Discounting for Time and Risk in Climate-Change Policy Analysis*

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* Based in part on joint work with Michael Gerst and Mark Borsuk

Introduction

The economics of climate change has generated rich literatures on a broad array of topics

- One key, long-standing question: How to balance the short-run costs and long-run benefits of climate stabilization?

- Stern (2007) and Nordhaus (2008) agree that public policies should aim to maximize the discounted sum of present and future welfare:

$$W = \sum_{t=0}^{\infty} N_t \frac{1}{1-\alpha} c_t^{1-\alpha} /(1+\rho)^t$$

- They disagree over the pure rate of time preference (ρ) and the elasticity of marginal utility (α)

Stern assumes that $\alpha = 1$ so that utility is logarithmic in consumption

- His key argument is that equal weight should be attached to the welfare of present and future generations

- Allowing for the low probability that an asteroid collision will lead to the extinction of our species, he therefore assumes that $\rho = 0.1$ %/year

Nordhaus assumes that households make individually rational savings-investment decisions given perfect foresight regarding future returns on investment

- Ramsey's rule:

$$1 + r = (1 + \rho)(1 + g)^{\alpha} \quad \Rightarrow \quad r \approx \rho + \alpha g$$

- Nordhaus assumes that:

r = 6% per year
g = 2.25% per year
α = 2

- Hence ρ = 1.5 %/year

This difference in parameters is critical to climate change policy

- Stern's approach is consistent with the 2ºC temperature change target embodied in the Copenhagen Accord, supporting sharp, short-term reductions in fossil fuel consumption

- Nordhaus favors a "policy ramp" approach in which major emissions reductions are deferred for several decades

My argument in this talk: The Stern/Nordhaus debate focuses on the value of two parameters in a modeling framework that is descriptively problematic

- This replicates the 1992 debate between Cline and Nordhaus in ways that abstract away from key aspects of the earlier literature on discounting and intertemporal choice (see Lind, *Discounting for Time and Risk in Energy Policy*, 1982)

I'll argue that:

- Stern's approach is easily reconstructed

- Nordhaus' analysis overlooks the (considerable) value of reducing risks to future generations

The Trouble with Stern

Stern's analysis has been criticized on the following grounds: If $\rho \approx 0$, the rate of savings and investment observed in real-world economies is far too low (see Nordhaus, 2007)

- Present consumption should be sharply reduced to increase economic growth to benefit future generations
- Parfit's (1983) *argument from excessive sacrifice* – the relatively poor people living today have no obligation to bear greater hardships to benefit future people who will (by assumption) enjoy a far higher material standard of living
- This casts doubt on both the descrptive and prescriptive basis for assuming $\rho \approx 0$

The problem here is the Ramsey growth setup – the assumption that a single parameter (ρ) captures both ***individual time preference*** and the ***ethical values*** pertaining to intergenerational conflicts

Howarth and Norgaard (1992) show how to resolve this problem – work with overlapping generations model in which:

1. Investment decisions are made by finite-lived, private individuals based on the utility derived from consumption in youth and old age

$$U_t = u(c_{ty}, c_{t+1o}) = \ln(c_{ty}) + \ln(c_{t+1o})/(1+\rho)$$

- Supporting ethical judgment: People have a right to pursue individual self-interest in markets (ρ = 0.5%/year $\Rightarrow$ realistic growth rate; see Howarth, 1998)

2. Climate change policies are based on classical utilitarianism, maximize the undiscounted sum of each generation's life-cycle well-being

$$W = \sum_{t=0}^{\infty} U_t$$

- Supporting value judgment: The climate system is a public trust resource that is jointly owned by present and future generations

- Public trust resources should be managed to attach equal weight to the interests of all beneficiaries ("the greatest good for the greatest number")

- This modeling approach supports deep cuts in greenhouse gas emissions while leaving capital investment decisions to the market (Howarth, 1998)

The Trouble with Nordhaus

As we've seen, Nordhaus' analysis is based on Ramsey's rule:

$$r \approx \rho + \alpha g$$

r = return on capital investment = 6% per year

α = elasticity of marginal utility = 2

g = consumption growth rate = 2.25% per year

What's wrong with this setup? It assumes:

