# External Costs of Climate Change

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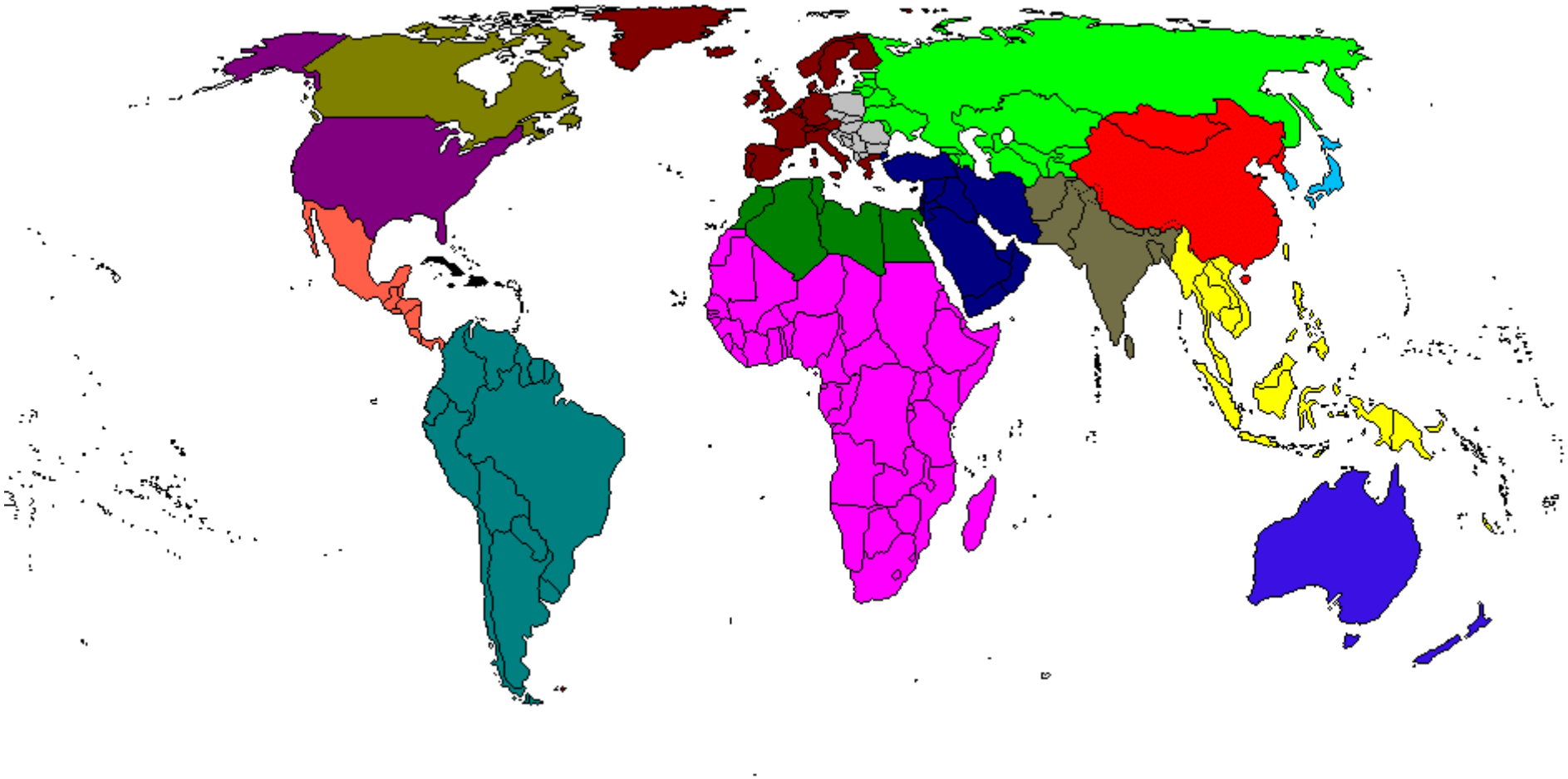
# FUND2.8

- The Climate Framework for Uncertainty, Negotiation, and Distribution, version 2.8
- FUND is an integrated assessment model, coupling demographics, economy, technology, carbon cycle, climate, and climate change impacts, so as to derive insights into climate policy
- The model has been in operation since 1994, has been reviewed, compared, assessed and used to advice EC, UN, US, UK, and banks, utilities and insurers

