Uncertainties in global changes: An excuse to do nothing?

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EUROPEAN COMMISSION
European Research Area

SEVENTH FRAMEWORK
PROGRAMME

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Toulouse School of Economics

Motivation

- Do we do enough for the future generations?
  - Climate change, biodiversity,…
  - Public debts, pension systems,…
  - Housing, infrastructure, R&D, research,…
- There are still much uncertainties about
  - the economic context in which this change will take place;
  - the LT impacts of our actions: climate change!

Uncertain damages

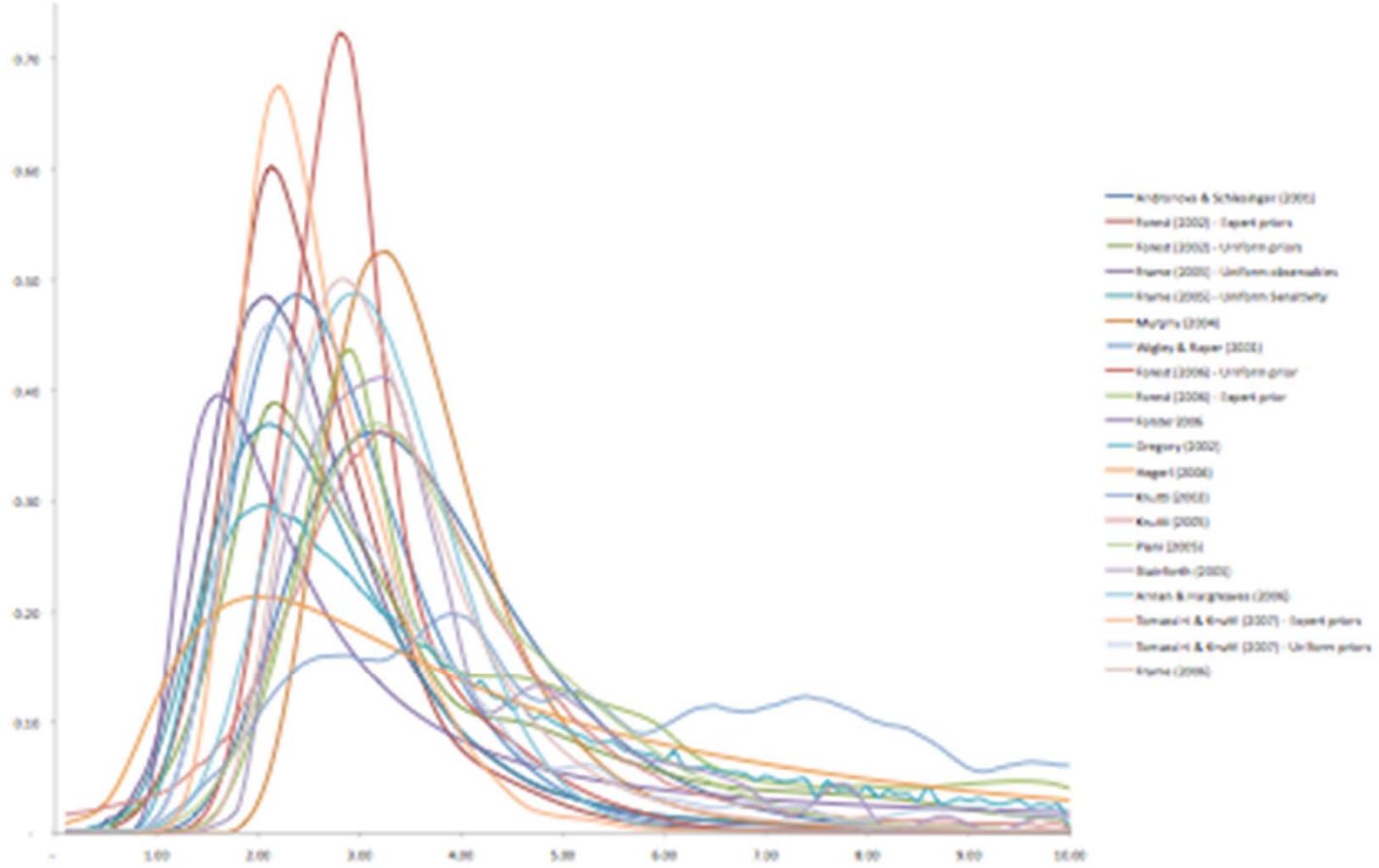
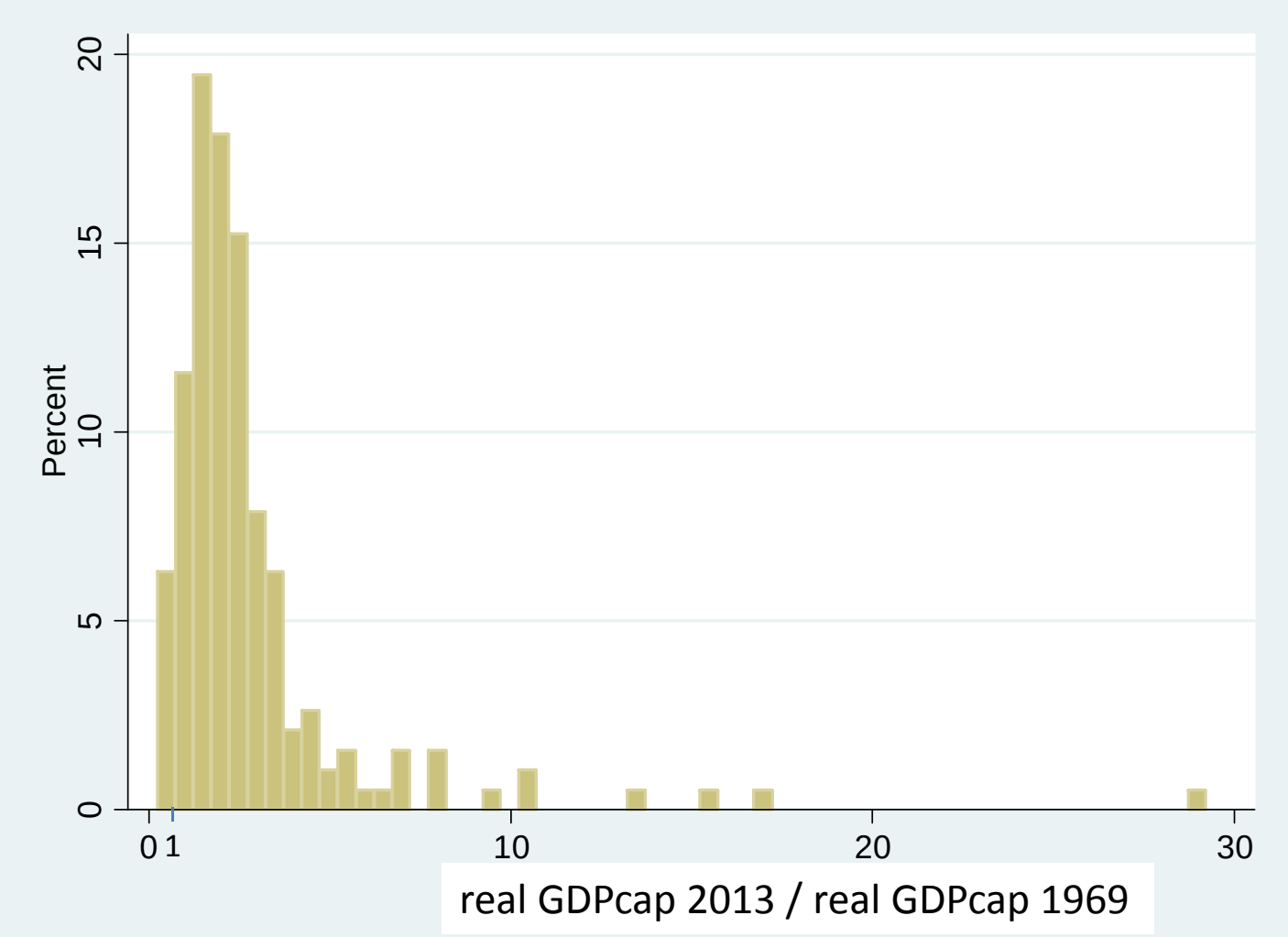


Figure 1: Estimated probability density functions for the climate sensitivity from a variety of published studies, collated by Meinshausen et al. (2009).