1. A representative household model
2. Rational investment behavior given perfect foresight. This abstracts away from uncertainty and investor risk aversion

Suppose we accept the representative household framework but assume that that households maximize their expected utility under conditions of uncertainty:

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

Suppose that a safe asset yields the return r_{st} while a risky asset pays the return r_{rt}. Then sequentially rational behavior implies that:

$$c_t^{-\alpha} = \frac{1}{1+\rho} E_t\left[c_{t+1}^{-\alpha}(1+r_{st+1})\right] = \frac{1}{1+\rho} E_t\left[c_{t+1}^{-\alpha}(1+r_{rt})\right]$$

This model (the *Consumption CAPM*) collapses to Ramsey's rule when economic agents have perfect foresight

Empirical facts:

- Safe capital assets yield average returns of r_s = 1% per year (government bonds)

- Risky capital assets yield average returns of E[r_r] = 6% per year (the stock market)

Following Lucas (1978) and Mehra and Prescott (1985), assume:

1. Consumption growth (c_{t+1}/c_t) is i.i.d.

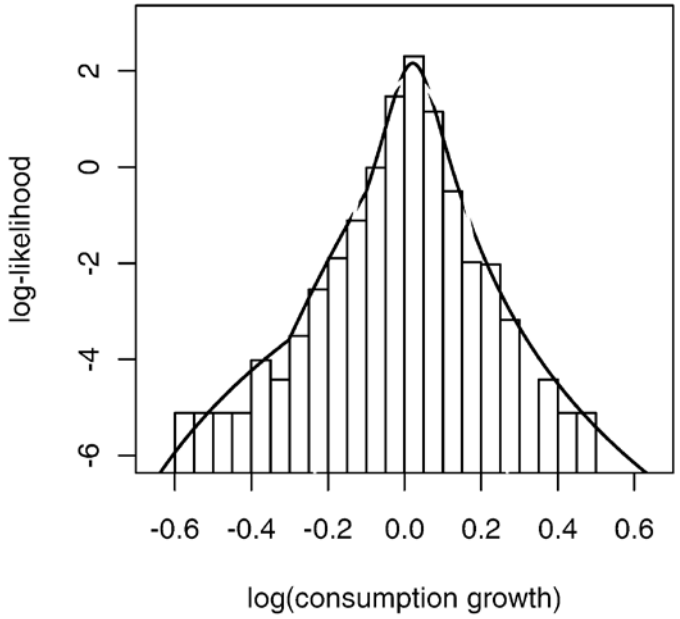
2. Returns on the risky asset are proportional to consumption growth $\Rightarrow 1+r_{rt+1} \propto c_{t+1}/c$

- These assumptions are valid in the Lucas Tree and Stochastic A-K macrofinance models (see Barro, 2006)

To complete our calibration, we draw on Barro's (2006, 2009) data on consumption growth in 24 countries in the 19th and 20th centuries

- Key point: This distribution has a fat lower tail, allowing for large consumption losses during "rare economic disasters"

- This contrasts with the Lucas/Mehra/Prescott assumption that consumption growth is log-normally distributed



Given these assumptions, the following preference parameters are consistent with observed economic behavior (see also Barro, 2006)

	Nordhaus	Gerst *et al.*
α	2	6.1
ρ	1.5%	2.6%

Note that α reflects the coefficient of relative risk aversion in the discounted utility model. Thus Nordhaus' model:

1. Understates the pure rate of time preference

2. Overstates people's willingness to bear risk

Our level of risk aversion is consistent with findings from finance and experimental economics (Heal and Kristrom, 2002; Atkinson *et al.*, 2009)

Uncertainty and DICE

How does this change in preferences affect climate stabilization policies? To find out, we constructed a stochastic version of Nordhaus' (2008) DICE model

Our model:

1. Replaces DICE's Ramsey growth model with a Lucas Tree specification in which baseline consumption follows a random walk