# FUND2.8 Impacts

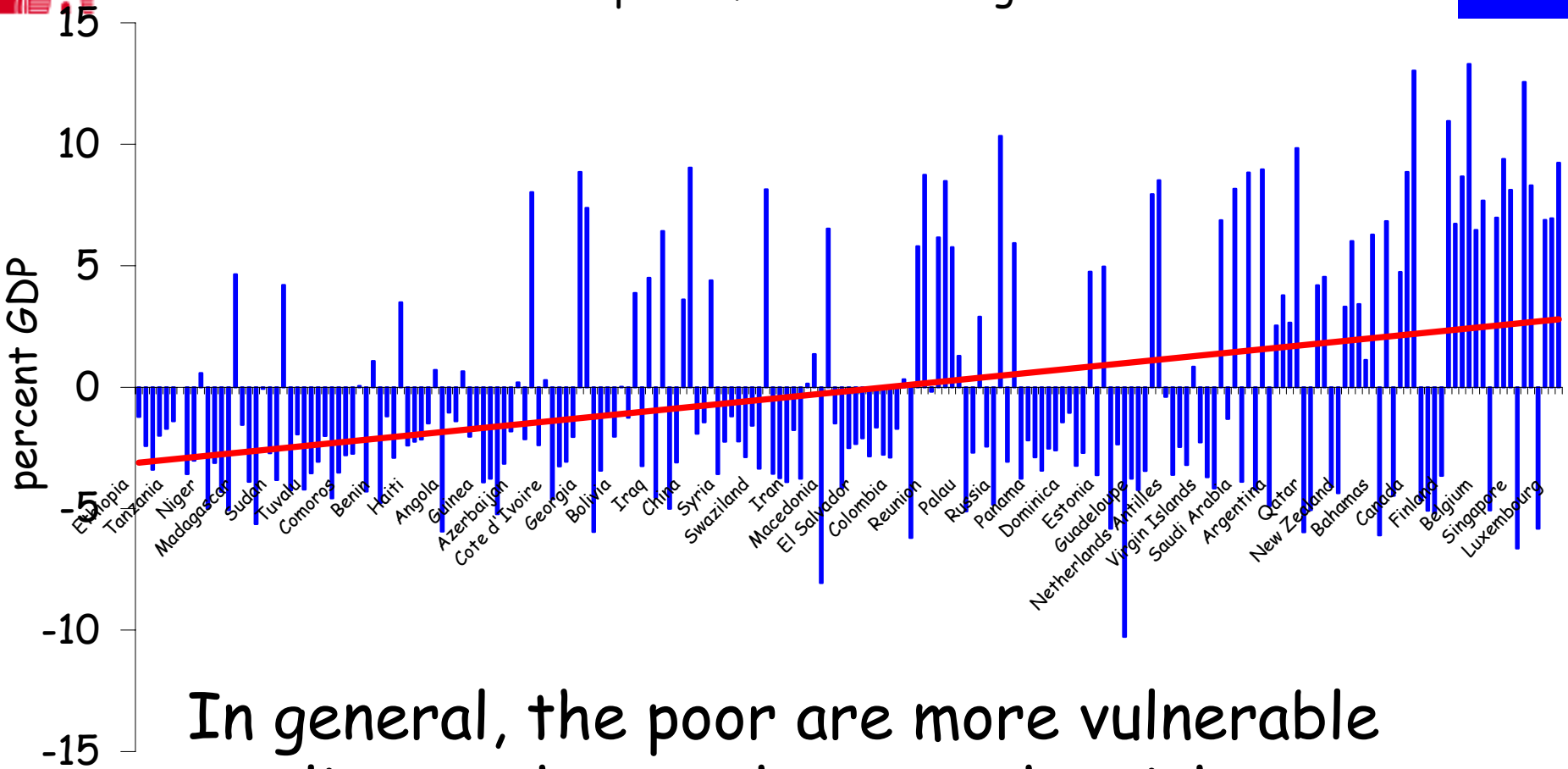
- FUND2.8 includes sea level rise, energy consumption, agriculture, forestry, water resources, cardiovascular and respiratory diseases, malaria, dengue fever, schistosomiasis, diarrhoea and ecosystems
- Other impacts are unknown
- Reduced forms of more complex models
- Valued using standard monetary valuation methods, particularly benefit transfer
- Vulnerability changes with development
- Up to 2300, 16 world regions / 207 countries



The 16 regions of FUND2.5 and higher

Note: Small Island States are a separate region.

## Monetised impact of climate change in 2050




In general, the poor are more vulnerable to climate change than are the rich, because of higher exposure and limited adaptive capacity.

# Marginal Damage Costs

- The marginal damage cost is the damage done by an additional tonne of CO2 emitted
- It is the change in the net present value of the monetised impacts, normalised by the change in emissions
- The marginal damage cost is the Pigou tax – it says how much we should spend on climate policy, by how much we should raise energy prices
- It is a normative concept; it tells us what to do

