

Science-based damage functions for economists

Introduction

Carbon Tracker published Professor Keen's report [Loading the DICE against pensions](#) (Keen 2023) in July 2023. Since then, Carbon Tracker has presented the report to the UK's *Prudential Regulation Authority*, who were very supportive. It has been cited in the UK Parliament, and discussed at the EU. The online website [Intercept](#) published a very hard-hitting story based on the report on Thursday October 19th 2023. Professor Keen spoke to the report at the European Central Bank on November 7th 2023, and will speak to investors at *Jefferies Bank Climate Day* on January 24th, 2024.

Carbon Tracker's report was cited by an *Institute and Faculty of Actuaries* report entitled [The Emperor's New Climate Scenarios: Limitations and assumptions of commonly used climate-change scenarios in financial services](#), which was co-authored by the climate scientist Professor Tim Lenton of Exeter University (Trust, Joshi, Lenton, and Oliver 2023). Lenton proposed a way that Keen's innovation of fitting a logistic damage function to [NOAA's Billion Dollar Damages](#) database could be extended to create a science-based damage function to replace the ones made up by economists. What follows is their joint research proposal. Given the significance of the issue, this project needs funding to enable it to be completed as soon as possible.

Funders of this project thus have an opportunity to be on the right side of history, and as well, could experience a first mover advantage that goes with such a strategy, prior to the release of the refereed academic papers that this research will generate.

The Problem

The economic analysis of climate change has been dominated by damage functions, which map expected levels of global warming to reductions in expected future levels of GWP (Gross World Product). Economists have developed their own empirical methods to calibrate these functions, and this has resulted in the consensus—as shown by [a survey of 738 economists](#) who have published in leading economics journals—that a trajectory towards 7°C of warming in 2 century's time will reduce GWP in 2220 by 20%, compared to what GWP would have been in the absence of global warming (Howard and Sylvan 2021, Figure 11, p. 23).

When estimated damages to future GWP are translated into a rate of annual economic growth, a 20% decline in GWP in 2220 means a fall in the annual rate of economic growth for the next two centuries of a mere 0.02% per annum. This is 1/5th of the accuracy with which economic growth is measured today, which implies that global warming will have imperceptible impact on human welfare, even out to 7°C of warming. This attitude is confirmed by the economics chapter of the IPCC 2014 report, which declared that:

For most economic sectors, the impact of climate change will be small relative to the impacts of other drivers (*medium evidence, high agreement*). Changes in population, age, income, technology, relative prices, lifestyle, regulation, governance, and many other aspects of socioeconomic development will have an impact on the supply and demand of economic goods and services that is large relative to the impact of climate change. (IPCC et al. 2014, p. 662)

Similarly, the 2022 IPCC report's economics chapter asserted that “warming of ~4°C may cause a 10–23% decline in annual global GDP by 2100 relative to global GDP without warming”, which implies a fall in the annual rate of economic growth of between 0.1% and 0.3% per annum. This is between a

20th and a 50th of the impact that the Global Financial Crisis had on annual economic growth between 2007 and 2010.

This economic consensus of trivial damages from substantial global warming cannot be reconciled with the scientific literature on climate change, where, for example, Xu and Ramanathan have described 3°C of warming as “catastrophic” and 5°C or more of warming as “implying beyond catastrophic, including existential threats” (Xu and Ramanathan 2017, p. 10315). But policymakers, the media, and most economic consultants are unaware of this “huge gulf between natural scientists’ understanding of climate tipping points and economists’ representations of climate catastrophes” (Lenton and Ciscar 2013, p. 585). Instead, they appear to treat the estimates by economists as if they were simply a translation of the physical dangers expected by scientists into the economic measure of changes to GWP.

This is far from the case. Instead, economists have calibrated their damage functions using approaches that betray a fundamental misunderstanding of what global warming is (Keen 2023, 2020; Trust, Joshi, Lenton, and Oliver 2023; Lenton et al. 2023; Keen et al. 2022). We are very confident that, had the empirical methods used by economists been refereed by scientists, then *not one* of the 39 key papers from which all “economics of climate change” papers and “Integrated Assessment Models” (IAMs) have been derived (Tol 2022, Table 1, pp. 19-20) would have been published.