2. Draws on Nordhaus' (2008) assumptions concerning the distributions over uncertain parameters

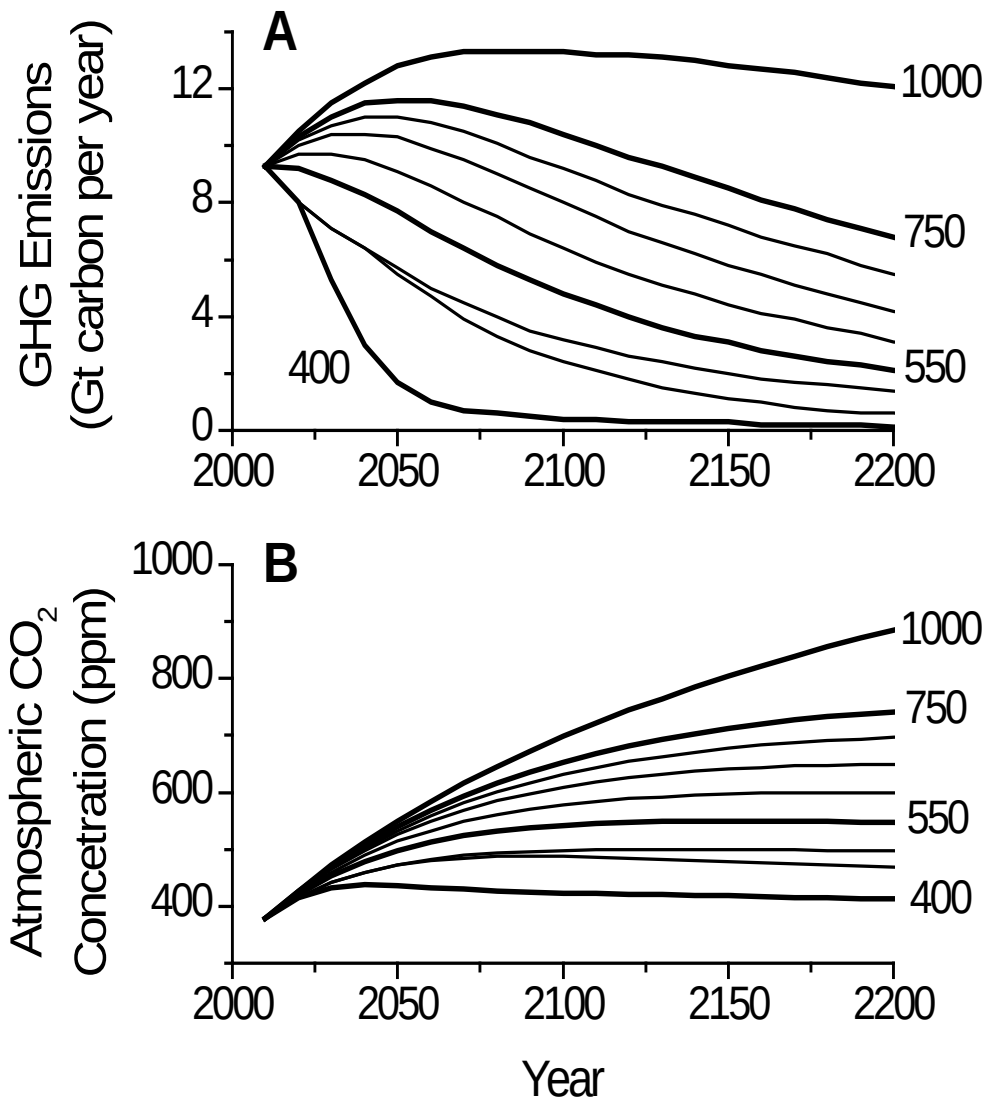
One key concern:

- Nordhaus (2008) assumes that climate sensitivity (the level of climate change caused by a doubling of greenhouse gas concentations) follows a normal distribution with mean 3°C and a standard error of 1.1°C

