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What's the damage (of that climate change cost-benefit model)?

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OCTOBER 18, 2018 12:30 AM

By: Guest Post

This is a guest post by [Kate Mackenzie](https://twitter.com/kmac?lang=en) (https://twitter.com/kmac?lang=en) – former Alphavillian turned climate finance thinktank person at Climate KIC Australia.

How much will climate change cost, and how much should we - or anyone - spend to avoid that cost?

One answer that's received a lot of attention in the past few days is contained in the work of Bill Nordhaus, who won the economics Nobel, in part for his work developing the Dynamic Integrated Climate Economic (DICE) model to answer pressing questions about how policymakers should respond to climate change.

DICE, like similar “integrated assessment models”* such as PAGE and FUND, attempts to identify the rate at which policymakers can apply a price on greenhouse gas emissions, by calculating a “social cost of carbon” (SCC).

A key component of that SCC is the discount rate. As Brendan [pointed out yesterday](http://ftalphaville.ft.com/2018/10/17/1539759744000/Economic-climate-models-are-elegant-brilliant-and-in-the-US-failing-us/) (http://ftalphaville.ft.com/2018/10/17/1539759744000/Economic-climate-models-are-elegant-brilliant-and-in-the-US-failing-us/), this is basically choosing how much or how little we care about our children's futures, and putting it into a model with the guise of objectiveness and precision. This idea – that our wealth today is more important than risks to others tomorrow - equates to a low SCC that justifies limited action to cut emissions (Nordhaus's recent work lands on a \$31/tonne rate for the US; consistent with about 2.5°C of warming).

The SCC number, of course, is the result of numerous inputs, variables, and assumptions. The discount rate is the most obviously troubling one, but there are more.

A [paper \(http://www.nber.org/papers/w19244\)](http://www.nber.org/papers/w19244) by MIT economist Robert Pindyck titled “Climate Change Policy: What do the models tell us?” begins with the sentence “Very little.” It goes on to provide a brief list of IAM problems:

These models have crucial flaws that make them close to useless as tools for policy analysis: certain inputs (e.g. the discount rate) are arbitrary, but have huge effects on the SCC estimates the models produce; the models' descriptions of the impact of climate change are completely ad hoc, with no theoretical or empirical foundation; and the models can tell us nothing about the most important driver of the SCC, the possibility of a catastrophic climate outcome. IAM-based analyses of climate policy create a perception of knowledge and precision, but that perception is illusory and misleading.

While the discount rate has the minor virtue of being reasonably transparent, most of the other inputs listed by Pindyck are harder to unpack without being at least partially immersed in climate change science. They mostly relate to how the scientific knowledge about climate change is transformed into an economic damages estimate.

It's the damages, stupid

Where do these estimates of damage come from? Nordhaus himself cautions that beyond 3°C the models are not useful, and his views on mitigating climate change have evolved; some of his [most recent work \(https://www.nber.org/reporter/2017number3/nordhaus.html\)](https://www.nber.org/reporter/2017number3/nordhaus.html) introduces an upper limit of 2.5°C.

Martin Wolf [wrote \(https://www.ft.com/content/f350020e-b206-11e7-a398-73d59db9e399\)](https://www.ft.com/content/f350020e-b206-11e7-a398-73d59db9e399) last year, “A planet 4°C warmer than the pre-industrial average would be so different from the one we are now used to that the implications are in significant part unknowable.” You'd be hard-pressed to find a climate scientist who disagrees; the new IPCC Special Report tells us that even 1.5C of global average warming will unleash hardship in parts of the world – (which makes more sense when you consider that those averages will not be evenly distributed, either spatially or temporally).

Yet the Integrated Assessment Models do generate damages estimates for 4°C, and higher; and because they treat growth as exogenous, [warming has to reach \(http://personal.lse.ac.uk/sternn/128NHS.pdf\)](http://personal.lse.ac.uk/sternn/128NHS.pdf) an absurd 19°C before GDP is cut in half.

A 2017 paper (<https://www.nature.com/articles/nclimate3411>) by Diaz and Moore attempts to tabulate all the criticisms identified with IAM damages functions. The table runs over almost two pages, so this is just an extract:

Table 2 | Synthesis of published damage function critiques, with key references.

