Economic impacts of tipping points in the climate system

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Economics View of Tipping Points, 28 November 2023
A tipping point (TP) is “a critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly”

Abrupt climate change is “change in the climate system that takes place over a few decades or less, persists...for at least a few decades and causes substantial impacts in human and/or natural systems”

TPs “may involve global or regional climate changes from one stable state to another...or to changes that occur faster than the rate of change of forcing...and include shifts from one equilibrium state to another and other responses of the climate system to external forcing”
Tipping elements/points in the climate system

Source: Armstrong McKay et al. (2022)
TPs are a *heterogeneous* class of phenomena that includes non-linear feedbacks and both reversible and irreversible phase changes.

This heterogeneity makes it challenging to incorporate climate TPs in economic models.

In popular discourse, TPs are identified with abrupt change on economic timescales (think “The Tipping Point” by Malcolm Gladwell), and some work in economics reflects this.

Crossing climate TPs may lead to abrupt changes on economic timescales, or not – it largely depends on the TP.
In our 2021 paper, we reviewed the climate economics literature in relation to TPs. We found that:

- Most studies either ignored climate TPs or had very indirect/partial coverage
- But we found 52 papers that explicitly modelled the economic consequences of at least one climate TP
- Most of these studies represented climate TPs in a highly stylised way, many by associating crossing a climate TP with an economic catastrophe/disaster
A good example of a stylised tipping process leading to an economic catastrophe

Source: Lontzek et al. (2015)
Climate tipping points in economics

We also found 21 studies based on geophysical foundations, i.e., with at least a reduced-form representation of the key underlying geophysical relationship(s) that govern the TP.

For example, Nordhaus (PNAS, 2019) built a reduced-form model of melting of the Greenland Ice Sheet, which can be meaningfully calibrated on ice sheet modelling results and then coupled to DICE.
The studies with geophysical foundations are fragmented – each takes an individual TP and employs a particular IAM with its idiosyncratic structure.

We sought to produce unified estimates of the economic impacts of climate TPs, synthesising studies that are geophysically realistic, using a ‘meta-analytic’ IAM.
## Tipping models replicated and synthesised

| Tipping point                                      | Papers                                          | IAM    | Model of TP   |
|----------------------------------------------------|-------------------------------------------------|--------|---------------|
| 1) Permafrost carbon feedback                      | Kessler (2017, *Clim. Chge. Econ.*)             | DICE   | Process-based |
|                                                    | Hope & Schaefer (2016, *Nat. Clim. Chge.*)      | PAGE09 | Process-based |
|                                                    | Yumashev et al. (2019, *Nat. Comms.*)           | PAGE-ICE| Process-based |
| 2) Ocean methane hydrates                          | Ceronsky et al. (2011, unpublished)             | FUND   | Tipping event |
|                                                    | Whiteman et al. (2013, *Nature*)                | PAGE09 | Tipping event |
| 3) Arctic Sea Ice/Surface Albedo Feedback          | Yumashev et al. (2019, *Nat. Comms.*)           | PAGE-ICE| Process-based |
| 4) Amazon dieback                                  | Cai et al. (2016, *Nat. Clim. Chge.*)           | DSICE  | Tipping event |
| 5) Greenland Ice Sheet disintegration              | Nordhaus (2019, *PNAS*)                         | DICE   | Process-based |
| 6) West Antarctic Ice Sheet disintegration         | Diaz and Keller (2016, *AER P&P*)              | DICE   | Tipping event |
| 7) Atlantic Meridional Overturning Circulation slowdown | Anthoff et al. (2016, *AER P&P*)              | FUND   | Tipping event |
| 8) India summer monsoon variability                | Belaia (2017, unpublished), based on Schewe and Levermann (2012, *ERL*) | RICE | Process-based |
Tipping points increase the social cost of carbon

Best estimate: +25%
95% C.I. = -0.3 to +186%
0.1 probability of doubling
0.02 probability of tripling

Dietz, Rising, Stoerk, Wagner, *PNAS*, (2021)
Tipping points add to global consumption risk

Dietz, Rising, Stoerk, Wagner, *PNAS*, (2021)
Tipping points increase climate damages almost everywhere

Dietz, Rising, Stoerk, Wagner, *PNAS*, (2021)
Concluding thoughts

Climate TPs are a serious reason for concern and increase the (already solid) case for limiting global warming to a low level, particularly if we conceptualise the uncertainties as deep/Knightian.

The numbers I presented are probable underestimates because, e.g., some TPs are missing and some climate impacts are missing from TPs that are included. It’s best to see this as work in progress and be careful in drawing too many conclusions.

But as we move beyond thinking about TPs as generic catastrophes in our models, we could open out a set of decision-useful insights for adaptation and economic policy.
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