# Marginal Damage Costs -2

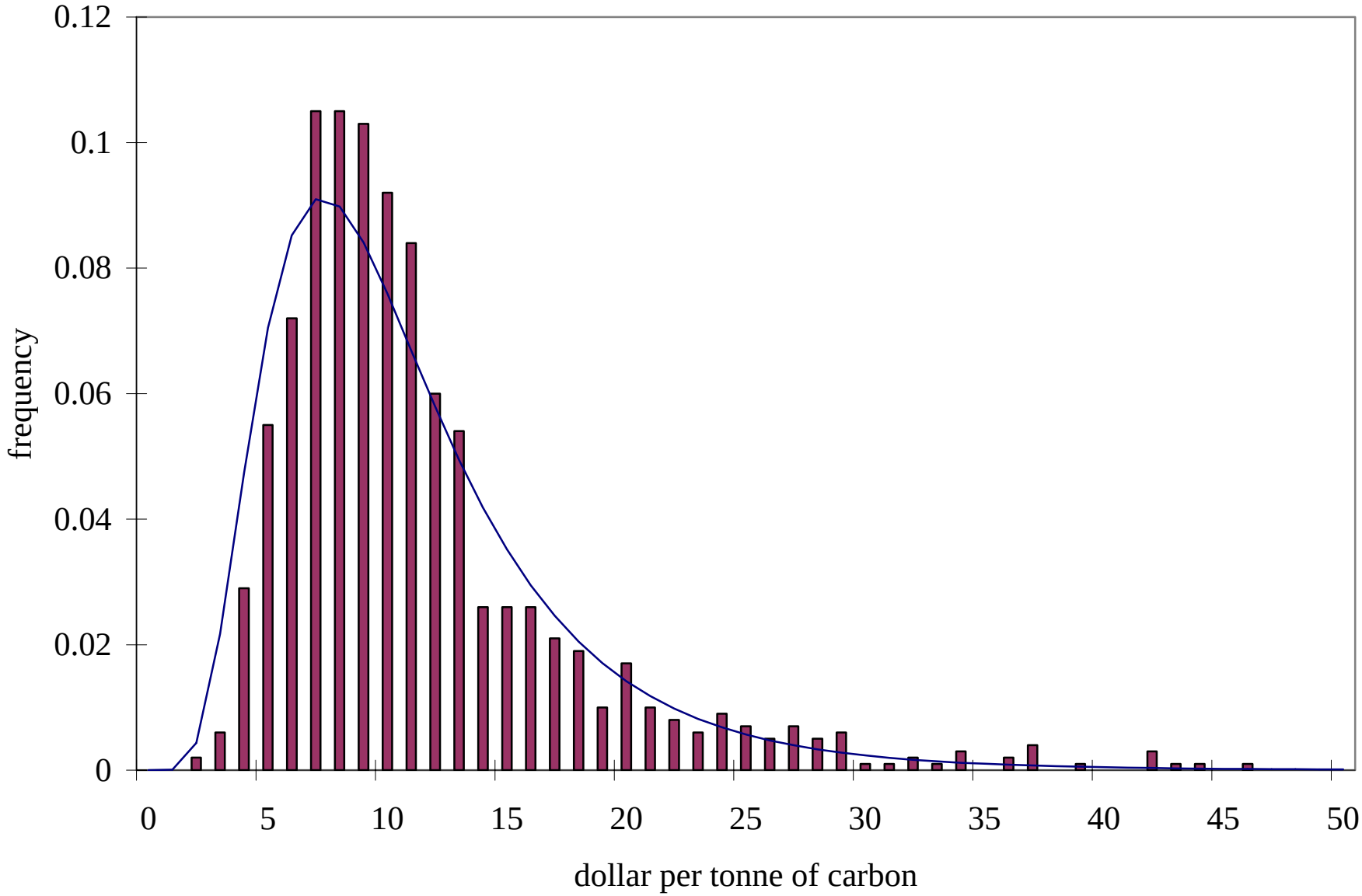
- The marginal damage cost is also a normative concept in that one cannot calculate it without making assumptions about values
- First, how much do we care about the future?
- Second, how much do we care about what happens in foreign lands?
- Third, how much do we care about risk?
- The answers to these questions are partly constrained by our behaviour in other issues, but they also depend on ethics

# Estimates

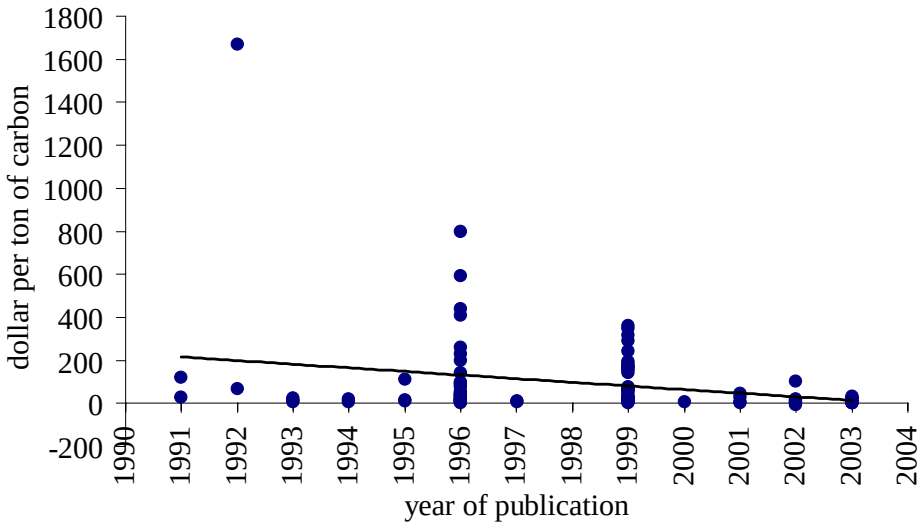
- Even if we fix the ethical position, there is no single estimate of the marginal damage costs of climate change
- Climate change impact research is large and active; insights constantly change, and with every update of the model, estimates change by 10-20%
- Emission scenarios, climate change, and impacts are all very uncertain
- Marginal damage cost estimates provide guidance, are no prescription; always interpret and use with caution

