“Uncertainty, Ethics, and the Economics of Climate Change”

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Introduction

Climate change is a problem that involves long time horizons and fundamental uncertainties

- This raises core issues of intergenerational fairness: How to balance the short-run costs and long-run benefits of climate stabilization?
- The U.N. Framework Convention on Climate Change (1992) calls for “the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent ***dangerous anthropogenic interference*** with the climate system”
- With Kyoto set to expire, one question is whether the upcoming Copenhagen climate summit will lead to an effective and durable agreement

In this presentation I'll advance two main arguments – deep cuts in greenhouse gas emissions are justified by:

1. A rights-based approach to questions of intergenerational fairness (the "fair-sharing principle")

   - Key idea – future generations are entitled to protection against potentially catastrophic environmental risks

2. The appropriate framing of uncertainty in the economics of climate change

   - Emissions reductions are a form of insurance. Relatively small investments in climate stabilization can substantially reduce risks to future lives and livelihoods

Framing the Issue

The Earth's temperature has risen by 0.8°C since 1900. Additional increase of 1.2-5.6°C is likely to occur by 2100 (IPCC, 2001)

The Millennium Ecosystem Assessment (2005) calls for stabilizing mean global temperature at a level 2°C above the pre-industrial norm

- This would require emissions reductions of >50% relative to current levels with full participation by developing countries
- A 2°C would be the warmest climate in the last three million years, when sea level was 25-35m higher than today (Hansen *et al*., 2006)
- Hansen's latest work calls for stabilization CO_2 concentrations at 350 ppm – significantly below current levels

Emissions Abatement Costs

Climate stabilization pits short-run economic costs against long-term environmental benefits

- Stabilizing CO_2 concentrations at 550 ppm would impose costs equivalent to a permanent 1% reduction in economic output (Stern, 2007)
- Minimizing costs would require:
  - Incentive-based policies (a carbon tax or cap-and-trade scheme)
  - Efficient revenue recycling
  - Mechanisms to promote the development and implementation of low-carbon technologies

Climate Change Impacts

Potential impacts: Biodiversity loss, storm intensification, changes in crop yields, sea-level rise, floods, droughts, spread of tropical diseases

- By 2050, 15-34% of terrestrial species may be committed to extinction due to anthropogenic climate change (Thomas *et al.*, 2004)
- Early estimates suggested that a doubling of greenhouse gas concentrations might impose costs equivalent to 1.75% of world economic output (IPCC, 1996)
- But catastrophe scenarios are also possible. An expert opinion survey by Nordhaus (1994) suggested a 5% probability that costs would exceed 25% of economic output

Climate Change Meets Environmental Justice

The distribution of emissions control costs raises thorny issues of equity

- Protecting poor households from regressive increases in energy costs
- How should emissions rights be divided between industrialized and developing countries?

But climate change impacts will fall hardest on the poor

- October 1998: Hurricane Mitch → torrential rains, mudslides, and flooding in Central America. Over 11,000 people died, with $5 billion in property damage (McCown *et al*., 1999)

Rights-Based Ethics

As I've noted, the UNFCCC calls for stabilizing greenhouse gas concentrations to “prevent dangerous anthropogenic interference with the climate system”

- This language lies behind the 2°C temperature target favored by the Millennium Ecosystem Assessment + the aggressive emissions control policies endorsed by the EU and the Obama Administration
- Economists such as Nordhaus, Mendelsohn, and Tol argue that this language is vague and inconsistent with welfare maximization
- Key point: The goal of climate stabilization is well-supported by rights-based ethical principles

The Fair-Sharing Principle

Thomas Jefferson (1789): “The earth belongs in usufruct to the living”

This approach:

1. Extends the Public Trust Doctrine to cover the interests of future generations

2. May be derived from a commitment to equality of opportunity (egalitarian liberalism

The Fair-Sharing Principle (Howarth, 2007): **“**Each member of present and future society is entitled to share fairly in the benefits derived from environmental resources. Specific stocks of environmental resources should not be depleted without rendering just compensation to members of future generations”

The Fair-Sharing Principle implies a moral duty to stabilize climate

- Stern (2007): Failing to stabilize climate would impose long-run costs equivalent to 5-20% of economic output
  - ➢ These costs involve pervasive threats to lives and livelihoods
- Climate stabilization → relatively small, short-run economic costs: Marginal reductions in consumption and GDP growth
- The Fair-Sharing Principle implies that present society has no right to impose major, uncompensated harms in the pursuit of modest gains
- Bromley (1989): Property rules (→ prevention of harm) are an appropriate response to long-term problems involving fundamental uncertainty

