Climate Change: Options and Policy Implications

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5th Congress

EAARE

Objective

- William Nordhaus 1991
- Minimize Sum of Damage (D) and Mitigation Costs (C) given the Emission-Temperature link
- Min $\int[D(T)+C(E)]e^{-rt}\,dt$ s.t. $T=f(\int E_t dt)$
- Efficient Mitigation for each polluter i, j:
- $MC_j = MC_i = \int MD(T)e^{-rt}\,dt$

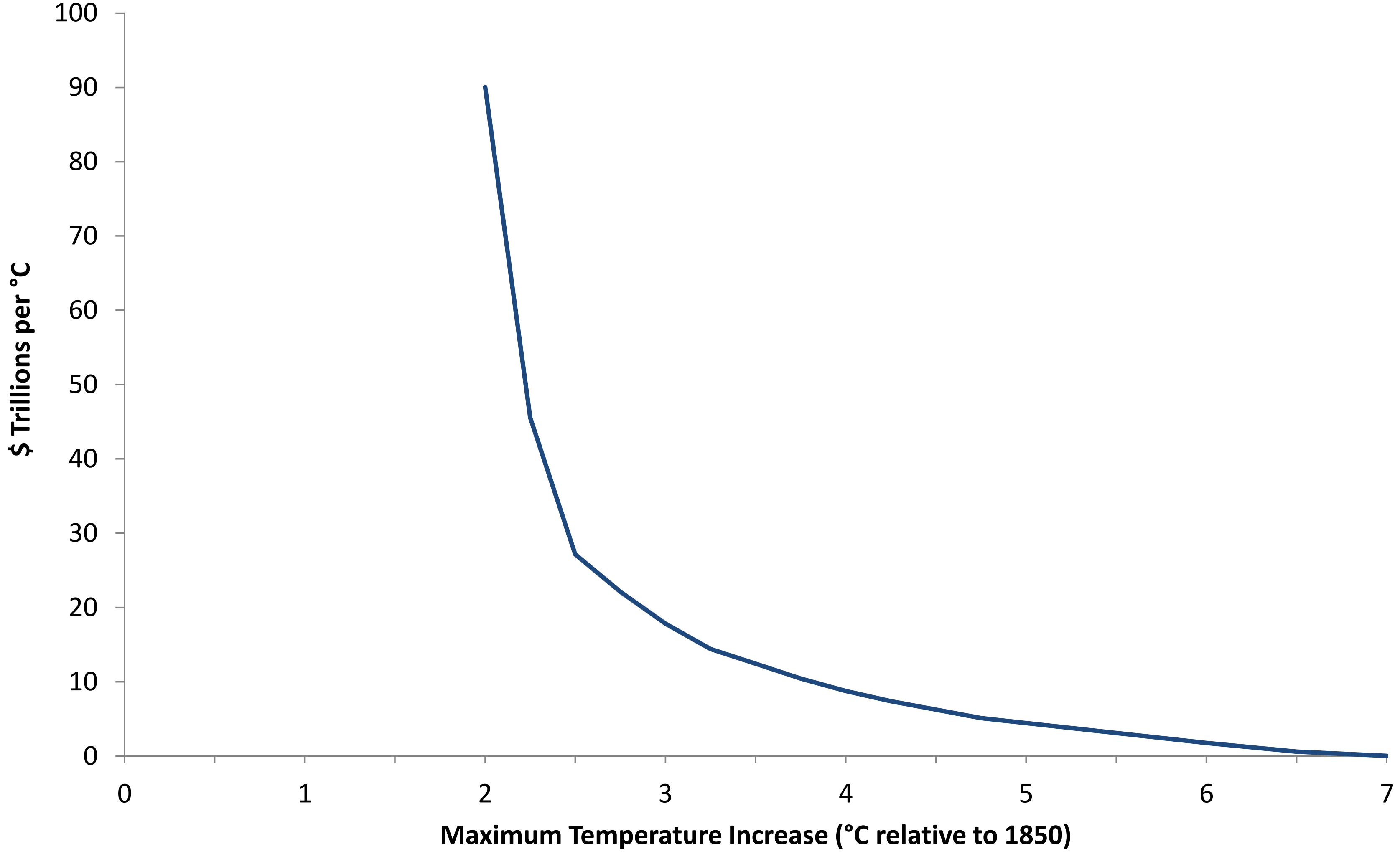
Challenge is to Measure Cost and Damage

- Must look out over a long time horizon
- GDP, energy, carbon intensity get more uncertain into the future
- Link between emission and damage uncertain especially over long time horizon
  - What is climate sensitivity?
  - How much damage at each climate?
  - Can adaptation lower damage?

Cost of Mitigation is High

- IAM literature has long argued lowering cumulative emissions is increasingly expensive
- Blanchard et al 2015 measure the marginal cost of temperature targets
- The calculation assumes efficient global mitigation starting in 2020

Marginal Abatement Cost for Alternative Temperature Targets



What damage justifies such targets?