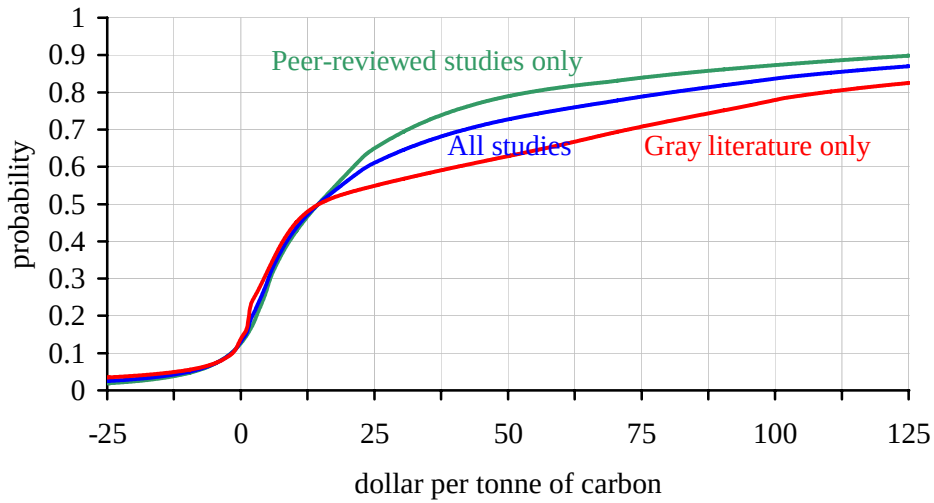
# Marginal cost estimates

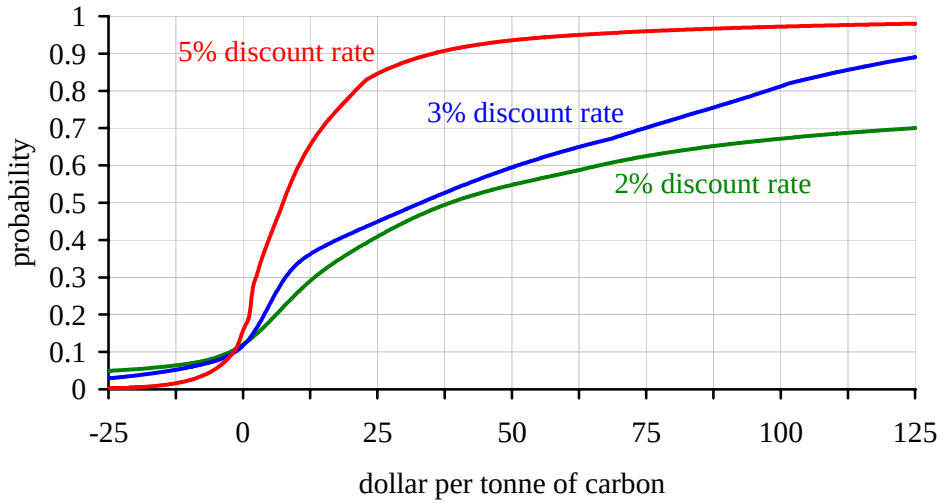
| | | 0% | 1% | 3% |
|---|---|---|---|---|
| Nordhaus 1994 | BG | | | 5 |
| | EV | | | 12 |
| Fankhauser 1994 | EV | | 20 (6-45) | |
| Tol 1999 | BG | 73 | 23 | 9 |
| | EW | 171 | 60 | 23 |
| | EVW | 244 | 82 | 35 |
| | | (143) | (51) | (22) |
| Downing 2000 | BG | 75 | 46 | 16 |
| Tol 2000 | BG | 20 | 4 | -7 |

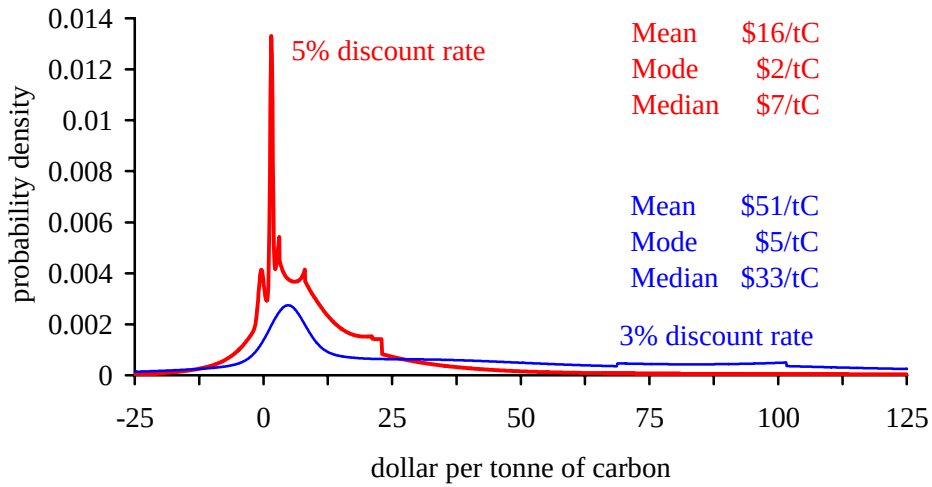

0.12
0.1
0.08
0.06
0.04
0.02
0
frequency
0
5
10
15
20
25
30
35
40
45
50
dollar per tonne of carbon