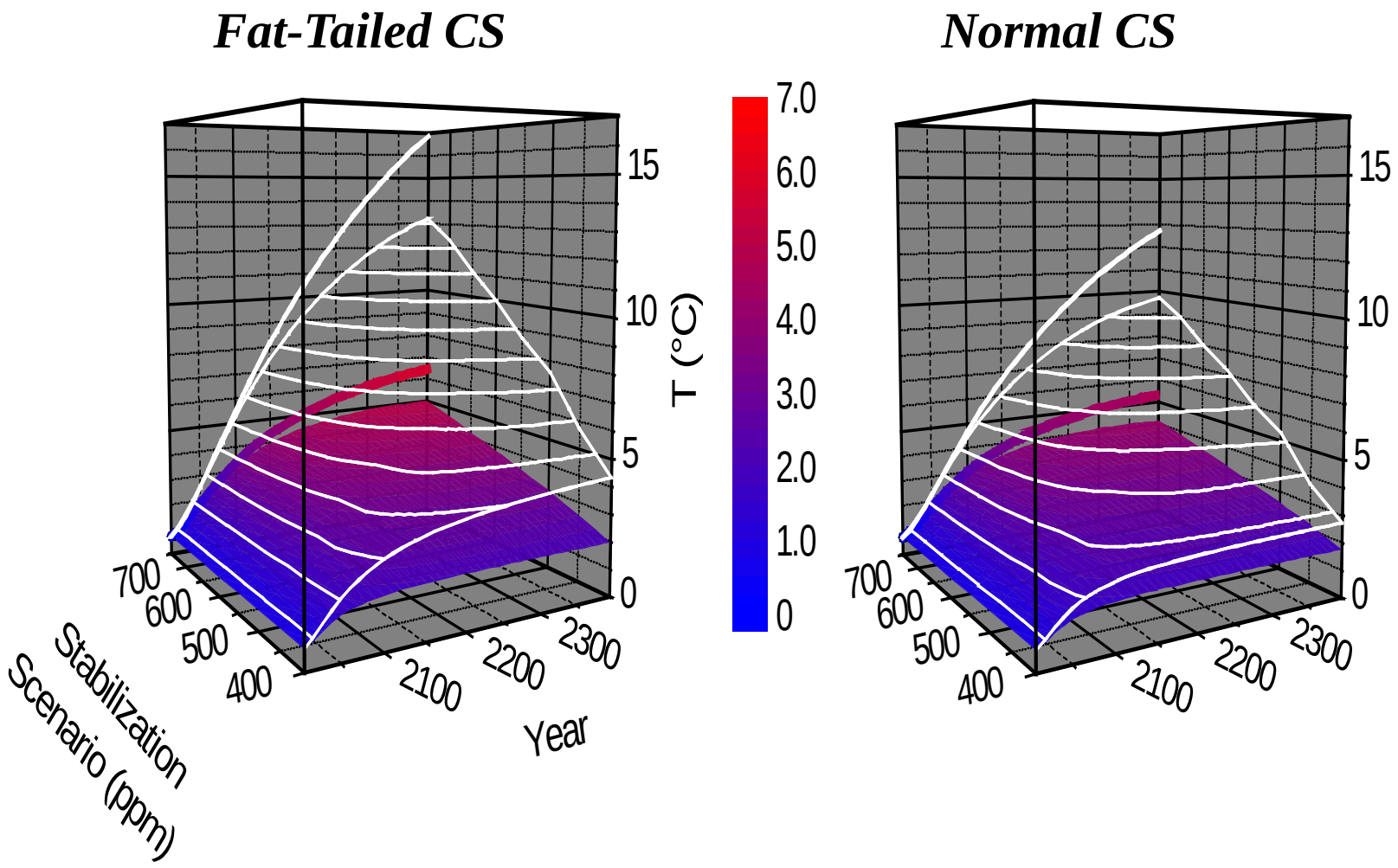
- Roe and Baker (2007), in contrast, find that climate sensitivity follows a fat-tailed distribution with a 20% chance of a value >5°C and a 4% chance of a value >10°C (see also Weitzman, 2007)

- We consider both possibilities but consider Roe and Baker more plausible given the state of the scientific literature