The Nordhaus DICE Model

Nordhaus (1992, 2008) has long opposed the goal of cutting greenhouse gas emissions to stabilize climate

- Nordhaus' DICE model:
  - Integrates the costs and benefits of climate change policy into a standard optimal growth framework
  - Calibrates time preference based on the average rate of return on global stock markets (~6% per year)
  - Calculates optimal emissions abatement rates given the assumption of perfect foresight
- The "policy ramp": In the short-run, only modest steps towards greenhouse gas emissions control are economically warranted
  - It's better to bear the future costs of climate change than the short-run costs of climate stabilization

The Ethics of DICE

The DICE model rests on strong ethical assumptions

- It discounts the welfare of future generations at a rate of 3% per year (95% per century), privileging the interests of present society
  - Why? In this model, lower discount rates imply higher rates of economic growth than those observed in the real world
  - People act “as if” they attached relatively little weight to the welfare of their children and grandchildren
- Stern (2007) shows that attaching equal weight to present and future welfare supports deep cuts in greenhouse gas emissions
  - But Stern’s approach also suggests that current consumption should be reduced to provide increased investment and higher rates of economic growth

DICE Meets Dynamic Stochastic Growth

Suppose, however, that we embraced Nordhaus' ethical stance but revised his model to consider risk and uncertainty (Gerst, Howarth, and Borsuk, in review). Households seek to maximize:

$$W = E\left[\sum_{t=0}^{\infty}\left(\ln(N_t) + \ln(c_t)\right)/(1+\rho)^t\right]$$

Production possibilities:

$$Y_t \equiv A_t K_t^{a} N_t^{1-a}(1 - d(T_t)(1 - c(\mu_t)) = N_t c_t + K_{t+1}$$

Total factor productivity (A_t) and population (N_t) follow random walks over time. $d(T_t)$ and $c(\mu_t)$ measure climate change damages and abatement costs

Given rational investment decisions, the savings rate remains fixed at the value $s = a/(1+\rho) = 0.223$ (the real-world historical average)

- Calibration approach: Choose $a = 0.231$ and $\rho = 0.003$ to match the marginal productivity of capital, measured by the 4% average return on a balanced portfolio of corporate stocks and bonds (Modigliani and Miller, 1958)