# A Meta-Analysis of the Marginal Damage Costs



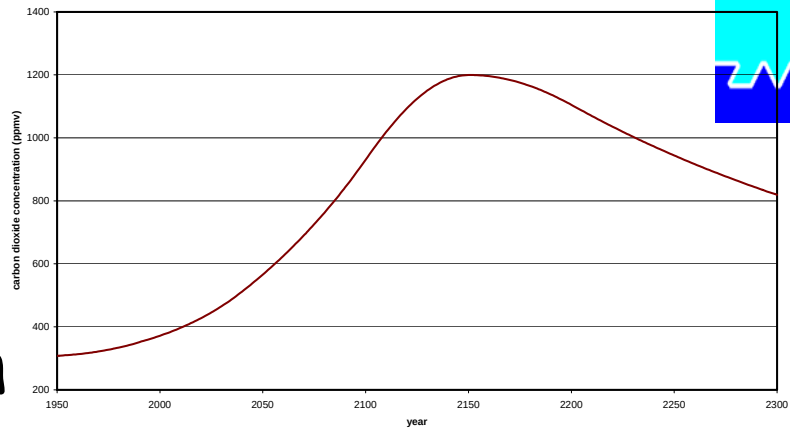



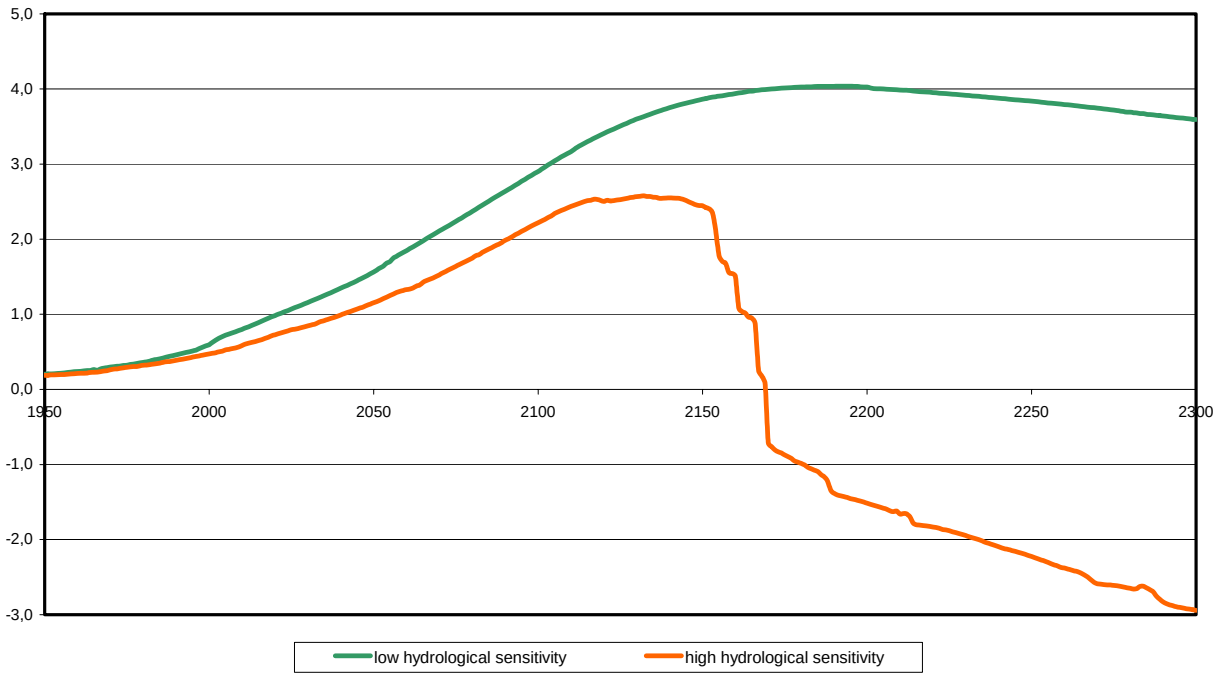
# Caveats

- Great uncertainty about climate change and its impacts
- Valuation of non-market impacts, particularly nature, is difficult
- Aggregation over space and time is controversial
- Most impact studies are static, ignore changes in vulnerability
- Indirect and interaction effects ignored
- Estimates are incomplete
- Small probability / high impact scenarios are omitted

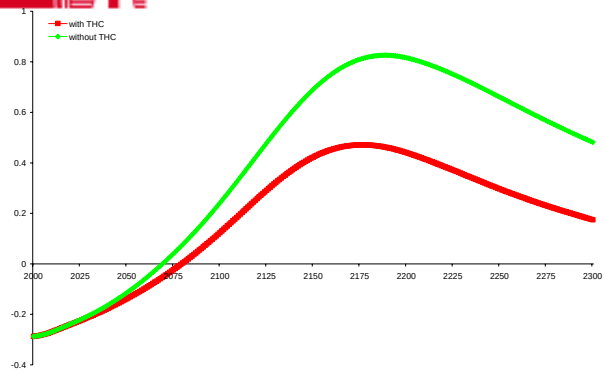
# Today, everyone's favourite bogeyman is the collapse of the thermohaline circulation



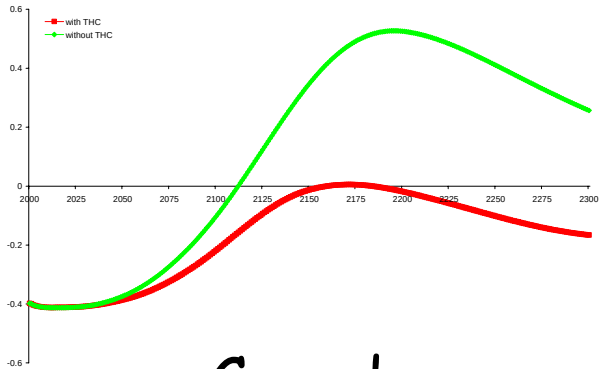

CO2 concentration



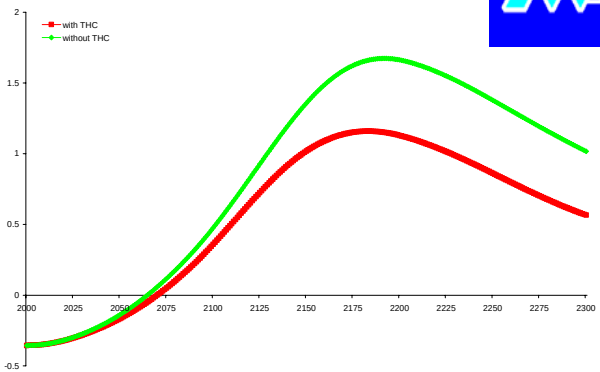

Winter surface air temperature over the North Atlantic Ocean at 56°N (after Rahmstorf & Ganopolski, 1999)