Damage function characteristic	Critique description	Model examples and implications for damage estimates	Key references
Extrapolation to high temperatures	Damage functions are calibrated based on impact studies of 1–3 °C warming, but extrapolated beyond this range when computing damages or SCC estimates for many emissions scenarios Damage estimates for higher levels of warming are extremely speculative and do not inform the choice of functional form (for example linear or quadratic)	DICE and FUND are calibrated to impact estimates for 1–3 °C warming, PAGE to 3 °C DICE damage function extrapolated to 6 °C and 12 °C implies yield global GDP losses of 8% and 26% respectively; Weitzman ⁶⁹ suggests that this is implausibly low and finds that a steeper slope (50% and 99% loss at 6 °C and 12 °C respectively) raises the SCC	70–72
Extrapolation to other regions	IAMs estimate global damages, but underlying impact studies focus disproportionately on a few regions (for example the United States and European Union), which are then extrapolated to other regions for global coverage	PAGE applies ad hoc regional adjustments based on coastline length to scale damage functions that are calibrated to European Union impact studies	9, 67, 73–75
Coverage of impact categories	Damage functions have incomplete coverage of climate change impact categories, often because underlying studies for calibration are lacking Represented sectors may have secondary impacts that are omitted (for example health effects from malnutrition due to impacts in the agricultural sector)	Sectors with limited or missing representation include ocean acidification, wildfires, energy supply, labour and capital productivity, crime, infrastructure, geopolitical instability and cultural heritage Many authors suggest that SCC estimates might thus be viewed as a lower bound, although some climate benefits are also missing from damage functions	3, 75–80

Other characteristics the authors identify in the IAMs criticisms include, “outdated scientific understanding”; “ignore or inadequately represent potential tipping points”, and “fail to capture the full range of parametric and stochastic uncertainty” and “damages to growth rates”. Mostly, the implications for damages estimates are to the downside.

Interpreting the costs (or... benefits?) of climate change as accurately as possible means tapping into a vast range of scientific work, and our understanding of what changes in the climate may mean are constantly evolving. For example, it's become well established (<http://www.nature.com/articles/s41586-018-0041-2>) in the past few years that 2C of warming will leave all of the world's coral reefs (<https://www.nature.com/articles/nature21707>) severely damaged. Ten years ago, the link between small increases in global temperature and coral death was still hotly debated among marine biologists. Twenty years ago, it had barely even been posited (<https://www.nature.com/articles/21955>).

Other effects are still emerging – where obtaining historical data is challenging, but increasingly pointing to climate change posing a threat. For example, the risk that the Atlantic meridional overturning circulation (AMOC) – which includes the Gulf Stream - might be affected (<https://www.nature.com/articles/d41586-018-04322-x>) by climate change is looking more likely, from research published this year.