- Productivity growth can then be modeled based on growth accounting

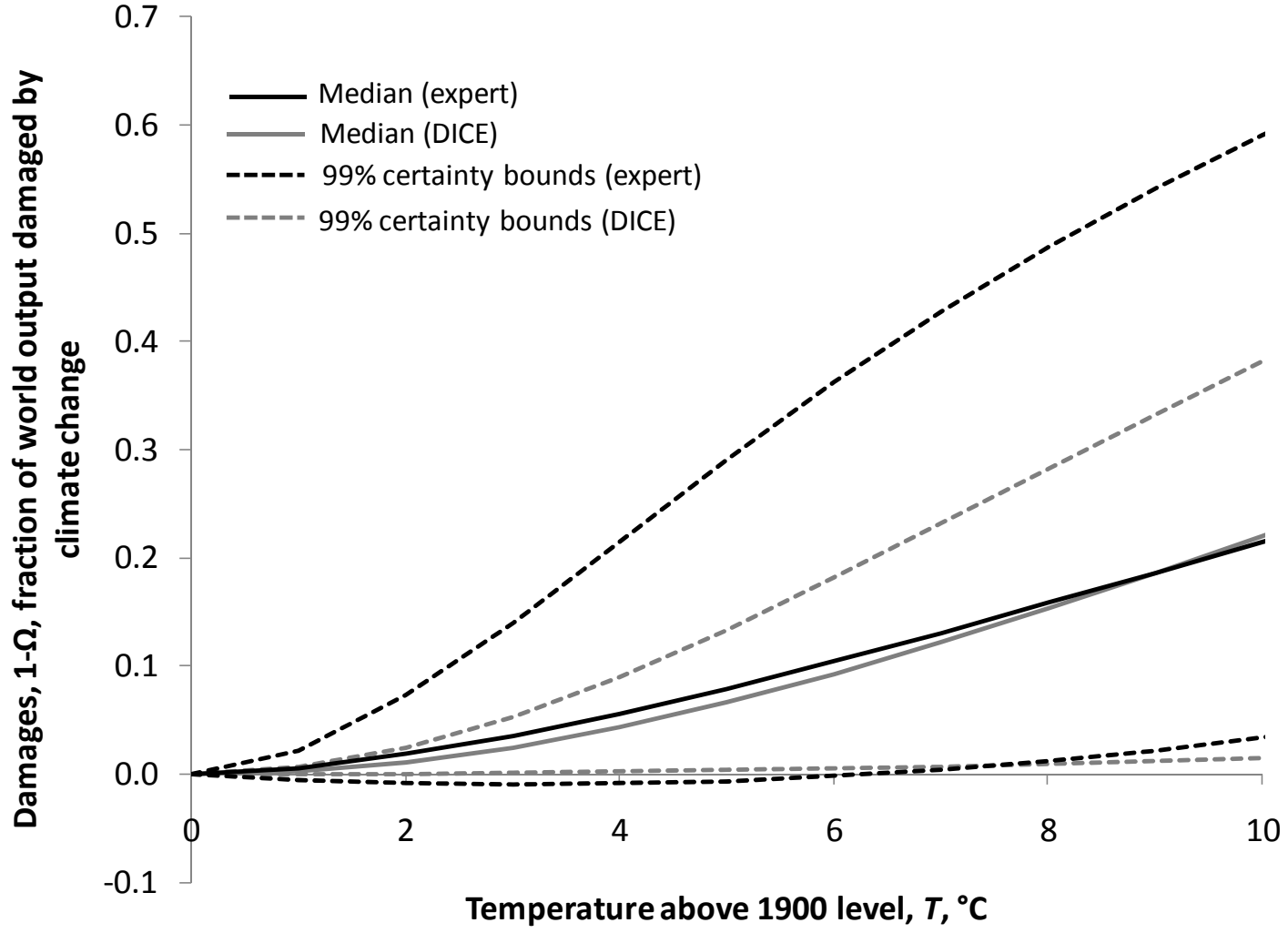
- We model population trends based on the work of Lutz *et al.* (2001) and the UN Population Division (2004)

We employ the DICE model's representation of damage costs, abatement costs, emissions trends, and climate dynamics (Nordhaus, 2008)

Two exceptions – we allow for fat-tailed distributions (Weitzman, 1998) for:

1. Climate sensitivity
    - A doubling greenhouse gas concentrations leads to a 20% chance of a 5°C temperature increase (Roe and Baker, 2007)
2. The damage cost function (Nordhaus, 1994; Rougharden and Schneider, 1999)
    - This builds on Bayesian decision theory: Using subjective probabilities based on expert opinion surveys to measure confidence in damage cost estimates