Growth uncertainty



Uncertain growth and the Discount rate (DR)

Long Run Risk and Decreasing Discount Rates

- Do we do enough for the future generations?
  - But future generations are expected to be wealthier!
  - In a growing economy, the DR is the minimum IRR of an investment that compensates for the increased intergenerational inequality that it generates.
- Uncertain growth: A precautionary argument for a smaller DR.
  - Shocks to the growth rate are iid: Flat term structure;
  - Shocks to the growth rate are persistent: DDR!

An example with an uncertain trend of growth

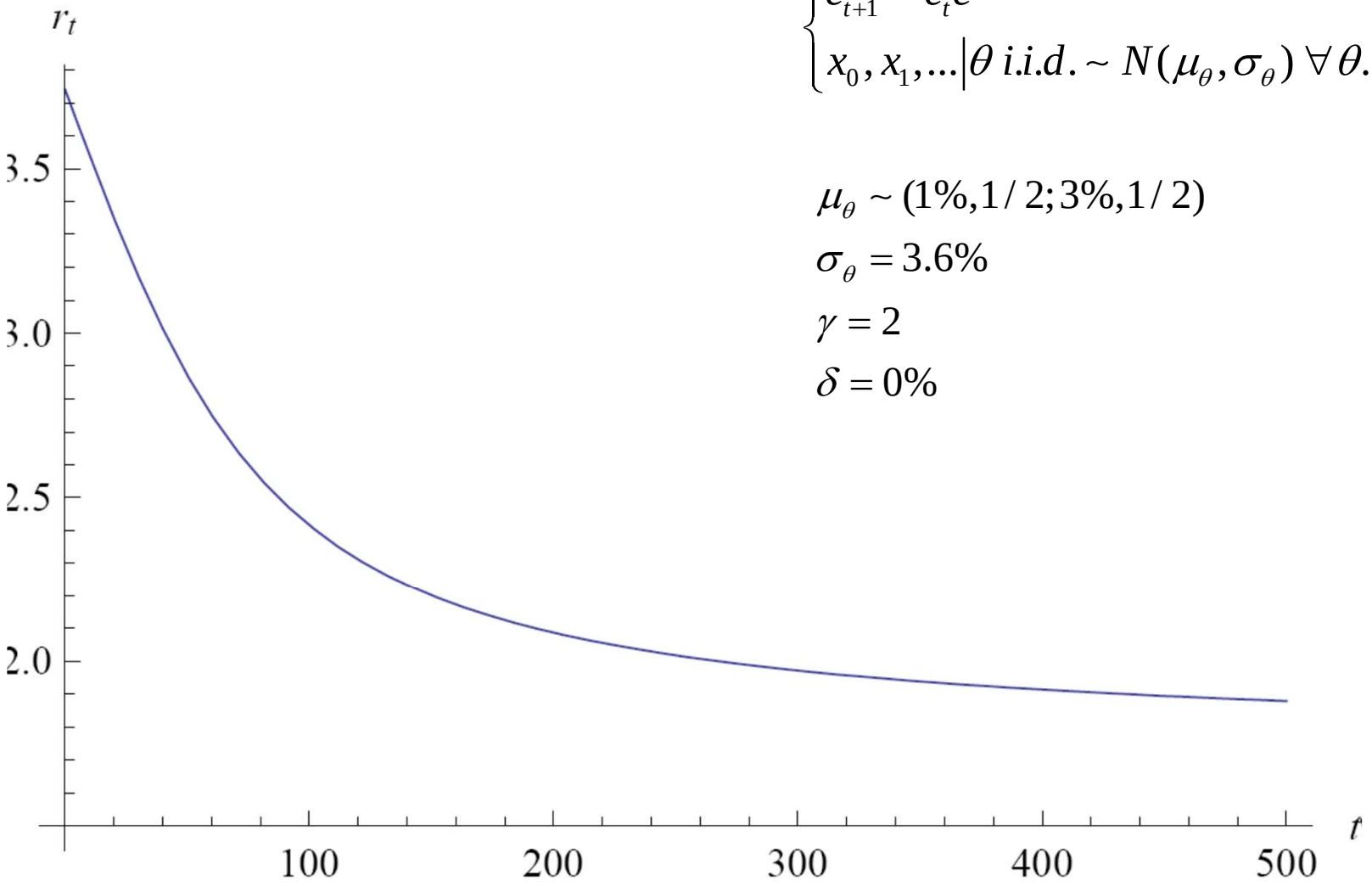
$$\begin{cases} c_{t+1} = c_t e^{x_t} \\ x_0, x_1, \ldots \middle| \theta \; i.i.d. \sim N(\mu_\theta, \sigma_\theta) \; \forall \theta. \end{cases}$$