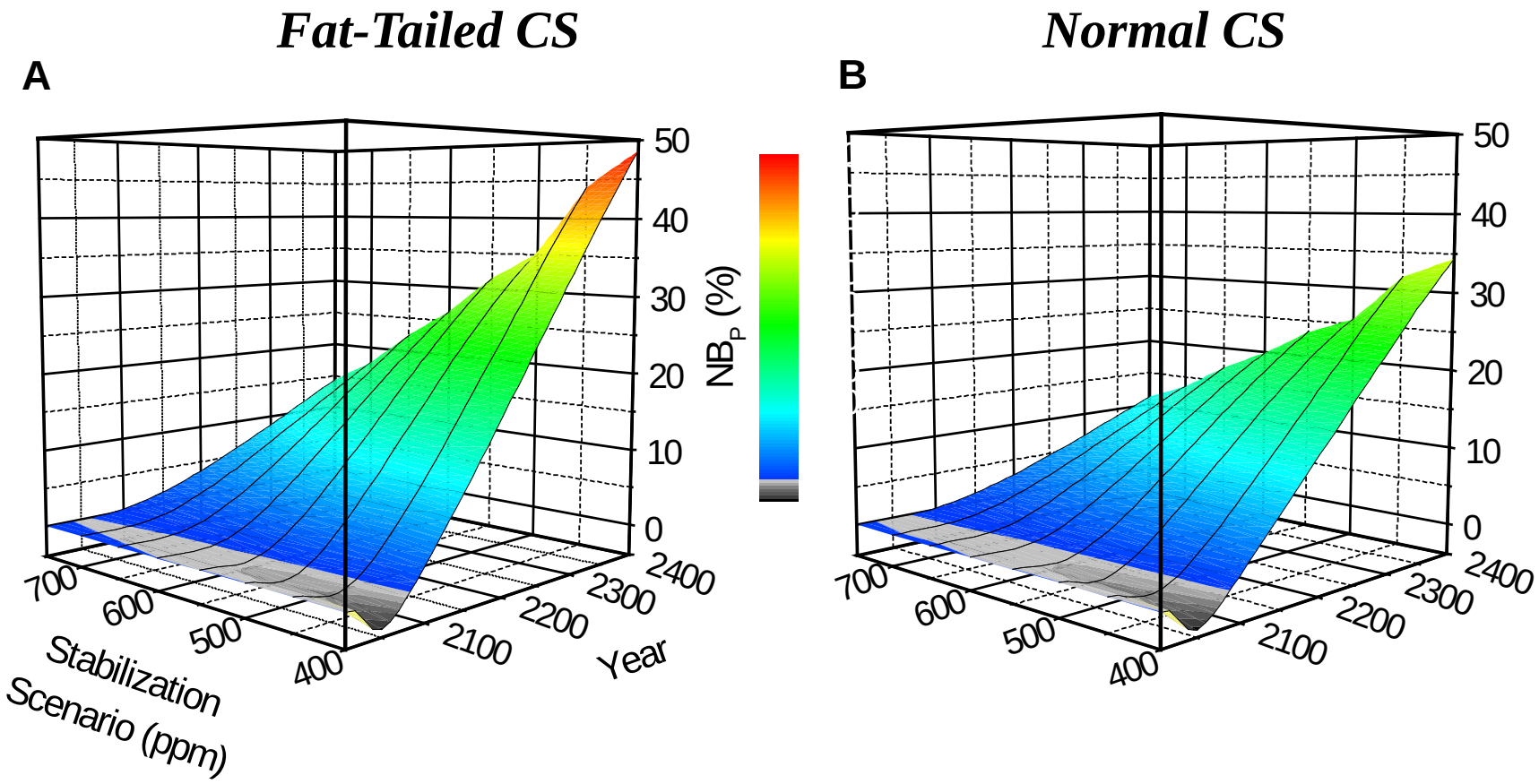
Policy Scenarios



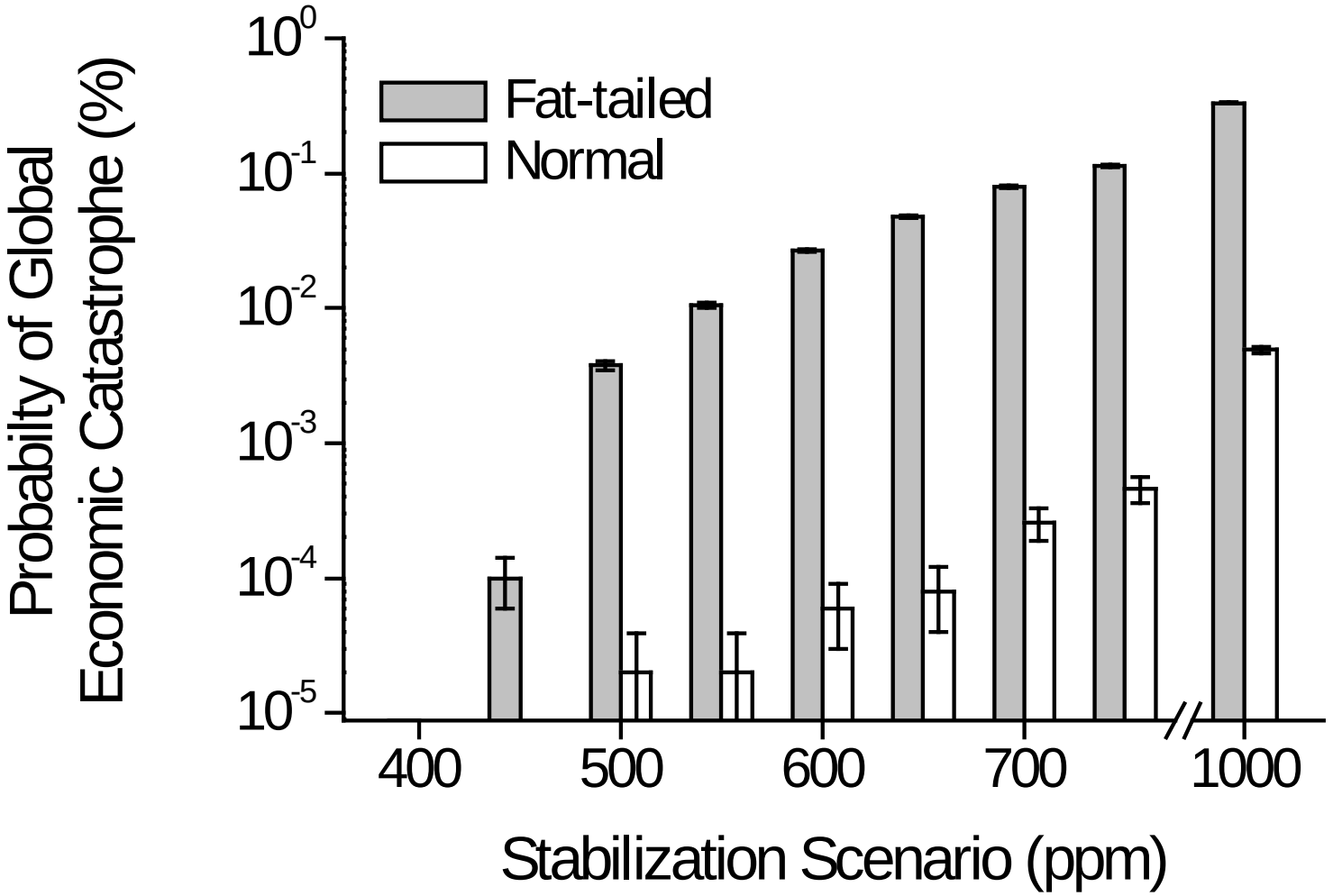
Temperature Change
(mean and 95th percentile)



Expected Net Benefits
(% of Consumption in 1000 ppm reference case)