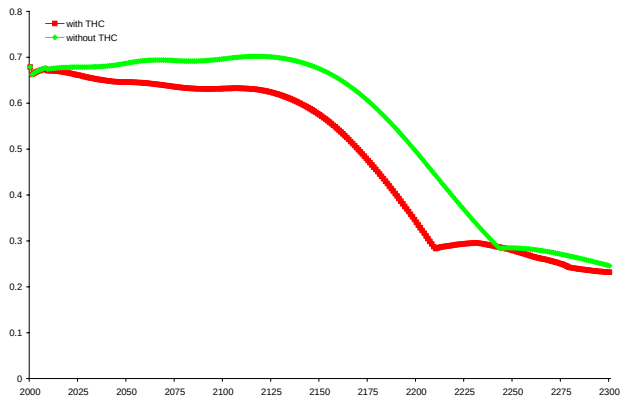

USA

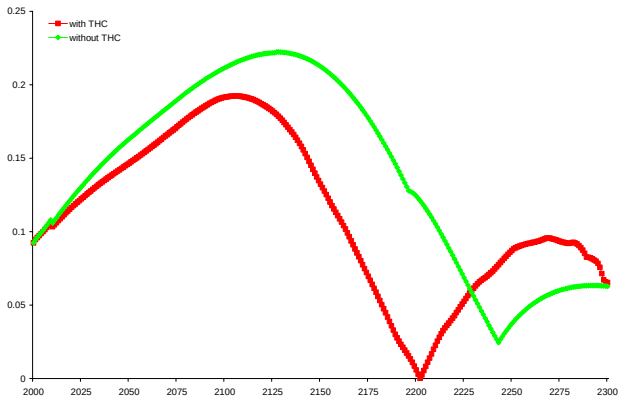


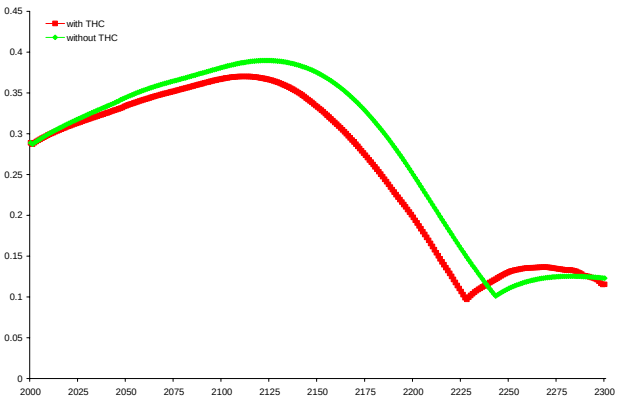

Canada



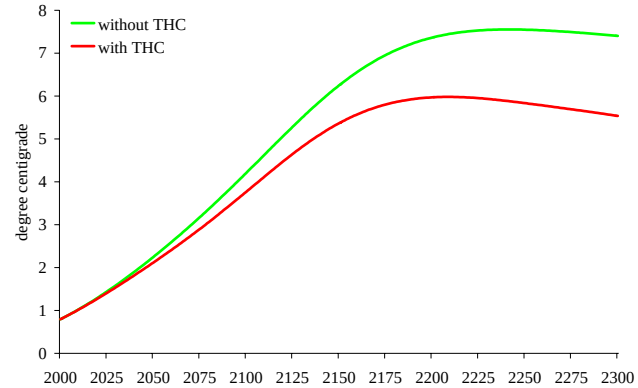

W-Europe



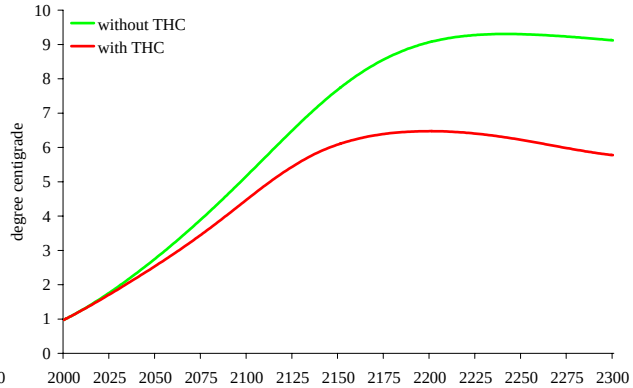



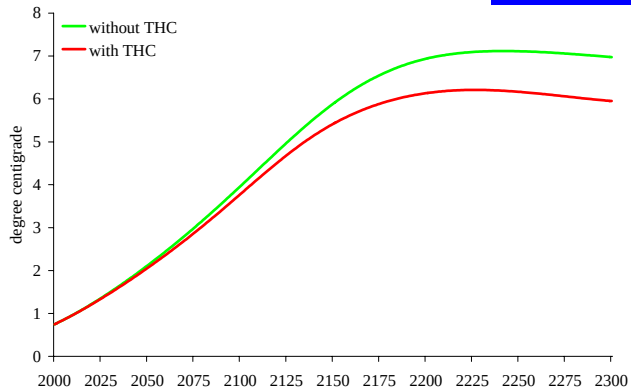

Annual damage costs (%GDP) of climate change in the Atlantic regions of FUND; top: market; bottom: non-market impacts