$\mu_\theta \sim (1\%, 1/2; 3\%, 1/2)$

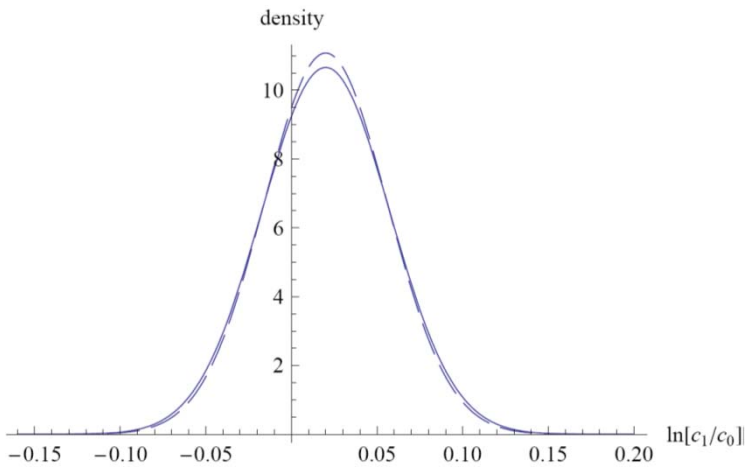
$\sigma_\theta = 3.6\%$

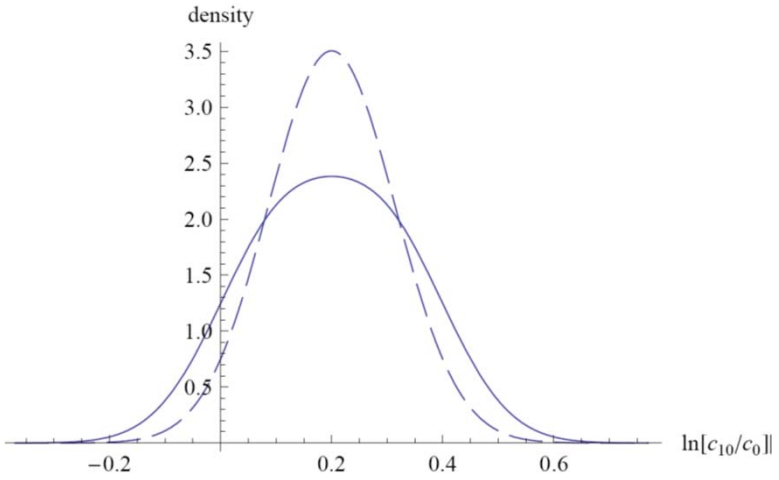
$\gamma = 2$

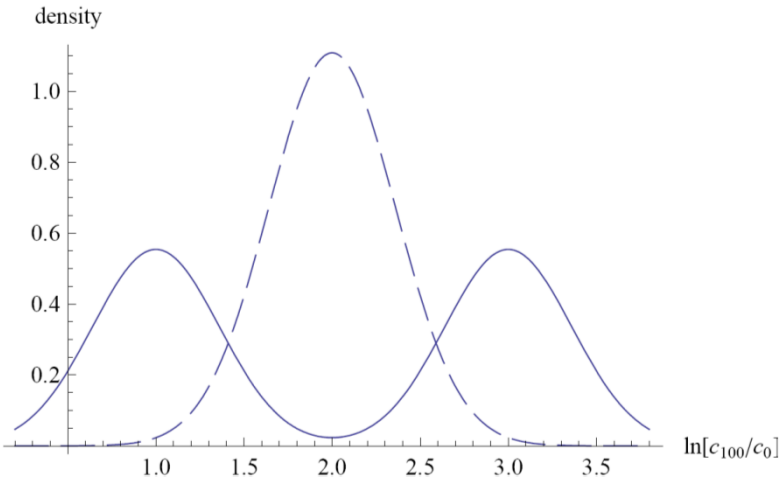
$\delta = 0\%$

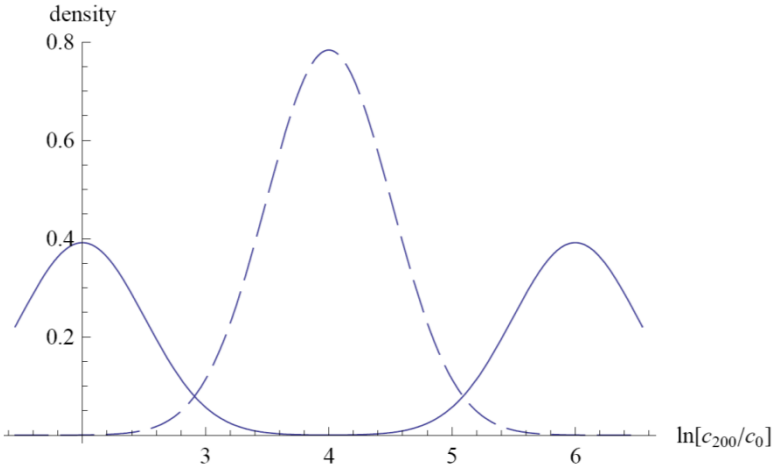


Intuition: fat tails





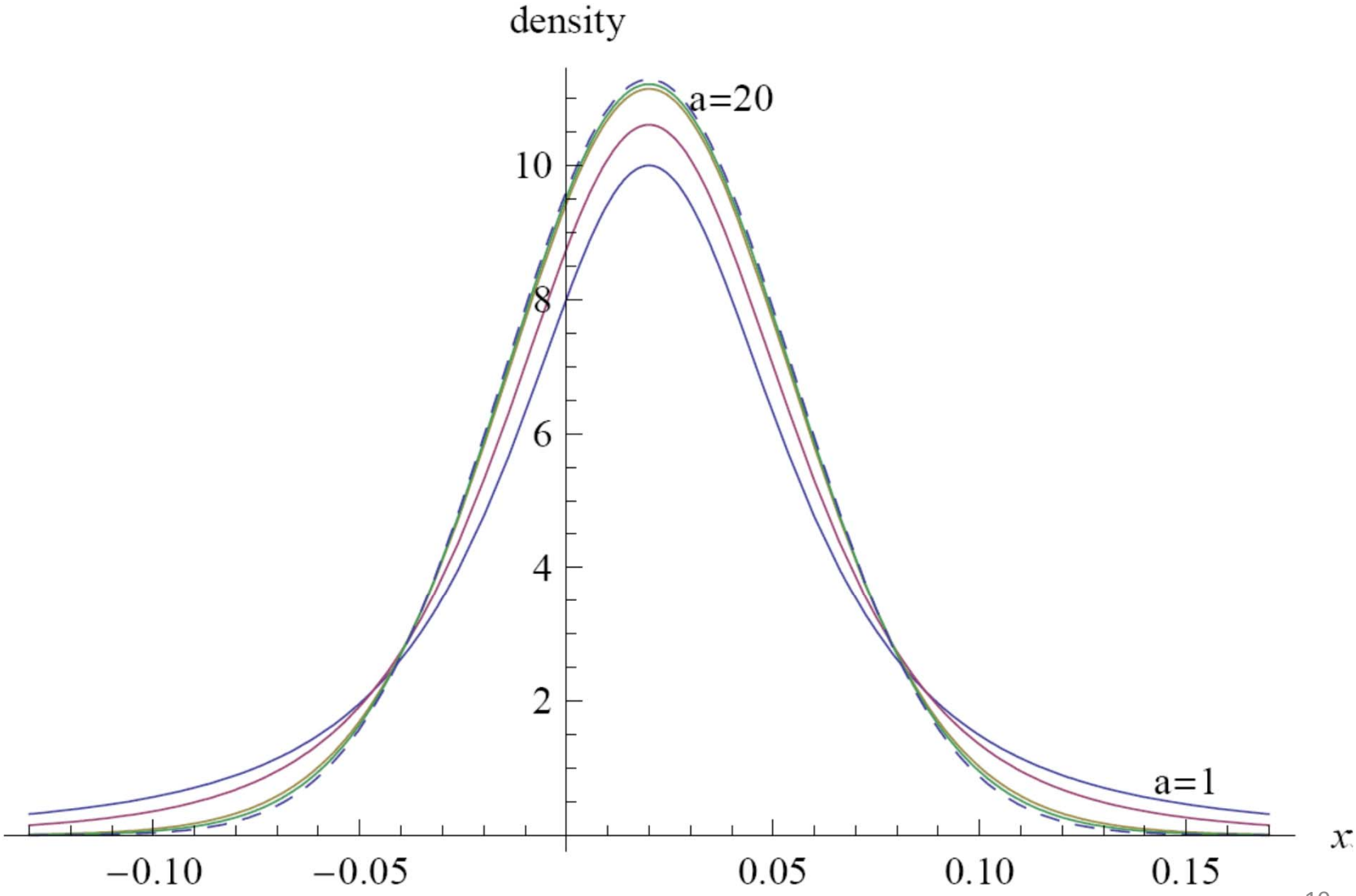




Weitzman (AER 2007)

