Nordhaus's Nobel Prize Is Safe, But The World Isn't

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I make some pretty serious claims here, and I believe they are all justified. I have truly never read anything as dispiriting as Nordhaus's work and that of his fellow Neoclassical climate-change-trivializing cronies. It makes working on the book very difficult, because I frequently just hang my head in shock and horror at what they've done, and what that probably means for the future of human civilization.

One of the provisions of the Nobel Prize is that once awarded, it can never be revoked. This has led to some embarrassing gaffes for the history books, with perhaps the worst to date being the award of the Nobel Prize for Chemistry in 1918 to a man who, as well as inventing an essential process in the manufacturing of fertilizer, had personally "supervised the first major chlorine gas attack at Ypres, Belgium, in 1915, which killed thousands of Allied troops." (Karl Ritter, 2016 "Five decisions that made the Nobel Prizes look bad"). Hugues Honore notes that Fritz Haber expected not a Prize, but a court martial:

> After Germany's defeat in the war, "he didn't expect to win a prize. He was more afraid of a court martial," Swedish chemist Inger Ingmanson, who wrote a book about Haber's prize, told AFP. (Hugues Honore, 2015, "The dark side of Nobel prizewinning research")

So William Nordhaus's Nobel Prize in Economics "for integrating climate change into long-run macroeconomic analysis" is safe, but the world isn't. When future generations look back to try to determine why humanity delayed taking action against climate change for so long, Nordhaus's DICE model (DICE stands for "Dynamic Integrated model of Climate and the Economy") will be regarded as one of the prime suspects.

I don't make this claim lightly. I have attacked mainstream economists in the past for making absurd assumptions, but Nordhaus's transgressions are in a different league altogether—and not a better one.

The pivotal problem with his research is not the one often mentioned by other critics—that he applies a high discount rate to future damages from Climate Change. Instead, the problem is the function he uses to estimate damages from Global Warming in the first place: his so-called "Damage Function". It is a simple quadratic: he asserts that an increase of ***x*** degrees Celsius over pre-industrial levels will reduce global GDP by a

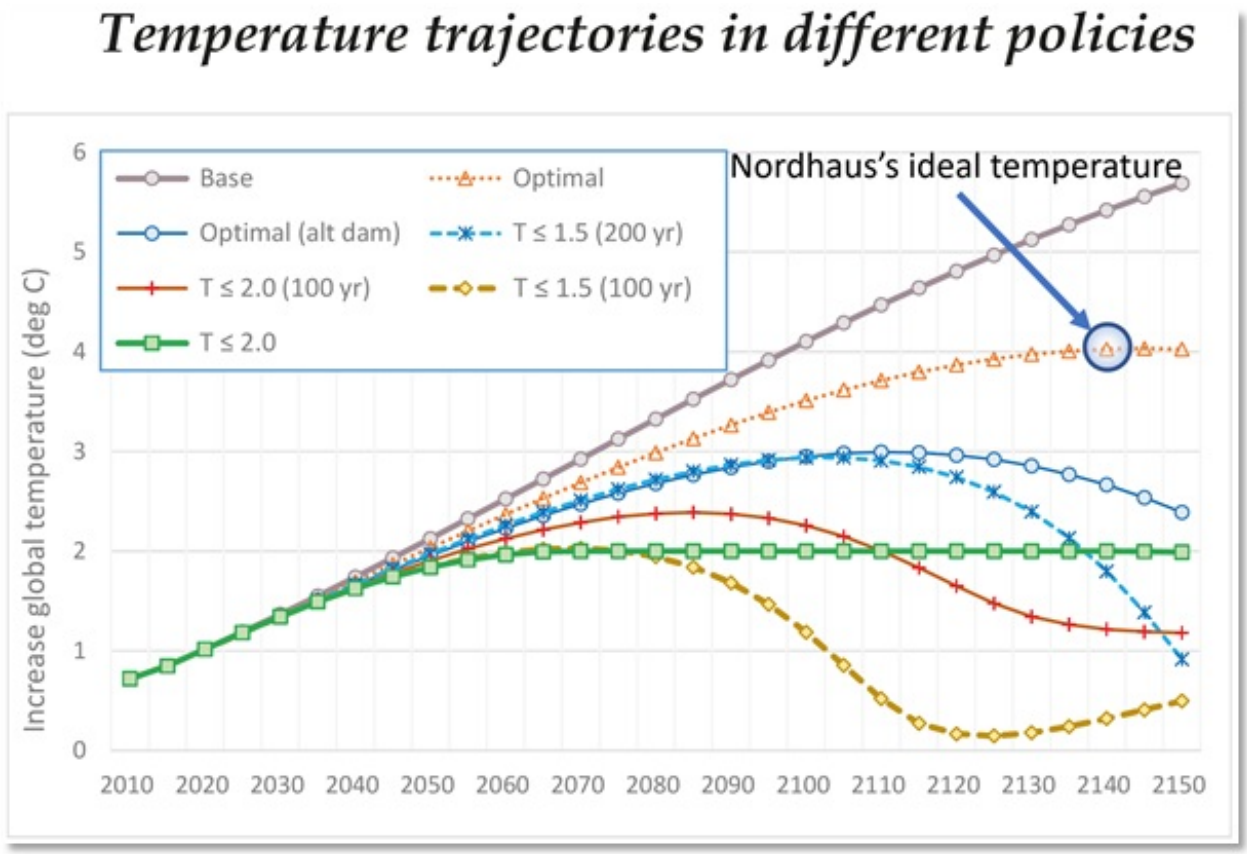
constant, multiplied by ***x*** squared.