Climate Change Damage Functions



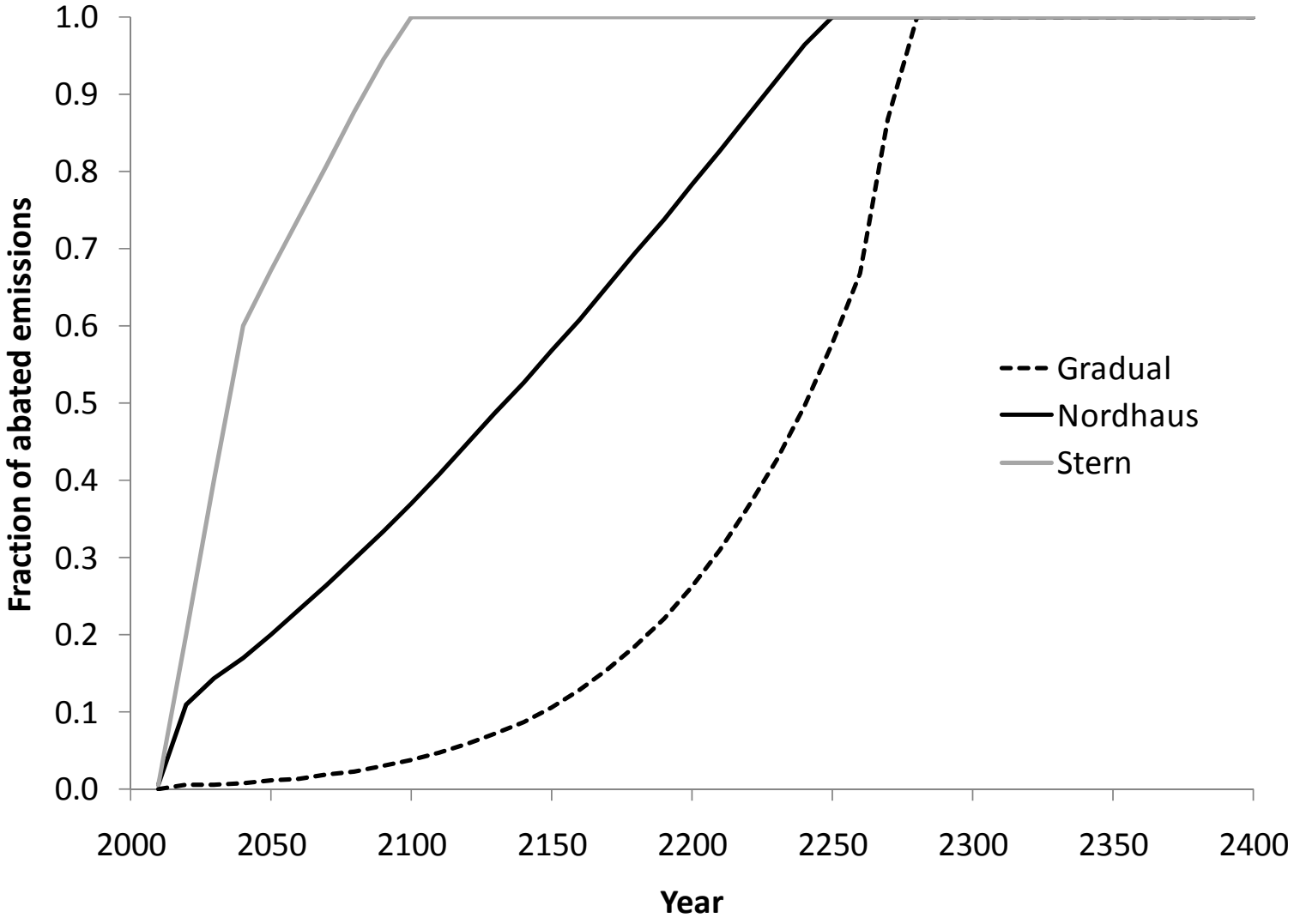
Policy Simulations

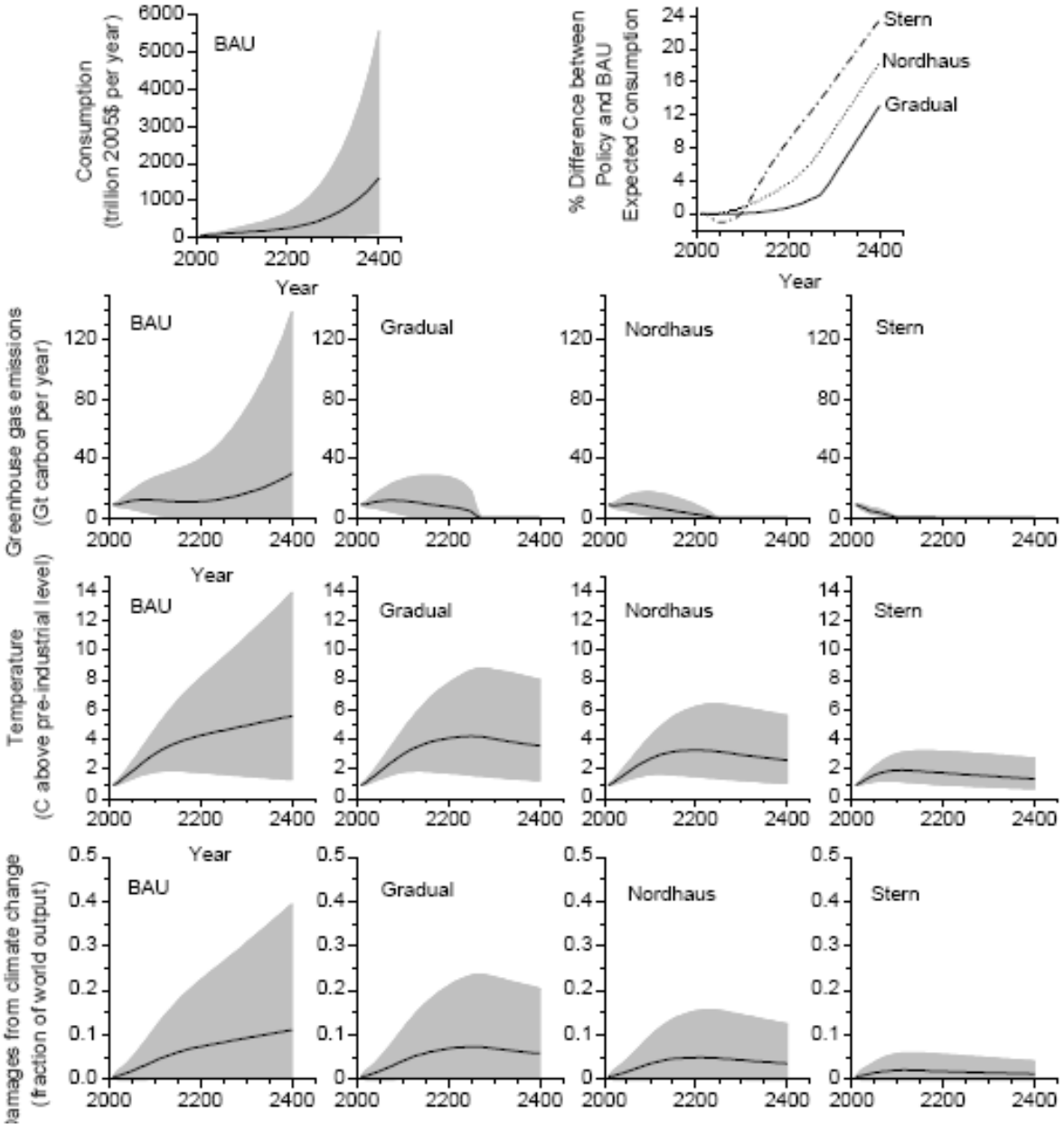
We conduct Monte Carlo simulations for four policy regimes described by Nordhaus (2008):