- Suppose now that we know that consumption follows a geometric Brownian motion, with an uncertain volatility.
- Suppose that our beliefs about the volatility have an inverted gamma distribution.
- The unconditional distribution of future consumption has a Student-t distribution, yielding fat tails.
- The DR equals minus infinity in that case.

Student-*t* and Normal



Uncertain damages and the climate risk premium

Uncertain climate damages and the discounting controversy

- Climate damages are uncertain. How should this affect our willingness to fight climate change?
- Let’s use standard tools!

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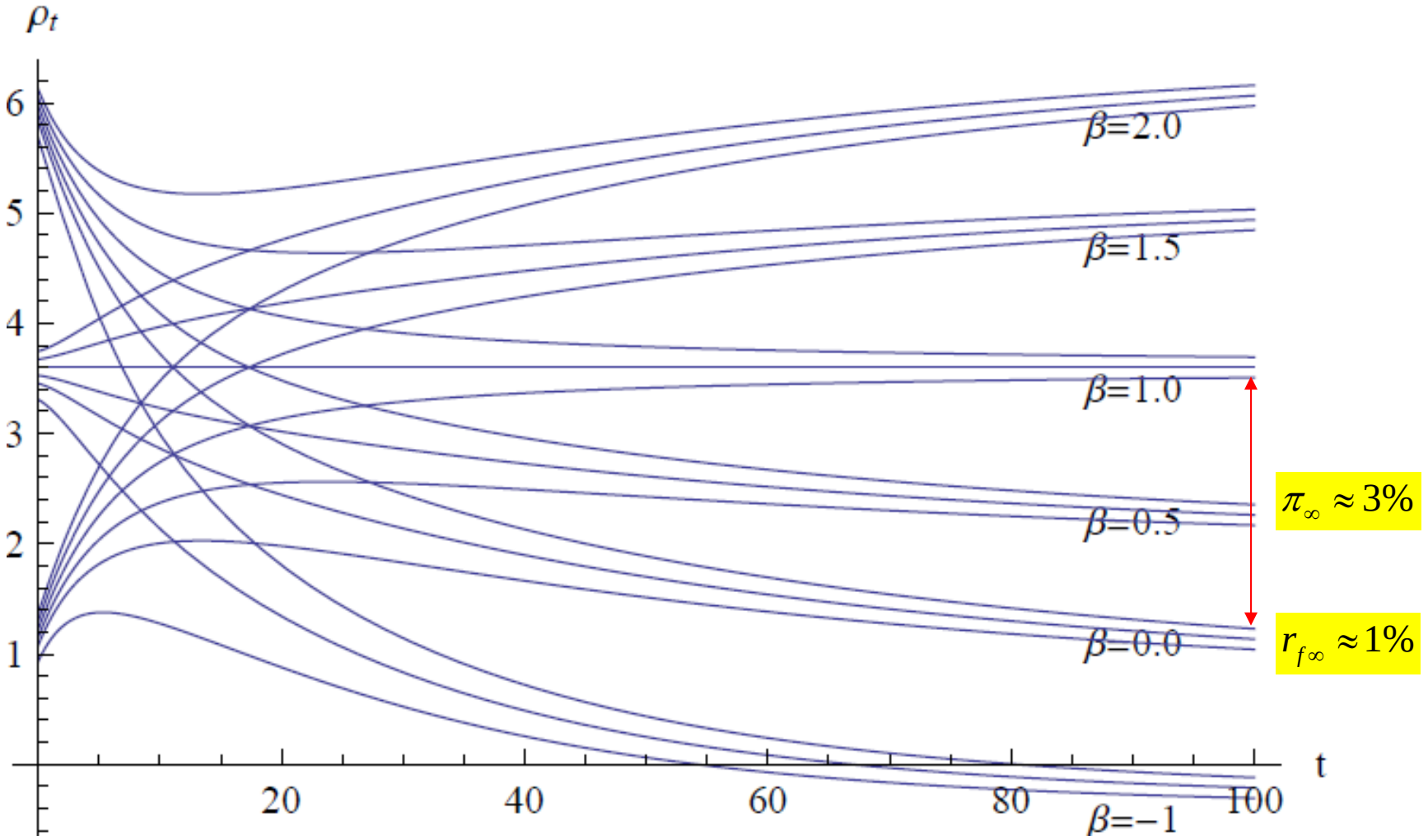
$$\rho = r_f + \beta\pi$$