The constant itself is also tiny: in his latest model, the coefficient he used is 0.227% (Nordhaus 2018, p. 345). Since his damage function is simply this constant multiplied by the change in temperature squared, he asserts that GDP has been reduced by 0.227% by the 1 degree of warming we have already experienced, that a 2 degree temperature increase will reduce GDP by four times this much (just over 0.9%), that a 3 degree increase would reduce GDP by nine times as much (just over 2%), and that a 6 degree increase would reduce GDP by 36 times as much (just over 8%).

To repeat, this is ***not*** because huge values for future damages are discounted back to trivial levels today by applying a high rate of discount: these are instead Nordhaus's assertions about how much lower GDP will be at some hotter date in the future, compared to what it would have been *in the complete absence of global warming*.

This is a trivial change in GDP, and by implication, in human welfare, from Global Warming. If it were true, there would be nothing to worry about. A 3.6% fall in GDP in one year is a very serious recession. But since it will take, on Nordhaus's calculations, till 2140 before we reach 4 degrees above pre-industrial levels—which he stated in his Nobel Lecture was the optimal temperature for the planet, balancing the benefits of attenuating climate change against the costs of doing so (see Figure 1)—the decrease in GDP growth per year thanks to Global Warming is trivial: 0.03% per year. That's nothing.

Figure 1: Slide 6 in Nordhaus's 2018 Nobel Prize Lecture, annotated



It's also nothing like the warnings coming from climate scientists, who are truly panicked about a 2 degree increase over pre-industrial levels. A recent paper, jointly authored by 16 climate scientists, asserted that global warming must be kept to 2 degrees or below, "because of the risk that...

> a 2 °C warming could activate important tipping elements, raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth System to even higher temperatures (Tipping Cascades) (Steffen, Rockström et al. 2018, p. 8254)

Nordhaus's damage function doesn't have tipping points: a quadratic is a smooth function with no discontinuities to it. A tipping point means a discontinuity: it's like paddling along a river in a canoe and then going over a waterfall. You could describe your paddle along the river with a simple linear "height above sea level falls 1 metre for every kilometre paddled", but that would be cold comfort once you went over the waterfall.