USA




Canada

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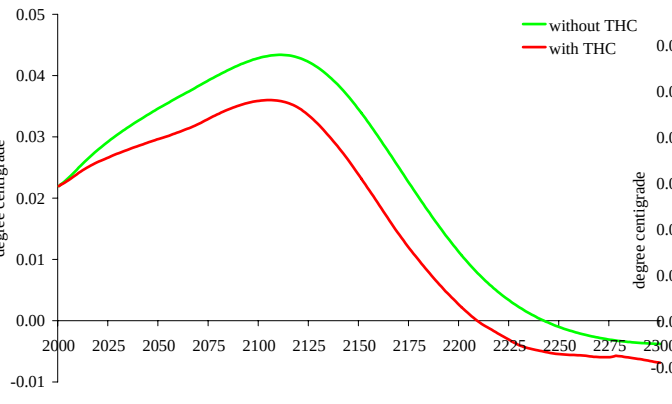
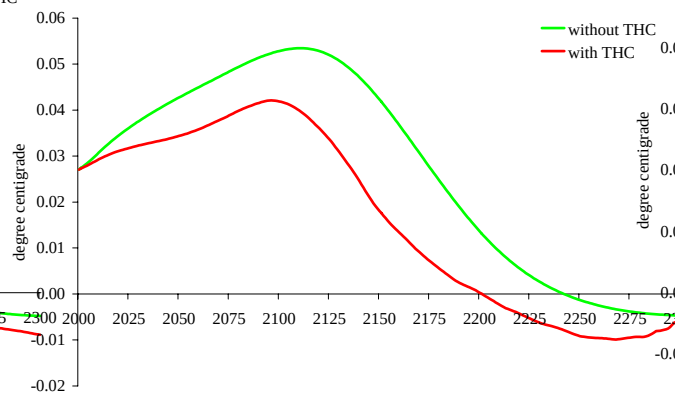
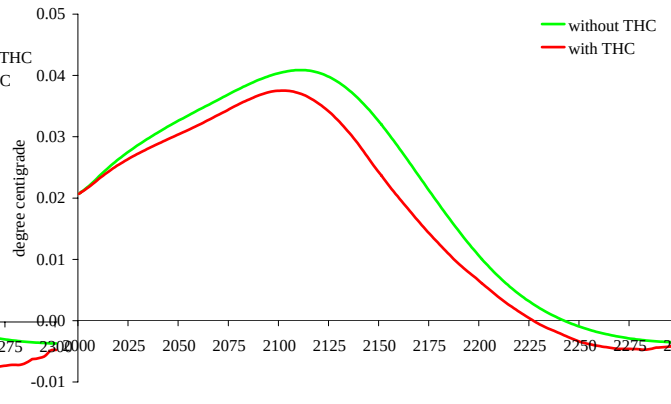



Annual mean surface air temperature over the Atlantic regions of FUND (top) and its rate of change (bottom)

# Extreme scenarios

| Case | $/tC | £/tC |
|---|---|---|
| Base | 18 | 10 |
| THC | 17 | 9 |
| Younger Dryas | 20 | 11 |
| 2689 MT CH4 | 23 | 13 |
| 8667 MT CH4 | 30 | 17 |
| 4.5 | 101 | 56 |
| 7.7 | 269 | 149 |
| 9.3 | 359 | 199 |

# Discounting

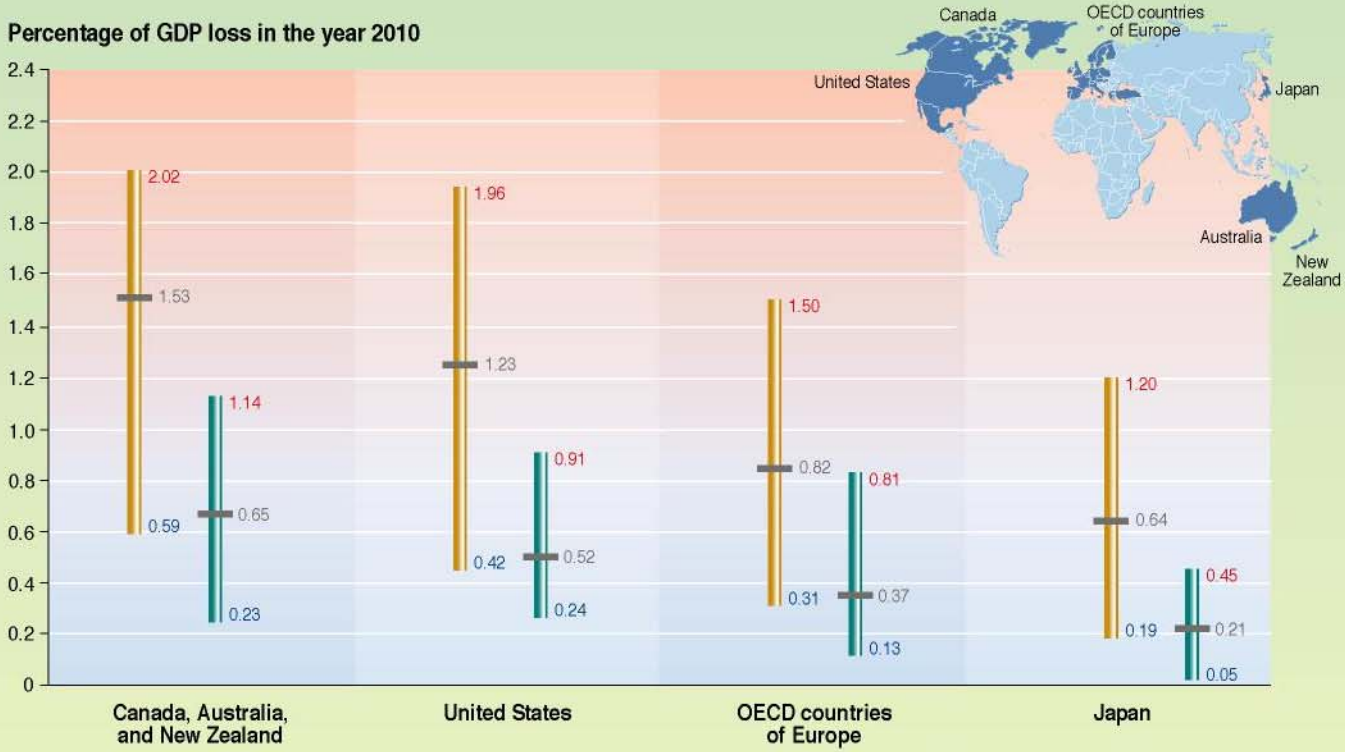
- Recently, arguments emerged that the discount rate should not be constant, but fall as the time horizon expands

| Constant | $/tC | £/tC |
|---|---|---|
| 2% | 58 | 32 |
| 3% | 11 | 6 |
| 5% | -2 | -1 |
| Declining | | |
| Greenbook | 18 | 10 |
| Weitzman | 88 | 49 |