Risk-free rate	Climate beta	Risk premium
RFR puzzle Discounting controversy	???	RP puzzle

Term structures of the risk-free discount rate and of the risk premium

- The persistence of shocks to consumption growth provides a simple justification for a decreasing RF rates: Long Run Risk, magnification of LT risk, and prudence.
- But in that context, the risk premium has an increasing term structure.
- Calibration with CRRA=2, mean reversion (LRR), and uncertainty on the LT trend.

Term structures as a function of the beta along the business cycle



The climate beta

- Has mitigation an insurance value?
- The negative-beta theory:
  - A high climate sensitivity implies large damages, low consumption, and a high payoff from mitigation.
- The positive-beta theory:
  - A higher growth implies a higher concentration of CO2, a larger marginal damage, and a larger payoff from mitigation.
  - “ *Those states in which the global temperature increase is particularly high are also ones in which we are on average richer in the future.*” (Nordhaus 2011)

A two-period DICE model

- Prototype DICE model:

T= Δ temperature
E= emission
Y= pre-damage production
D= damage
Q= post-damage production
C= consumption

$$T = \omega_1 E \quad (1)$$

$$E = \omega_2 Y - I_0 \quad (2)$$

$$D = \theta_1 T^{\theta_2} \quad (3)$$

$$Q = e^{-D} Y \quad (4)$$

$$C = \alpha Q \quad (5)$$

- Investment I_0 to reduce emissions.
- Two sources of uncertainty: climate sensitivity and economic growth.

Calibration

Variable	*Value*	*Remark*
t	50 years	Time horizon between dates 0 and 1.
$Y = e^{\sum_{i=1}^{t} x_i}$	$x_i \; iid \sim N(\mu, \sigma^2)$ $\mu = 1.5\%, \sigma = 4\%$	Y_0 is normalized to unity. The growth rate of production follows a normal random walk.
ω_2	1	Normalization
ω_1	0.45	This implies that the expected increase in temperature in the next 50 years equals $\omega_1 EY = 1°C$.
θ_2	$\sim N(1.5, 0.5^2)$	Centered around the "consensus interval" [1,2].
θ_1	$\sim U[1\%, 6\%]$	This means that the damage at the average temperature increase of 1°C is uniformly distributed on [1%, 6%] of pre-damage production.
α	0.75	Consumption equals 75% of post-damage production.

$$E \ln \frac{Y_{50}}{Y_0} = 75\% \qquad \sigma\left(\ln \frac{Y_{50}}{Y_0} \right) = 28\%$$