How did Nordhaus justify using a smooth function to describe the impact of Global Warming, when climate scientists are saying that there are serious tipping points, and hence by implication, that to be realistic, a "damage function" must have a discontinuity? By misconstruing their research, that's how! In the manual for his DICE model, he makes the following claim:

> The current version assumes that damages are a quadratic function of temperature change and does not include sharp thresholds or tipping points, *but this is consistent with the survey by Lenton et al. (2008)*. (Nordhaus and Sztorc 2013, p. 11. Emphasis added.)

I decided to check this remarkable claim—*and found that it was false*. A smooth function is ***inconsistent*** with Lenton's survey of climate scientists. Lenton's paper, clearly entitled "Tipping elements in the Earth's climate system" (Lenton, Held et al. 2008), was a first step by climate scientists to identify what components of the Earth's climate system might trigger runaway global warming:

> In discussions of global change, the term tipping point has been used to describe a variety of phenomena… We offer a formal definition, introducing the term "tipping element" to describe subsystems of the Earth system that are at least subcontinental in scale and can be switched—under certain circumstances—into a qualitatively different state by small perturbations. *The tipping point is the corresponding critical point—in forcing and a feature of the system—at which the future state of the system is qualitatively altered*. (Lenton, Held et al. 2008, p. 1786. Emphasis added)

Lenton's survey considered only large regional components of the planet's climate (systems that were that least 1,000km long), and which could be triggered this century by the increase in temperature that would result from taking no action on climate change. They concluded that "the greatest (and clearest) threat...

> is to the Arctic with summer sea-ice loss likely to occur long before (and potentially contribute to) GIS [Greenland Ice Sheet] melt. Tipping elements in the tropics, the boreal zone, and West Antarctica are surrounded by large uncertainty and, given their potential sensitivity, constitute candidates for surprising society. The archetypal example of a tipping element, the THC [Atlantic thermohaline circulation, part of which is the Gulf Stream that keeps Europe warmer than it otherwise would be] appears to be a less immediate threat, but the long-term fate of the THC under significant warming remains a source of concern (Lenton, Held et al. 2008, p. 1791-92)

How on Earth did Nordhaus read this paper and think that it justified using a smooth function, rather than one with tipping points? I can't know of course, but I believe that Nordhaus either didn't read the paper then, or at best, scanned it until he found a sentence that appeared to support the conclusion he wanted to reach, and then stopped. There is such a sentence, at the start of the paper's third paragraph:

> Many of the systems we consider do not yet have convincingly established tipping points. (Lenton, Held et al. 2008, p. 1786)

Read out of context, that could imply that the existence of tipping points hasn't been proven—and that therefore a smooth function like a quadratic is fine. But everything else in the paper—including the sentences either side of that one—screams that a smooth function should not be used. The paper even opens its conclusion with a warning against using smooth functions:

> **Conclusion**

> *Society may be lulled into a false sense of security by smooth projections of global change*. Our synthesis of present knowledge suggests that a variety of tipping elements could reach their critical point within this century under anthropogenic climate change. (Lenton, Held et al. 2008, p. 1792. Emphasis added)

Far from supporting Nordhaus's approach, this warns against it—and with good reason. It's simple to show just how misleading Nordhaus's function is by using one that is otherwise identical to Nordhaus's, but has a tipping point. This is a function with ***x*** [the actual temperature minus the pre-industrial temperature] cubed, divided by a tipping point temperature minus ***x***. Figure 2 is taken from Nordhaus's manual for his DICE program (Nordhaus and Sztorc 2013, p. 12), and shows a smooth increase in damages of up to 5% of GDP with a 5°C increase over pre-industrial levels.