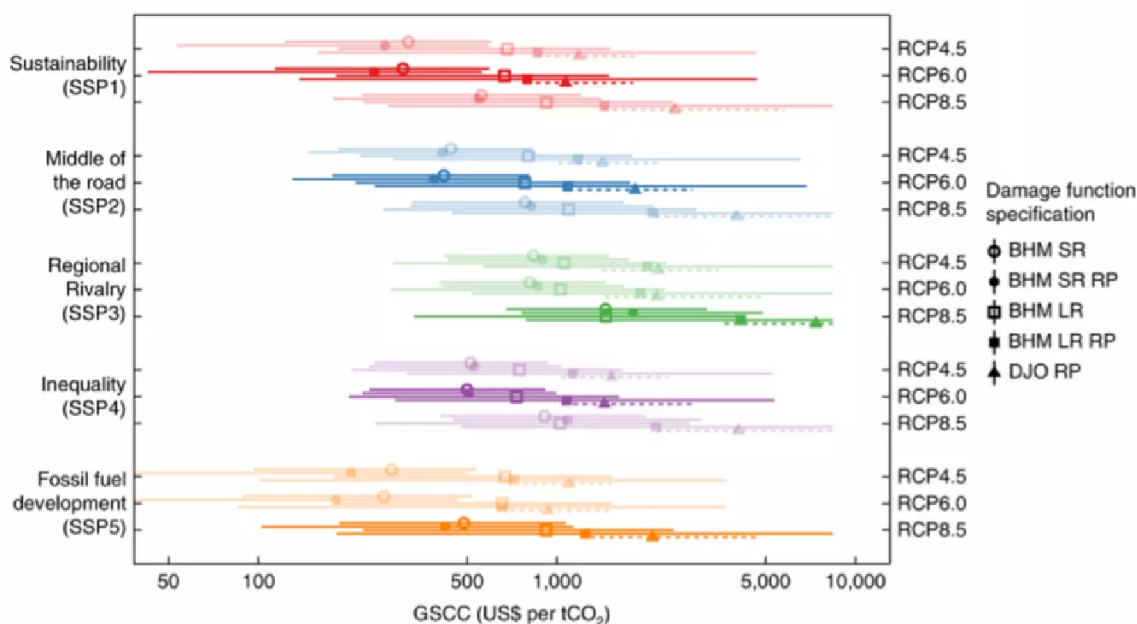
An alternative damage function

One of the most impactful pieces of work to change the way costs of climate change are estimated comes from three US economists: Marshall Burke, Solomon Hsiang, and Edward Miguel. They developed an [empirical damages function \(https://www.nature.com/articles/nature15725\)](https://www.nature.com/articles/nature15725) based on historical country-level correlation between temperature and GDP. Although this still leaves out many things – for a start, future temperatures will clearly be in ranges not historically seen – it represented progress.

Earlier this year, Kate Ricke and three other researchers used Burke et al's damage function to [estimate a social cost of carbon \(https://www.nature.com/articles/s41558-018-0282-y?utm_source=Nature_community&utm_medium=Social_media_advertisingCommunity_sites&utm_content=BenJoh-Nature-MultiJournal-Social_Sciences-Global&utm_campaign=MultipleJournals_USG_SOCIAL\)](https://www.nature.com/articles/s41558-018-0282-y?utm_source=Nature_community&utm_medium=Social_media_advertisingCommunity_sites&utm_content=BenJoh-Nature-MultiJournal-Social_Sciences-Global&utm_campaign=MultipleJournals_USG_SOCIAL) per country; for a “middle of the road” socio-economic scenario with a correspondingly high emissions scenario [RCP6.0; which is the second-highest available], they came up with a median of \$417 per tonne of CO₂.

Fig. 1: GSCC in 2020 under various assumptions and scenarios.

From: [Country-level social cost of carbon](#)



Median estimates and 16.7% to 83.3% quantile bounds for GSCC under SSPs 1–5, and RCPs 4.5, 6.0 and 8.5. For each SSP, the darker colours indicate the SSP–RCP pairing with a superior consistency (Methods and Supplementary Table 4). The five specifications of damage function are four BHM models (short run (SR) and long run (LR) pooled and with the rich and poor (RP) distinction) and the DJO model. The values displayed assume growth-adjusted discounting with a pure rate of time preference of 2% per year and elasticity of marginal utility substitution (μ) of 1.5. Supplementary Fig. 2 compares these results with fixed discounting (rate of 3%). Coloured bars represent the 66% CIs.

The work wasn't easy; lead author Prof Ricke wrote in a short piece in a short accompanying “behind the paper” piece, “Our paper took nearly two years to get through peer review; things got heated.”

We were subjected to quite a bit of substantive criticism that required us (led by Laurent Drouet) to re-up the sensitivity analysis again and again. I learned a lot through this process: about climate econometric models with fixed effects, about the entrenchment of the principle of utility maximization and plenty more.

Yet, as Econospeak [points out \(http://econospeak.blogspot.com/2018/10/nobel-prizes-in-economics-awarded-and.html\)](http://econospeak.blogspot.com/2018/10/nobel-prizes-in-economics-awarded-and.html), criticism of the established IAMs is hardly marginal; some of the main critics are Lord Stern at LSE – whose famous Review used PAGE, albeit with a low discount rate - and Martin Weitzman, a professor of economics at Harvard.

Weitzman and Nordhaus have debated how to cost climate change over many years (here is [Nordhaus's response \(https://ideas.repec.org/p/cwl/cwldpp/1686.html\)](https://ideas.repec.org/p/cwl/cwldpp/1686.html) to Weitzman's Dismal Theorem – which he proposes in part as an alternative to IAMs).

But they are not exactly bitter rivals. In fact Nordhaus, in [his press conference \(https://www.youtube.com/watch?v=zQw-TJxfl-Q\)](https://www.youtube.com/watch?v=zQw-TJxfl-Q) after being awarded the Nobel prize, said he was surprised that neither Weitzman nor Stern – both of whom he described as brilliant – were co-recipients of the award**.

Weitzman [contends \(https://www.mitpressjournals.org/doi/pdf/10.1162/rest.91.1.1\)](https://www.mitpressjournals.org/doi/pdf/10.1162/rest.91.1.1) that not only are the inputs to IAMs problematic, but indeed the entire exercise of cost-benefit analysis based on expected utility to climate change is flawed “for what is inherently a fat-tailed situation with potentially unlimited downside exposure”.