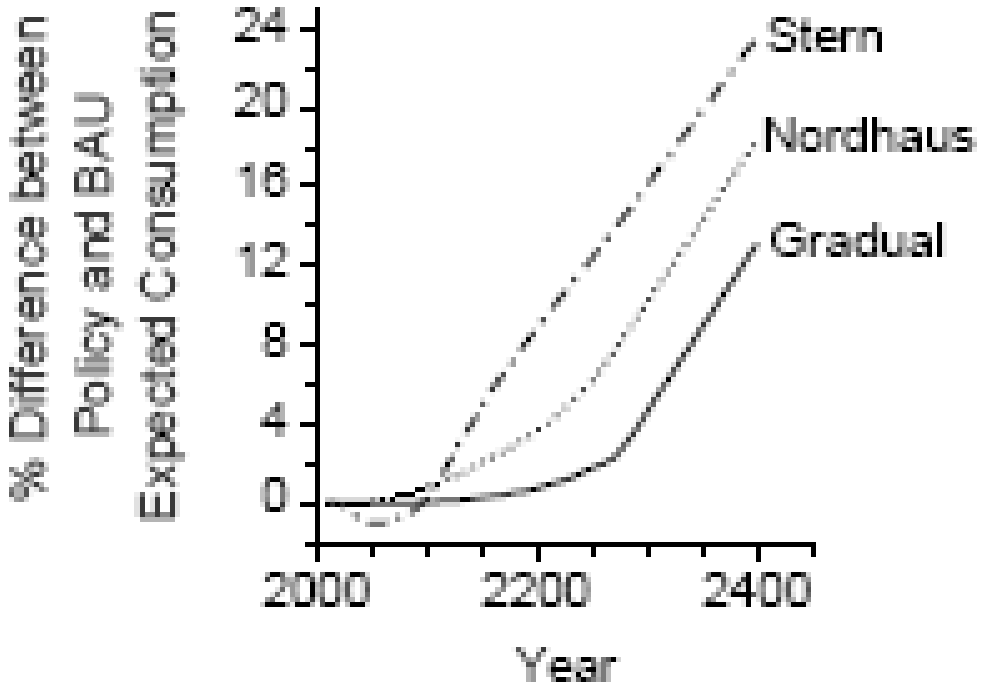
1. Business-as-usual
2. Stern emissions control rates (deep emissions cuts)
3. Nordhaus emissions control rates (policy ramp)
4. Gradual (emissions controls deferred until 22^{d} century)