Figure 2: Nordhaus's smooth "damage function" and the data points to which it was fitted

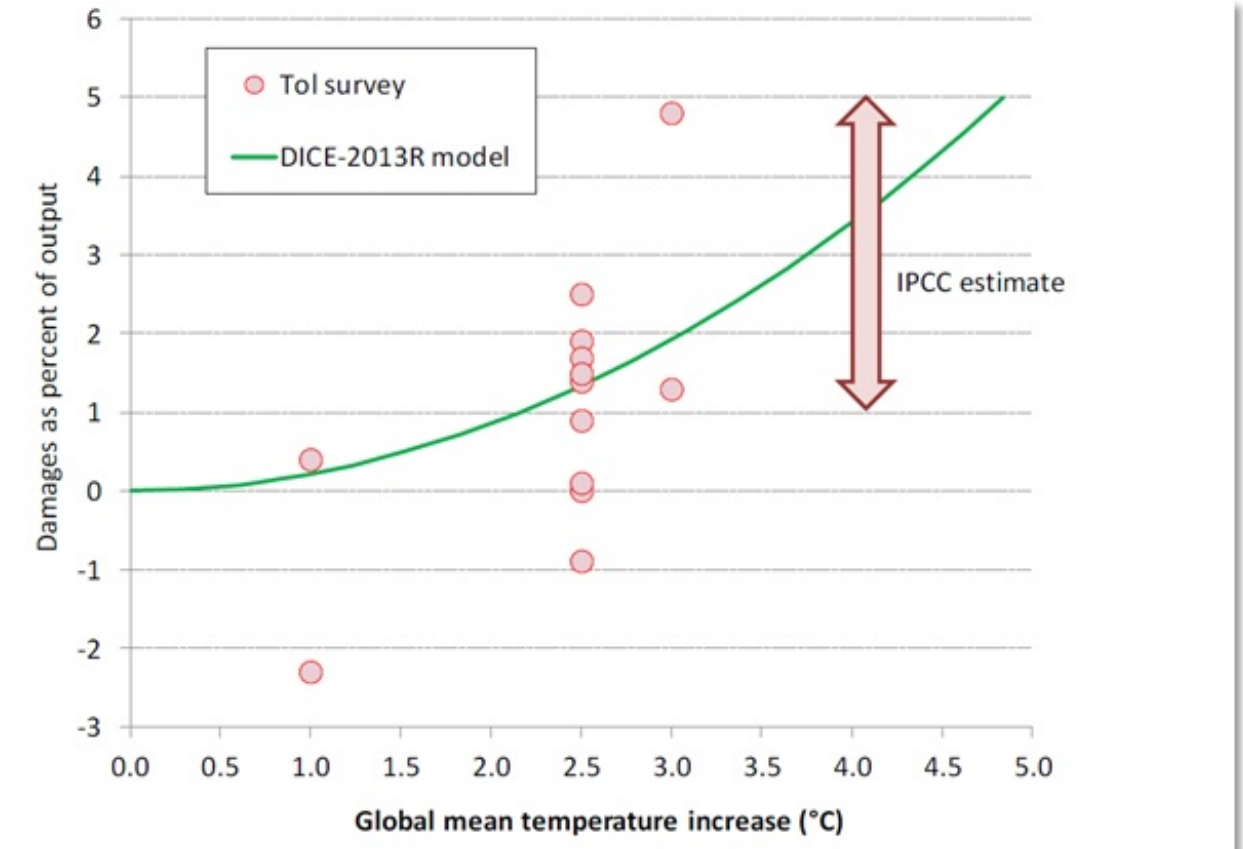
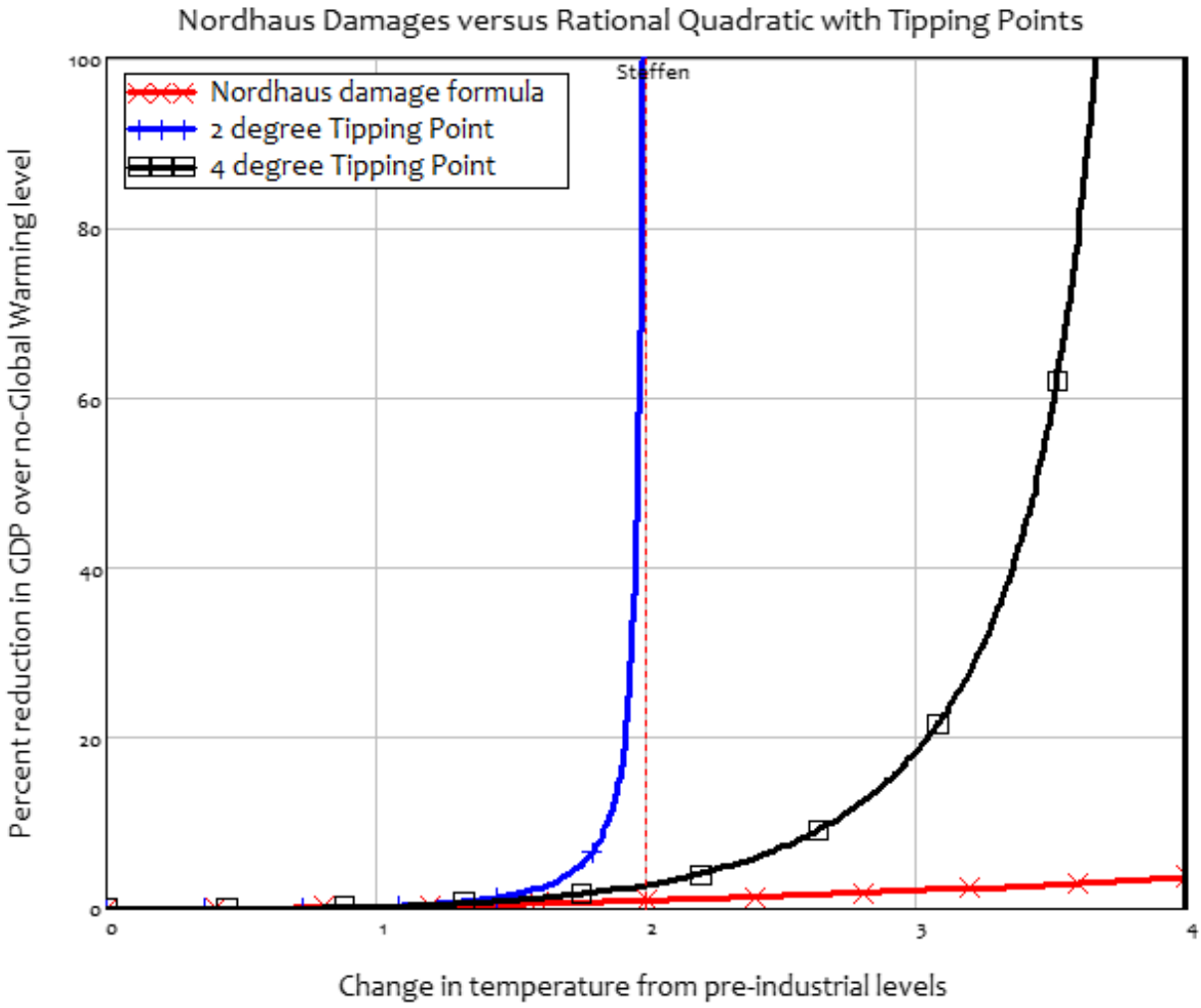