Unfortunately, this did not happen, so that trivial and manifestly erroneous estimates of the economic damages from global warming have become the foundation of how the dangers of climate change have been assessed for both policy formation and portfolio allocation.

We cannot turn back time and prevent these papers—or their modelling offspring of IAMs—from being created. We have to accept that climate change policy will be dominated by economic damage functions. But we can produce science-based damage estimates that can displace the deluded estimates made up by economists, so that IAMs will instead generate estimates of damages to GWP that are based on scientific knowledge, rather than economic fantasy.

The Proposal

In his report for Carbon Tracker, Keen showed the impact of extrapolating current climate change damages forward using a logistic function, rather than the quadratic function that is the default in economic IAMs (Keen and Hanley 2023, pp. 37-46; Keen 2023, pp. 36-40). Lenton developed this idea further in *The Emperor’s New Climate Scenarios* (Trust, Joshi, Lenton, and Oliver 2023), suggesting that:

A practical fix may be to ‘invert’ scenario analysis and use a reverse stress test approach, as used in financial services risk management. This would start with what we want to avoid, then work backwards from there. (Trust, Joshi, Lenton, and Oliver 2023, p. 24)

These ideas have been combined by Keen and Lenton into a method for developing damage functions using the wisdom of scientists, rather than the delusions of economists.

Lenton and Keen will replicate the Howard and Sylvan survey, but with scientists who have published climate change papers in the top 25 science journals. The scientists would be surveyed on the temperature level they believe would lead to the complete collapse of humanity’s agricultural and industrial systems.

A logistic function will be used to back cast from the scientific consensus—which we expect to lie in the range of 3-5°C. A high-order polynomial damage function will be derived from this function, and this would be used in place of the normally quadratic damage functions currently used by economists

(this is necessitated by the fact that the programs economists use to simulate economic damages—such as GAMS, in which Nordhaus’s DICE model is estimated—cannot handle logistic functions).

This on its own is not enough however: economists could ignore this function, as they have ignored past criticisms, and they could continue using their own erroneous damage estimates. *These papers need to be removed from academic literature.* We will do *ex-post* what should have been done *ex-ante*: scientists will referee the strictly climate-change aspects of economic papers on economic damages from global warming. If this refereeing process recommends that these papers should not have been published, then we will contact the relevant journals to insist that the publication of these papers be rescinded.

Even if these economic journals so not comply with that request, any consultant or body with fiduciary responsibilities will arguably be in breach of those duties if they continue using damage functions based on the work of economists.

The Team

Professor Keen is a Distinguished Research Fellow at University College London. Professor Lenton holds the Chair in Climate Change at the University of Exeter.

Keen and Lenton are uniquely qualified to undertake this proposal.

Keen has been a long-standing critic of mainstream economics, and is a leading developer of an alternative paradigm—see his popular books *Debunking Economics* (Keen 2011) and *The New Economics: A Manifesto* (Keen 2021). He is recognized as one of the 20 most influential economists in the world today by the Academic Influence website (see [Top Influential Economists Today | Academic Influence](#)).

There have been many critics of the work by economists on climate change (Ackerman and Munitz 2012; Ackerman and Stanton 2008; Ackerman, Stanton, and Bueno 2010; Aldred 2012; Auffhammer 2018; Auffhammer, Hsiang, Schlenker, and Sobel 2013; Cline 1992; Darwin 1999; DeCanio 2003; Howard and Sterner 2017; Pindyck 2013, 2017; Stern 2022; Stern, Stiglitz, and Taylor 2022). Remarkably however, *none* of these papers criticised the absurd empirical assumptions that “climate change economists” have made.

This may reflect the mainstream economic attitude that “assumptions don’t matter” (Friedman 1953). However that belief applies, if at all, only to “simplifying assumptions”. In contrast, these manifestly false assumptions are critical to the conclusions by economists that damages from climate change will be slight. Since these assumptions are wrong, so are their conclusions. Keen was the first to criticise these assumptions, originally in “The appallingly bad neoclassical economics of climate change” (Keen 2020), and then in Carbon Tracker’s report (Keen and Hanley 2023; Keen 2023).