For this cases, we characterize:

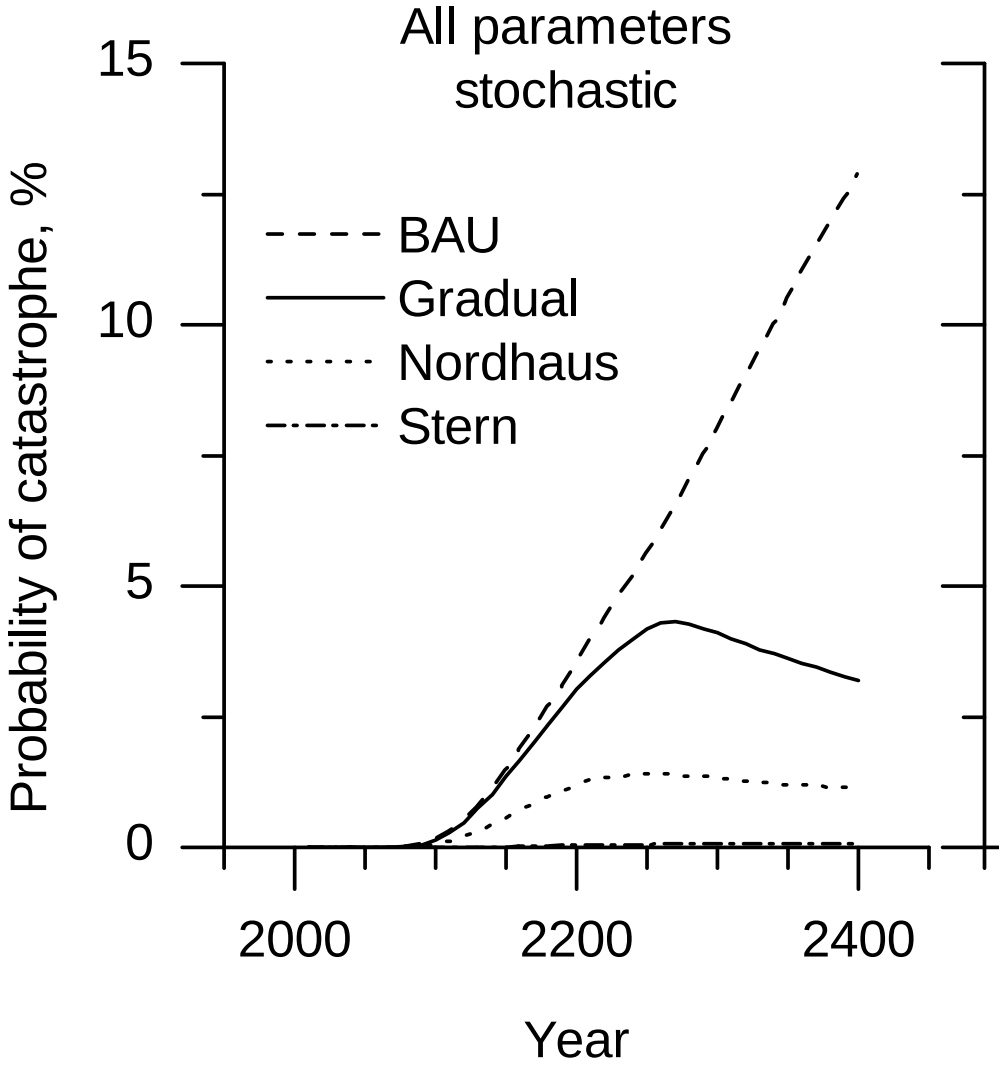
- Catastrophic risks
- Welfare effects (accounting for uncertainty)


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fraction of abated emissions
2000
2050
2100
2150
2200
2250
2300
2350
2400
Year
Gradual
Nordhaus
Stern

