The Coalition of Finance Ministers for Climate Action

Climate tipping points

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Climate tipping points

The term "climate tipping point" refers to the likes of Amazon dieback, shutdown (or slowdown) of the Atlantic Meridional Overturning Circulation (AMOC), thaw of boreal permafrost, or acceleration in the disintegration of ice sheets. The concept of a climate tipping point encapsulates two essential aspects of current understanding of climate change. First, it might well not be a steady process but rather could involve relatively sudden and substantial changes. Second, such changes might be irreversible on timescales relevant to human societies (i.e., hundreds to thousands of years).

These aspects are counter to widely held perceptions about the threats posed by climate change: that they are gradual (even if that means a gradual increase in extreme events) and potentially reversible (for instance through carbon dioxide removal technologies). An awareness of tipping points is of significance to Ministries of Finance for two reasons. First, they substantially affect how countries should think about the risks of climate change and thus the value they place on decarbonization and resilience building. Second, they alter how countries go about the process of their adapting societies to be resilient to the climate of the future and thus maintain geopolitical and economic stability.

Tipping points have the potential to cause huge economic shocks. Direct regional consequences could lead to cascading impacts around the world through trade, migration, and conflict. They may be expected to affect global gross domestic product, wealth distribution within and across nations, and, of course, revenue and tax. Getting a handle on the likelihood of such events, and a picture of the potential outcomes, requires an acknowledgement of the complexity of the physical climate system and how it interacts with our societies and economies.

State of research

Predicting the likelihood and/or timing of crossing a tipping point under any particular scenario for global climate policies is hampered by the fundamental characteristics of human-induced climate change—specifically, the nonlinear connections between different aspects of the climate system and the fact that the system is being driven into a state it is has never been in before; i.e., the problem is extrapolatory (Stainforth, 2023a). As a consequence, scientists may have robust information that certain tipping points are plausible (maybe even expected) under particular scenarios for emissions but are unlikely to have the probabilities of occurrence that are sought by those modeling the economy. There is a thus a significant need to bring economic modelers and physical scientists together to ensure effective use of robust knowledge on climate change but without overinterpreting data (both observational and model-based). New approaches to economic assessments are needed if a good understanding of the risks related to physical climate tipping points is to be captured.

It is useful to consider research on climate tipping points in three domains: (i) information about the likelihood of crossing a tipping point, (ii) information about the consequences of crossing a tipping point, and (iii) early warning systems (EWS) that tell us how close the planet is to a tipping point.

Scientists' understanding of all three is dominated by research using global climate models (GCMs) and Earth system models (ESMs). These are highly complex and computationally demanding models; they are usually run on supercomputers. There are calls for tens of billions of dollars to be invested in new hardware to run high-resolution versions of these models (Tollefson, 2023). Proponents of this approach argue that this will provide more reliable and detailed climate predictions, but there are foundational issues that undermine such claims (Stainforth, 2023a). Indeed, in the climate science community there are growing debates over how to interpret these models in relation to future climate, with many doubting the value of investing in increasing model resolution (Stainforth, 2023b; Stainforth and Calel 2020).

It is clear that tipping points are of substantial importance for economic planning, but the limited state of today's scientific understanding in this field means that economic assessments also face conceptual and deep uncertainties. The challenge is therefore to develop economic approaches that use our robust scientific understanding without over-interpreting the latest model and observational results. There is a small but growing community of researchers tackling this issue (Hazeleger et al., 2015; Shepherd, et al., 2018; Shepherd, 2019; Dessai et al., 2018). A number of ways forward exist, ranging from physically based storylines (Hazeleger et al., 2015; Shepherd, et al., 2018; Shepherd, 2019; Dessai et al., 2018) to various approaches in the field of decision-making under deep uncertainty, to new proposals for the exploration of model uncertainty (Stainforth, 2023a; Stainforth et al., 2007a, b).

Relevance to Ministries of Finance

It is important to embed robust assessments of the latest understanding of climate tipping points into economic strategy and policy because they could have a first-order effect on the impacts of climate change on national output and welfare. They impact both the character and spatial pattern of the changes that should be expected and the timing and rate at which these changes may occur. It is also critical, however, to fully allow for the current, best understanding of the uncertainties in these factors; knowledge of uncertainty is part of knowledge about climate change (Stainforth, 2023a) and the gap between science and economics needs to be more effectively connected.

The barriers to making these assessments arise from the need to bring together mathematical understanding of complex and chaotic systems with the latest philosophical understanding of how to relate models to reality when dealing with extrapolatory, nonstationary situations such as climate change. This needs to be done within the context of the current understanding of climate physics, computational methods, AI, economics, and so on.

Ways forward

The lack of connections within academia means that the economic sciences are not effectively integrating either the relevant, robust understanding in the physical and mathematical sciences, or the differing opinions and perspectives that represent the state of research today. There is an urgent need to acknowledge uncertainties and ambiguities better while integrating what is known confidently, if imprecisely, about the threats and risks. MoFs perhaps need to approach climate tipping points from a horizon-scanning perspective. Economic modeling needs to be faced with the ambiguities in the physical science and seek out the robust messages across the combined economic/social/physical system.

What is missing in the academic study of tipping points is twofold. First, it lacks a big picture analysis of the risks and physical consequences of crossing climate tipping points that allows for diverse academic perspectives on the uncertainties and conditionalities. Crucially, this must involve stepping back to question how to interpret model-based information for both predictions and uncertainty quantification. Second, it lacks a similar big-picture, questioning analysis of the economic assessments of tipping points and the consequences for the global and national economies. These two tasks are inextricably intertwined.

MoFs need to be deeply engaged with this analytical process. Indeed, they should drive it, because climate tipping points have the potential to fundamentally affect both the scale of the financial impacts of climate change and the distribution of those impacts. The consequences of crossing a climate tipping point could substantially affect, for instance, global food supply, or undermine the billions currently being invested in climate adaptation and resilience building. A better and more robust assessment of current knowledge about tipping points, and potential future climate in general, could a) help anticipate and prepare for global trade shocks, and b) ensure that the huge investments in climate adaptation and new infrastructure to respond to the climate crisis are made in the context of the best possible understanding of the risks they will face in the future. At the moment this is not the case. A significant new initiative is required.

A note on the term “tipping point”

The concept behind a climate tipping point is that once a threshold is crossed, the onset of climate change processes may be inevitable. One must be careful, however, when considering this idea of a threshold. Once a certain amount of the Amazon is gone, or the AMOC is reduced by a certain amount, it may become inevitable that the reduction will continue. However, this threshold is not necessarily in global temperature or atmospheric greenhouse gas concentrations. For instance, above a certain global temperature it may be inevitable that the Greenland ice sheet will ultimately disintegrate, but if the temperature is only temporarily above the threshold and is subsequently brought down, then this disintegration may be prevented. There is thus a strong link between consideration of tipping points and discussions of overshoot scenarios and the arguments for carbon dioxide removal (CDR). This is quite different to the Amazon example, where once a certain fraction is lost it may be inevitable that the rest will go. The idea of a threshold is real, but it cannot necessarily be simply mapped onto a global warming level, as might be expected given the high profile that "guardrails" such as 1.5°C and 2.0°C receive.

Further reading

ClimTIP project: https://www.climate-tipping-points.eu/

Institute and Faculty of Actuaries (2023) *Climate Scorpion Report*

Lenton, T. et al. (2023) *The Global Tipping Points Report,* University of Exeter, Exeter, UK.

TIPMIP project: https://tipmip.pik-potsdam.de/

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