Lenton is a climate scientist who has long been aware of the ludicrous assumptions that economists have made to trivialise the dangers of climate change (Lenton and Ciscar 2013). He has also previously conducted a very careful expert survey of climate scientists to assess the likelihood of climate tipping points being triggered (Lenton et al. 2008). He has been a prominent contributor to the academic literature on tipping points, which was recognized by the OECD when he was commissioned to assess the possible impacts of losing the AMOC (OECD 2021).

The Methods

This research project will lead the development of scientifically sound damage function suitable for economists' Integrated Assessment Models (IAMs), using three methods:

1. An expert survey, similar in design to (Howard and Sylvan 2021, p. 23), would be used to identify temperature increases that climate change scientists expect would terminate human industrial civilisation. A logistic damage function would then be extrapolated back to current and pre-industrial temperatures from the median and range of such temperature estimates.
2. An empirical assessment of the temperature increase to GWP relationship will also be undertaken, using wet bulb temperature (WBT) rather than ambient surface temperature. WBT takes into account both temperature and humidity, and provides a more comprehensive understanding of the actual thermal conditions, which are a better indicator of the climatic impact on people's ability to work and survive. Using WBT offers a more nuanced and insightful approach to understanding the impacts of climate change on various sectors of the economy. This method would provide a physically grounded alternative damage function. It would also enable the survey-based damage function to be applied on a country-by-country basis.
3. The project will also address the question of the scientific credibility of the estimates that economists have made of economic damages from climate change. There are, according to Tol, a mere 39 papers that are the basis of the empirical estimates that economists have given of damages from climate change (Tol 2022, Table 1, p. 19), along with a similarly small number of studies of the economic impact of triggering tipping points (Dietz, Rising, Stoerk, and Wagner 2021). We contend that had scientists refereed the strictly climate-change and global-warming aspects of these papers, then none of them would have been published. We will test this hypothesis by assembling a panel of climate scientists to ex-post referee these papers.

The Outcomes

1. Two damage functions will be generated, which should in future be used by economists in IAM studies. These will be a replacement for the damage functions that economists currently use, which are normally quadratic—such as the damage function in Nordhaus's DICE IAM:

The parameter used in the model was ... 0.227 percent loss in global income per degrees Celsius squared with no linear term. This leads to a damage of 2.0 percent of income at 3°C, and 7.9 percent of global income at a global temperature rise of 6°C. (Nordhaus 2018, p. 345)

Given the serious problems with the empirical methods used by economists to date, a damage function developed by scientists is virtually certain to generate much higher damage estimates than are made in the existing literature on the economics of global warming.

2. Papers establishing that the empirical assumptions by economists about climate change are false will be published in leading science journals. These papers will call on economic journals to withdraw all economic papers whose empirical assumptions about global warming are rejected by the panel of scientific referees.
3. The project leaders, in conjunction with supporting organisations like Carbon Tracker, will contact the editors of the journals which published any of these papers that are rejected in this ex-post refereeing process, to insist that their publication be retracted.

Budget

The project needs to be completed as quickly as possible, given the urgency of the climate crisis, and expectations by some scientists of a 0.5°C increase in temperatures in 2024.¹ We have budgeted to allow the project principals to work on this full-time, and to employ a market research company to manage the practical aspects of the survey.

Component	Expected Cost
Senior Research Fellows (2) salaries plus on-costs	£360,000
Senior Research Impact Fellow	£120,000
Market Research Company Survey Fees	£200,000
Refereeing payments: £750 per paper x 4 referees x 40 papers	£120,000
Preparatory Workshop	£60,000
Postdoctoral Fellow	£85,000
Postdoctoral Associate	£67,000
Administrative Assistant	£50,000
Publicity budget	£200,000
Total	£1,262,000

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¹ <https://mailchi.mp/caa/global-warming-acceleration-el-nino-measuring-stick-looks-good?e=3763203384>.

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