Figure 2. Estimates of the Impact of Climate Change on the Global Economy
This figure shows a compilation of studies of the aggregate impacts or damages of global warming for each level of temperature increase (dots are from Tol 2009). The solid line is the estimate from the DICE-2013R model. The arrow is from the IPCC (2007a). [impacts_survey.xlsx]

Figure 3 plots Nordhaus's function along with two functions with tipping points, one at the 2°C point chosen by Steffen et al. as the danger point for the planet, the other at the 4°C level that Nordhaus sees as "optimal" for the planet. The difference between the realistic tipping point functions and Nordhaus's unrealistic smooth function are dramatic. Even if Nordhaus happens to be lucky, and the actual tipping point is twice as high as climate scientists fear it is, the 3 degrees of warming that he predicts would only reduce GDP by 2% would instead reduce it by 18%. That is not some far-distant concern either: we are already at 1°C warming over pre-Industrial levels, and even Nordhaus predicts we'll hit 3 degrees of warming in 2070 (see Figure 1). That's just five decades away, when today's Extinction Rebellion campaigners would hope to be entering retirement.

Figure 3: Two tipping point functions versus Nordhaus's function



If the climate scientists are right, and 2 degrees is the tipping point, then even on Nordhaus's calculations (see Figure 1), we have just 25 years to avoid catastrophic damage to both the biosphere and the economy.

Not only has Nordhaus ignored these warnings by climate scientists, the only changes he has made to his damage function over the years since he first designed DICE model have been to make the function *less* able to handle tipping points, and to *reduce* the already tiny coefficient he uses: he has reduced it from 0.35% in 1999, to 0.284% in 2008, 0.267% in 2013 (Nordhaus and Sztorc 2013, pp. 86, 91 and 97), and 0.236% in 2018 (Nordhaus 2018, p. 345).

This is the next mystery in DICE: how did he get such tiny numbers for the impact of climate change in the first place? Here we have to delve into the source of the "data points" to which DICE is fitted: the dots on Figure 2, which come from a survey of economists' predictions about the impact of climate change by Richard Tol (Tol 2009). There are many weaknesses in these predictions, but without a doubt the worst is an assumption behind at least five of the 14 data points to which Nordhaus fitted his quadratic: the assumption that the effect of climate on income in different parts of the world today can be extrapolated to the effect of changes in climate on GDP across the whole planet over time. In Tol's words, these data points are based on the assumption...

> that the observed variation of economic activity with climate over space holds over time as well… (Tol 2009, p. 32)

What does this mean? It means that these economists took data about the income and temperature levels in different parts of the USA today, performed regressions between them, and found a weak nonlinear relationship between income and temperature. Extrapolated to the global level, above what Nordhaus describes as the optimal average temperature of 12°C (Nordhaus 2006, p. 3514), the higher the temperature, the lower the income. Below that level, the higher the temperature, the higher the income.

Since most of the world's GDP is generated in regions with a lower average temperature than 12°C, several of these economists concluded that an increase in global temperature of 2.5°C would actually *increase* global GDP. That is the case with the bottom dot for a 2.5°C increase in Figure 2 above: it shows a *minus* 1% damage to GDP from a 2.5°C increase in temperature—in other words, these economists (Mendelsohn, Schlesinger et al. 2000) predicted that a 2.5°C increase in temperature will cause global GDP to *rise* by 1% (see Figure 4). In their words:

> The results indicate that there will be large benefits from warming in the Former Communist bloc (the former Soviet Union and Eastern Bloc countries). The benefits in this region almost offset losses throughout the tropics in the Experimental results. The Soviet benefits account for two-thirds of the net global benefits in the Cross-sectional results. The results also suggest that there will be large benefits in North America and small benefits in Western Europe.

> The critical factor that these benefiting countries have in common is that they are currently cool so that warming is helpful. (Mendelsohn, Schlesinger et al. 2000, p. 42)

Figure 4: Mendelsohn's predictions of the impact of climate change on global GDP (Mendelsohn, Schlesinger et al. 2000, p. 41)

R. Mendelsohn et al. / Comparing impacts across climate models

Table 3
Aggregate impacts in 2100 by GCM model Cross-sectional responses (billions of 1990 $/year).