However the excellent book, *Climate Shock*, which Weitzman co-authored with Gernot Wagner, is more sympathetic, pointing out that these models are built with just a fraction of the resources that go into, say, analysing the market performance of different brands of toothpaste. The entire realm of climate change costs, they write, deserves more attention and more resources.

Nordhaus says his approach to modelling has fundamentally changed the way environmentalists and economists approach climate policy: “shifting from a pure engineering approach — “do this and don't do that” — to approaches like cap-and-trade or carbon taxes that emphasise market mechanisms”. Still, at a time when tangible progress in averting climate change is coming more from the engineers of zero-carbon technologies than from economists, maybe it's time to ask whether that was really a step forwards.

* Confusingly, there is another type of climate IAMs – with names like MESSAGE, IMAGE and REMIND – but these do not have a cost-benefit function.

** Thanks to an Econospeak commenter for pointing out the timing of Nordhaus's important comment.

Related links:

[A high price for ignoring the risk of catastrophe \(https://www.ft.com/content/4fb95100-9882-11e3-8503-00144feab7de\)](https://www.ft.com/content/4fb95100-9882-11e3-8503-00144feab7de) – FT

[Climate Shock \(https://gwagner.com/books/climate-shock/\)](https://gwagner.com/books/climate-shock/) – Gernot Wagner and Martin Weitzman's book

[Climate Impact Lab \(http://www.impactlab.org/\)](http://www.impactlab.org/) – a new interdisciplinary research hub

[Adding Up the Cost of Climate Change in Lost Lives \(https://www.wsj.com/articles/adding-up-the-cost-of-climate-change-in-lost-lives-1533121201\)](https://www.wsj.com/articles/adding-up-the-cost-of-climate-change-in-lost-lives-1533121201) - WSJ

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luzh 2 days ago

This article at first appears to support yesterday's one arguing that the entire idea of trying to think rationally about how we value our descendants future is immoral, and then switches to just arguing that such models are imperfect and deserve more resources. I'm sure it's easier to pretend to yourself that your own private discount rate is zero when you're waiting in the business lounge for your transatlantic flight.

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FearTheTree

2 days ago

@luzh Calls to mind Tom Steyer tooling around in his Gulfstream (emitting 8x the per/capita CO2 of commercial jet travel), while warning about climate change and asking the struggling working-class family to pay an exorbitant energy tax.

Carbon emissions for some

No carbon emissions for others

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L.Cleverdon

2 days ago

@FearTheTree @luzh

I've yet to hear Tom Steyer asking anyone - let alone your *"struggling working class family"* - to pay an exorbitant energy tax.

If you've no better argument than trying to slander those who advocate action on climate, then you demonstrate pretty neatly just how desperate Climate Denialists are these days.

I gather the Trumpy clown has, via his staff, begun pushing the meme that AGW is real, but its too big to stop . . . Maybe you should try it ?

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FearTheTree

2 days ago

@L.Cleverdon @FearTheTree @luzh I don't deny that the climate is changing. It's constantly changing. 10K years ago, Manhattan was under a mile of ice, and residents of Chicago would have looked up and seen a hundred-foot high glacier where Lake Michigan sits.

Rather, I'm not arrogant as to believe that man can do anything about sunspots or orbital tilt. And I also believe that just as man adapted 10k years ago,, he will adapt again.

With respect to Steyer, google Tom Steyer carbon tax

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6 replies

Tom Hawbuck

2 days ago

Seems to me that the bus has already left. The latest figures from Columbia Climate Science and Awareness Solutions show that "global temperature has reached a level of at least 1°C relative to pre-industrial climate even in the presence of La Nina cooling". Hansen reports that using La Nina minima probably provide a better estimate than using el Nino maxima, and they provide more recent rates. He says "As the figure shows, the most recent two La Ninas imply a warming rate of 0.38°C per decade, at least double the longer term rate!" As we are now moving into an el Nino period, he expects temperatures to rise over the next few months. My view is that given global population continues to rise (and population increase is never discussed by metro liberal types) and the probability that melting arctic ice and tundra will add more greenhouse gases to the atmosphere, we are in for a rough time. Huge storms, coastal

flooding, loss of habitat etc. I think it is probably too late to do anything to stop this, but much more effort needs to be put into mitigating its effects. Unless stuff is done, Ely will return to being an island in the Fen and Peterborough will be a coastal resort. See <http://csas.ei.columbia.edu/2018/10/15/global-warming-acceleration-plus-miscellaneous/>

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FearTheTree

1 day ago

@**Tom Hawbuck** Chinese scientists would disagree.