# Conclusion

- External costs of carbon dioxide can be estimated, but
- … They are incomplete, with unknown bias
- … They are highly uncertain, primarily because impacts occur in a distant future
- … They are strongly dependent on ethical assumptions on discounting and aggregation
- Nonetheless, the estimates provide some guidance for policy
- Alternatively, one may look at avoidance costs

# Projections of GDP losses in Annex II countries in the year 2010 from global models




**Range of outcomes for two scenarios**

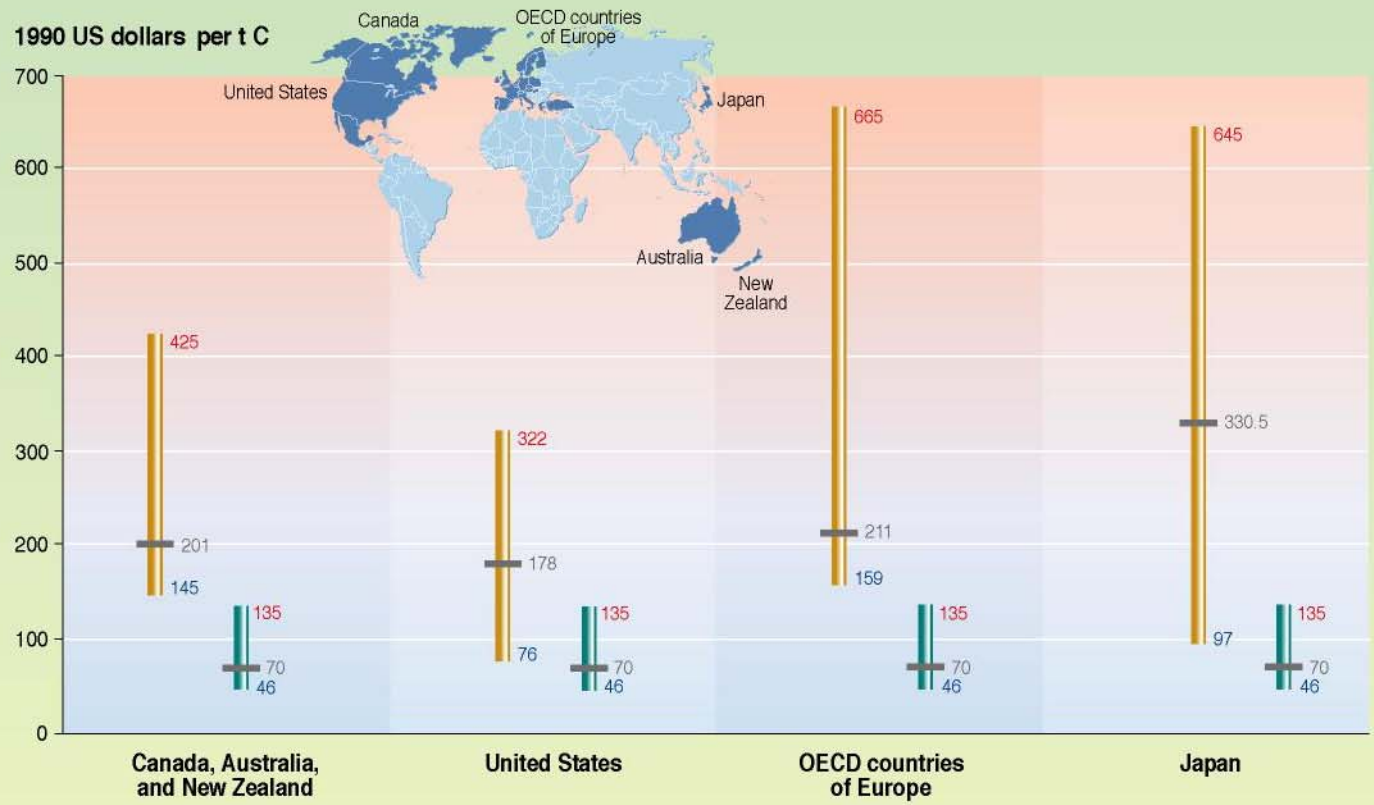
Absence in international trade in carbon emissions rights: each region must take the prescribed reduction

Full annex B trading of carbon emissions rights permitted

The three numbers on each bar represent the highest, mean, and lowest projections from the set of models.

SYR - FIGURE

# Projections of marginal cost in Annex II countries in the year 2010 from global models

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SYR - FIGUR

# The costs of a 25% emission reduction from baseline, decomposed

| | Japan | EU | USA | Canada |
|---|---|---|---|---|
| C-price | 323 | 205 | 231 | 127 |
| Loss (%) | 15 | 2.2 | 0.5 | 1.1 |
| Loss (bln $) | 48 | 160 | 43 | 7 |
| *Direct* | 11 | 23 | 43 | 3 |
| *Distortion* | 28 | 109 | 0 | 3 |
| *Oil markets* | 0 | -1 | -3 | 0 |
| *Other goods* | 0 | -2 | -1 | 0 |
| *Capital* | 1 | 0 | -1 | 0 |
| *Other* | 10 | 20 | 5 | 1 |

Paltsev et al., 2004