GCM	Continent[a]							
	Total	Africa	Asia	LatAm	WEur	Comm	NAm	Ocean
BMRC	150	−10	32	−3	2	100	29	−1
CCC	152	−18	31	−6	5	108	33	−2
GF30	185	−5	35	3	6	106	41	−2
GFDL	184	−9	31	2	5	114	42	−1
GFQF	165	−12	35	0	6	98	41	−3
GISS	131	−15	17	−7	7	94	38	−2
HEND	97	−28	8	−10	5	95	32	−4
OSU	116	−15	0	−3	6	93	37	−1
POLS	173	−16	39	−7	6	101	53	−4
POLD	175	−10	21	−2	8	112	48	−2
UIUC	98	−31	−1	−14	5	99	42	−2
UKMO	136	−21	16	−5	6	104	39	−3
WANG	119	−22	1	−9	7	102	43	−3
WASH	143	−13	22	−2	5	96	38	−3
AVERAGE	**145**	**−16**	**21**	**−5**	**6**	**102**	**40**	**−2**

[a] The continents above are Africa, Asia, Latin America, Western Europe, the former Soviet Union and Eastern bloc, North America, and Oceania.

If anything, this assumption that income and temperature differences today can be used to predict the result of global warming over time, is even more insane than Nordhaus's quadratic damage function itself. It may well be that incomes in parts of the world with average temperatures of 10°C are lower than in parts with average temperatures today of 12.5°C. But that tells you absolutely nothing about the impact on GDP of increasing global temperatures by 2.5°C.

In fact, it ignores the key danger of global warming: the impact of retaining much more energy in the biosphere, because waste energy that would otherwise escape harmlessly into space is trapped by the higher level of CO2. That additional energy will set off huge changes in the planet's climate. This issue is completely ignored by these studies—so it's important to get a handle on just what they are ignoring.

The planet is already 1°C warmer than in pre-industrial times. To increase the temperature of the atmosphere by another 1.5°C—the level considered by Mendelsohn—requires just over a kilojoule of energy per kilogram of atmosphere. At sea level, the atmosphere weighs roughly 10,000 kilograms per square metre, and the planet's area is 510 million square kilometres. To raise the temperature of all of that air by 1.5°C requires 7.7x10^14 gigajoules of energy.

To put that in context, that is equivalent to exploding *12 billion* Hiroshima-size atomic bombs (the bomb dropped on Hiroshima in WWII, which unleashed a force equivalent to exploding 20,000 tons of TNT). That is roughly 2 atomic bombs for every person alive today—or setting off 40,000 tons of TNT per person.

When you factor in that the atmosphere absorbs only 3% of the increased energy retained by additional greenhouse gases (the oceans take 90% and land masses the remaining 7%), the amount of additional energy needed to emulate the impact of raising global temperatures by another 1.5°C via increased CO2 is closer to 60 atomic bombs per person—or exploding about 1 million tons of TNT for every person alive today.

Does that sound beneficial to GDP to you?

Nordhaus's damage function drastically underestimates the damage from global warming, and ignores the existence of tipping points in the climate that we are already very close to triggering. Consequently, rather than "integrating climate change into long-run macroeconomic analysis", as the Nobel citation puts it, he has led humanity up a garden path towards a probable slaughterhouse.

The other "Integrated Assessment Models" designed by other economists are little better. They should all be thrown out—*which, when you read between the lines, is precisely what real climate scientists are saying*. They put this a lot more politely than me, which is possibly why economists like Nordhaus continue to ignore them. Here are Steffen and his 15 collaborators—including Lenton—from just last year:

> With these trends likely to continue for the next several decades at least, *the contemporary way of guiding development founded on theories, tools, and beliefs of gradual or incremental change, with a focus on economy efficiency, will likely not be adequate to cope with this trajectory*. Thus, in addition to adaptation, increasing resilience will become a key strategy for navigating the future. (Steffen, Rockström et al. 2018, p. 8257)

Ignore this then: ***the contributions of economists to the study of climate change have trivialised the dangers and thereby helped delay critical action of preventing climate change. They should be thrown out of the IPCC, and replaced by scientists who have some understanding of the dangers of unleashing that much more energy on our sensitive biosphere.***

William Nordhaus will take his Nobel Prize to the grave, but we should leave his funeral procession as soon as possible.

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