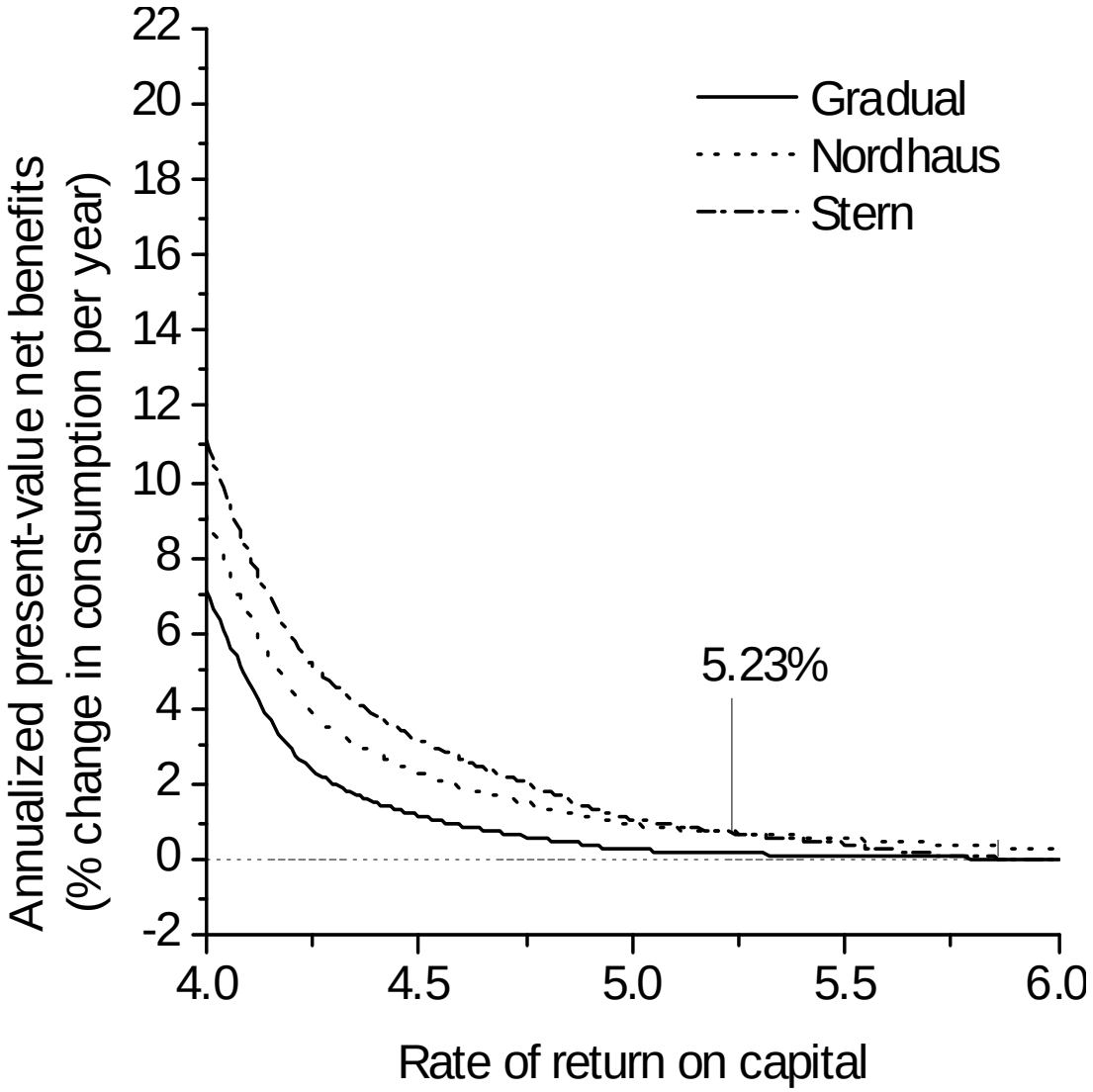

Consumption (trillion 2005$ per year)
BAU
Year
% Difference between Policy and BAU Expected Consumption
Stern
Nordhaus
Gradual
Greenhouse gas emissions (Gt carbon per year)
Temperature (C above pre-industrial level)
Damages from climate change (fraction of world output)
BAU
Gradual
Nordhaus
Stern


% Difference between
Policy and BAU
Expected Consumption
24
20
16
12
8
4
0
2000
2200
2400
Year
Stern
Nordhaus
Gradual

Probability of Catastrophe: Climate Change Damages Exceed 25% of Economic Output



Net Benefits of Emissions Control (% of BAU Consumption)



Conclusions

Key conclusion of this presentation – deep cuts in greenhouse gas emissions are justified by both:

1. A rights-based approach to intergenerational fairness
2. The appropriate framing of risk and uncertainty in integrated assessment models

- Pushed to choose, I'd emphasize rights-based ethics as the best way to approach this issue
- But important insights emerge by de- and reconstructing standard economic models