth economic scenarios. This allows not only for a better understanding of the feedbacks between climate and human economic activity, but also provides valuable contributions to research on how the transition to a social and ecological economy might be achieved.

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