Otherwise the Chinese military would not be investing tens of billions of dollars on artificial islands in the South China Sea, or billions on ports in the Maldives and other low-lying areas across the world

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Clive Elsworth

2 days ago

It would be great if reformed IAMs could release much needed funding for promising scientific trials. One such proposal is rather than allow the sun's energy to warm the oceans, use it to cool them using the simplest, safest, most natural and best value technology available - Iron Salt Aerosols (ISA). In addition it is estimated to suck 12Gt CO₂/annum from the atmosphere for less than \$1/tonne: <http://ironsaltaerosol.com/>

Surely insurance companies ought to be interested?

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L.Cleverdon

2 days ago

@**Clive Elsworth**

Interesting proposal but potentially very bent. Carbon Recovery at < \$1.0 / TCO₂ is Exxon Mobil's idea of a wet dream. If convinced of the company's patent meaning massive future profitability, many Australians might be willing to invest heavily in it. . . .

Notably no marine biologists or climate scientists in the team, nor named as advisors, nor proposed as joining in the future. Also an odd error in declaring the GWP of methane as 28 x CO₂, with no mention of relevant period, when IPCC AR5 advanced methane's 20yr period GWP from 28 to 34, IIRC.

The addition of Iron Salts Aerosol [ISA] is claimed to generate growth of plankton whose photosynthesis draws carbon from the atmosphere at a rate of 10,000 tonnes carbon per tonne of ISA distributed. At a release rate of " a few grams per km² per day" this implies plankton growth each day per km² sufficient to hold say 30 to 50 kgs of carbon - which is actually a very substantial volume growing each year per km² and then dying before falling to the seabed and rotting.

In the proposal's Summary there is no mention of any means by which that rotting avoids generating extreme oceanic oxygen depletion and the expansion of dead zones in which nothing can live.

It seems well worth submitting the proposal to appropriately skilled scientists for evaluation and, potentially, for accreditation for trials by a yet-to-be-mandated UN authority. But until then:

"Buyer Beware !"

Regards,

Lewis

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CH

2 days ago

@L.Cleverdon @Clive Elsworth Thank you for posting this!

I had occasion to work on the plan to create a deep-water port in Alaska via detonation of one or more thermonuclear weapons at suitable seismic faults in the ocean floor. From an economic and physics standpoint the model was mathematically flawless. (Only deep water port in North America is Halifax, Nova Scotia, all other harbors must be dredged).

Most fortunately, someone remembered what you just mentioned, shouldn't we consult some marine biologists? The model was hastily shelved. This new monstrosity deserves to follow the fate of its predecessor.

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Clive Elsworth

2 days ago

@L.Cleverdon @Clive Elsworth Thank you for your reply which I appreciate. Robert Tulip is a retired marine biologist who worked for the Australian Government for several decades. I believe John Macdonald is also a marine biologist. At least I know he has been heavily involved in development of marine permaculture. Their website is very new and your feedback highlights the importance of appearing credible, so I have forwarded your feedback to Robert.

I met Robert Tulip through the Healthy Climate Alliance google group, on which a number of notable climate scientists participate, such as Peter Wadhams (occasionally). Robert's posts always seem well considered and well informed, albeit I'm neither a marine biologist nor climate scientist. (I did well at physics and chemistry at school and studied engineering at University.) I have had several Zoom conversations with Robert and find him to be a committed (if frustrated) advocate of sensible climate action.

Btw I share your perplexity on methane. A google of "methane half-life in the atmosphere" returns:

"Methane is a relatively potent greenhouse gas with a high global warming potential of 72 (averaged over **20 years**) or 25 (averaged over **100 years**). Methane in the atmosphere is eventually oxidized, producing carbon dioxide and water. As a result, methane in the atmosphere has a half life of **seven years**."

So, I think we can assume that methane released today will have a warming effect much larger than even 72 x CO₂ in its first few years, highlighting the urgent need to both reduce methane emissions and remove existing atmospheric methane. HFCs are even worse and ISA is purported to reduce them as well, though no figures are given. To me, the need for research funding and appropriate approvals is clear.

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