- Use DICE-2013 (Nordhaus 2013) to calculate alternative quadratic damage functions
- DICE-2013 has the following damage function
- $D=GDP*.000267*T^2$
- This damage function leads to a maximum temperature of 3.3°C
- Raise (lower) coefficient above to lower (raise) temperature maximum

Max Temp	Damage Parameter	Year Emissions Stop	Social Cost of Carbon 2020 ($/ton)
4°C	.0001335	2155	10.7
3°C	.0003658	2110	28.7
2°C	.0011695	2065	85.3

Annual Damage

- Applying each damage function to DICE 2013 yields a separate optimal mitigation path starting in 2015
- Emissions accumulate and temperatures rise
- Annual damage increases with higher GDP and temperature
- For each temperature target, there is a date where emissions fall to zero.

DICE Predicts Annual Damage

- For each temperature target, there is a path of annual damage that rises over time
- The key to temperature targets is that damage has to be high enough to eventually choke off emissions
- Calculation reveals annual damage for 2°C, 3°C, 4°C targets at 2065, 2110, and 2155 when emissions should fall to zero for each target respectively

Annual Damage in Billions (Damage/GDP)

Maximum Temperature	Annual Damage 2065	Annual Damage 2110	Annual Damage 2155
4°	2,200 (0.8%)	10,600 (1.5%)	**24,000** **(2.4%)**
3°	5,100 (1.8%)	**19,200** **(3.2%)**	31,400 (3.1%)
2°	**11,400** **(4.1%)**	27,400 (4.6%)	43,600 (4.3%)

Why are these damages so high?

- Very expensive to drive emissions to zero
  - Social cost of carbon is \$218 in 2110 in 3°C scenario
- Damage from a ton of emission is spread out across centuries
- Emission (ton) in 2015 causes about \$1160 of undiscounted damage but has a present value of just \$17

What are measured damages by sector?

- Market: Agriculture, coasts, energy, forestry, water
- Nonmarket: health, ecosystems
- Effects include mean climate change and extreme events
- Two catastrophes included: slowing ocean circulation and melting West Antarctic Ice Sheet

Assumptions

- Assume carbon dioxide fertilization
  - Confirmed by laboratory experiments
  - Consistent with ecosystem change over last million years
  - Built into modern ecosystem models
- Assume efficient private adaptation:
  - Benefit of change in behavior or investment exceeds cost
  - Predicted behavior for profit maximizing and utility maximizing individuals
  - Lowers damage by average factor of 4

Public Adaptation

- Public adaptation has many joint beneficiaries
- Examples include pollution control, pubic health, conservation, coastal protection
- Assume governments will do public adaptation efficiently
  - Governments poor record of efficiency
  - But more likely to do adaptation efficiently than mitigation since it directly serves constituents

Annual Market Impacts (billion USD)

Sector	2065	2110	2155
Temperature	2°C	3°C	4°C
Agriculture	55 (30)	-25 (100)	-125 (200)
Forestry	4 (2)	8 (4)	0 (8)
Water	-20 (25)	-60 (50)	-120 (100)
Coastal	-40 (20)	-300 (150)	-500 (250)
Energy	-15 (10)	-50 (50)	-100 (100)

Annual Nonmarket Impacts (billions USD)

Sector	2065	2110	2155
Temperature	2°C	3°C	4°C
Storms	-10 (5)	-50 (25)	-100 (50)
Ecosystems	5 (20)	10 (25)	-30 (100)
Health	0 (50)	-50 (100)	-100 (200)
Ocean Circulation	2.5 (2.5)	-50 (50)	-250 (400)
Melting Ice Sheets	-20 (50)	-150 (200)	-250 (400)

Aggregate Impacts (billions USD)

Sector	2065	2110	2155
Temperature	2°C	3°C	4°C
TOTAL	-39 (86)	-717 (302)	-1575 (703)
(% of GDP)	-0.02% (0.04%)	-0.14% (0.06%)	-0.16% (0.07%)

Annual Damage Gap (billions USD)

Temperature Target	Needed Damage	Likely Damage	Damage Gap
2°C	$11,400	$39	$11,300
3°C	$19,200	$717	$18,500
4°C	$24,000	$1,575	$22,500

Damage Gap

- Huge discrepancy between damage that is needed to justify targets and damage we can predict
- Very unlikely that damage can be found to justify 2°C target- too soon and too marginal
- Higher targets involve far future events and more significant temperature signal- may find damage- but there is a lot of missing damage

Policy Implications

- Nordhaus 1991 conclusion still holds- purpose of climate policy is to slow the accumulation of greenhouse gases
- Policies to terminate greenhouse gas emissions are premature
- Adaptation is going to have to be actively pursued
- We have time to create efficient global governance of climate change