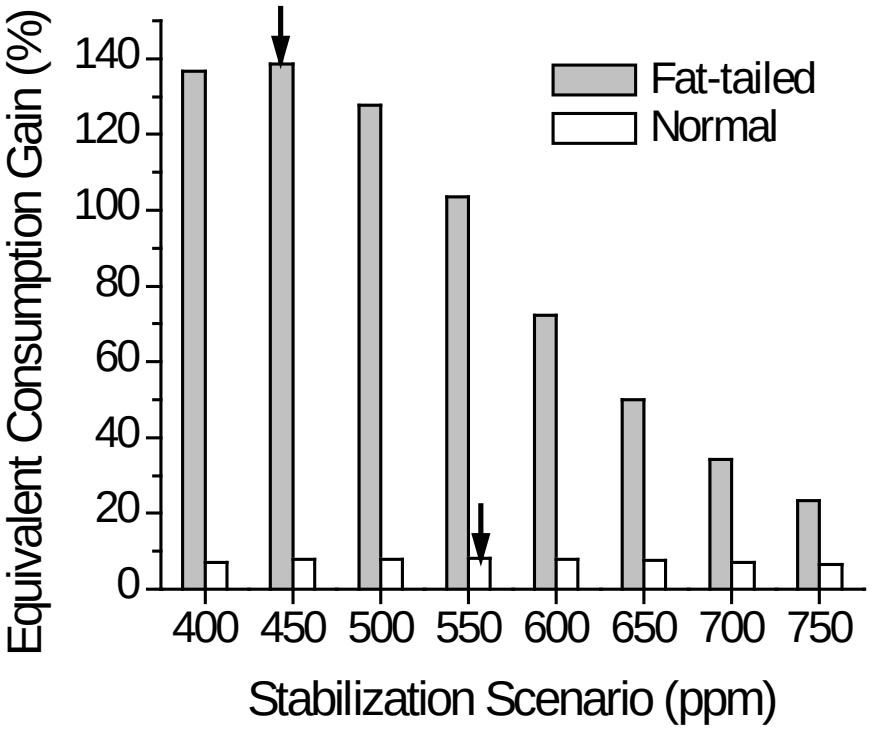


Probability of a Consumption Collapse (through 2400)

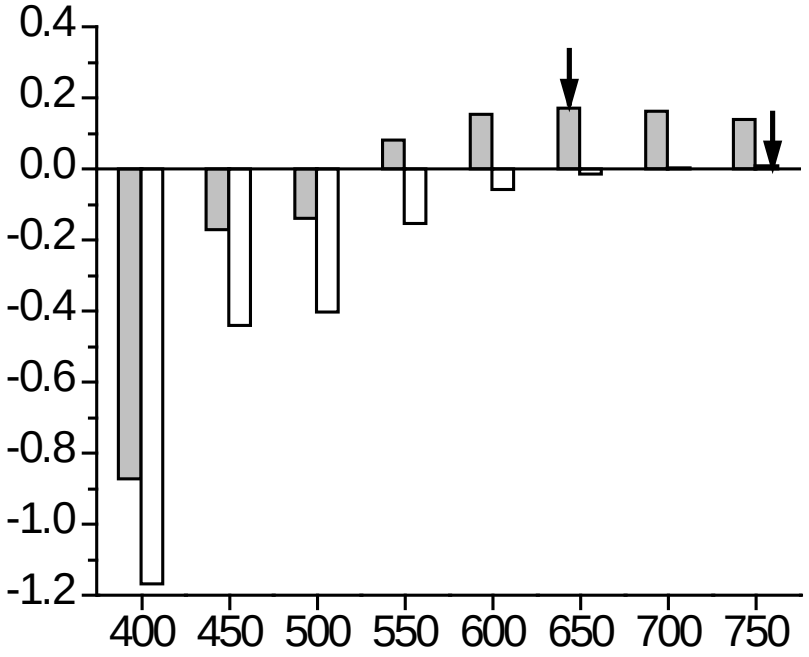


Net Benefits of Climate Stabilization
(relative to 1000 ppm reference case)

Gerst et al. Calibration



Nordhaus Calibration



Conclusions

In this talk, I've argued that the Stern/Nordhaus debate over the pure rate of time preference can be beneficially restructured

- Stern should distinguish between personal time preference and concepts of intergenerational justice. He needs a thicker account of how values and institutions are interrelated

- Nordhaus abstracts away from the role of risk and uncertainty in motivating investment decisions. This causes him to substantially understate people's risk aversion

- Bottom line: Climate stabilization is justified by a risk management approach that emphasizes the rights/interests of future generations