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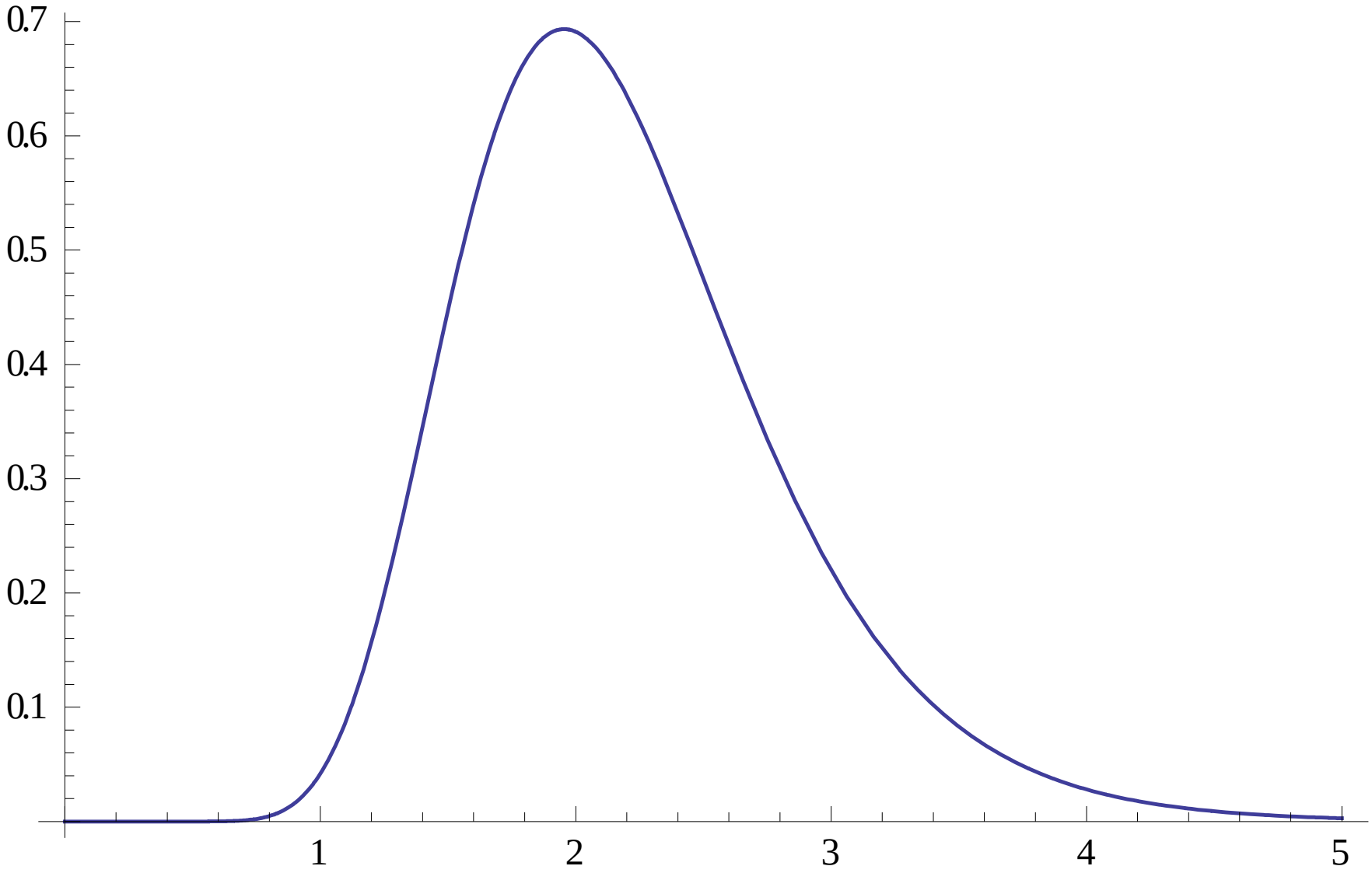
Distribution of GDP_{2060}/GDP_{2010}



$E\Delta T_{50} = 1°C$

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$D \sim (\Delta T)^{1.5}$ "on average"

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$$D\left|\Delta T = 1°C \sim U[1\%, 6\%]\right.$$

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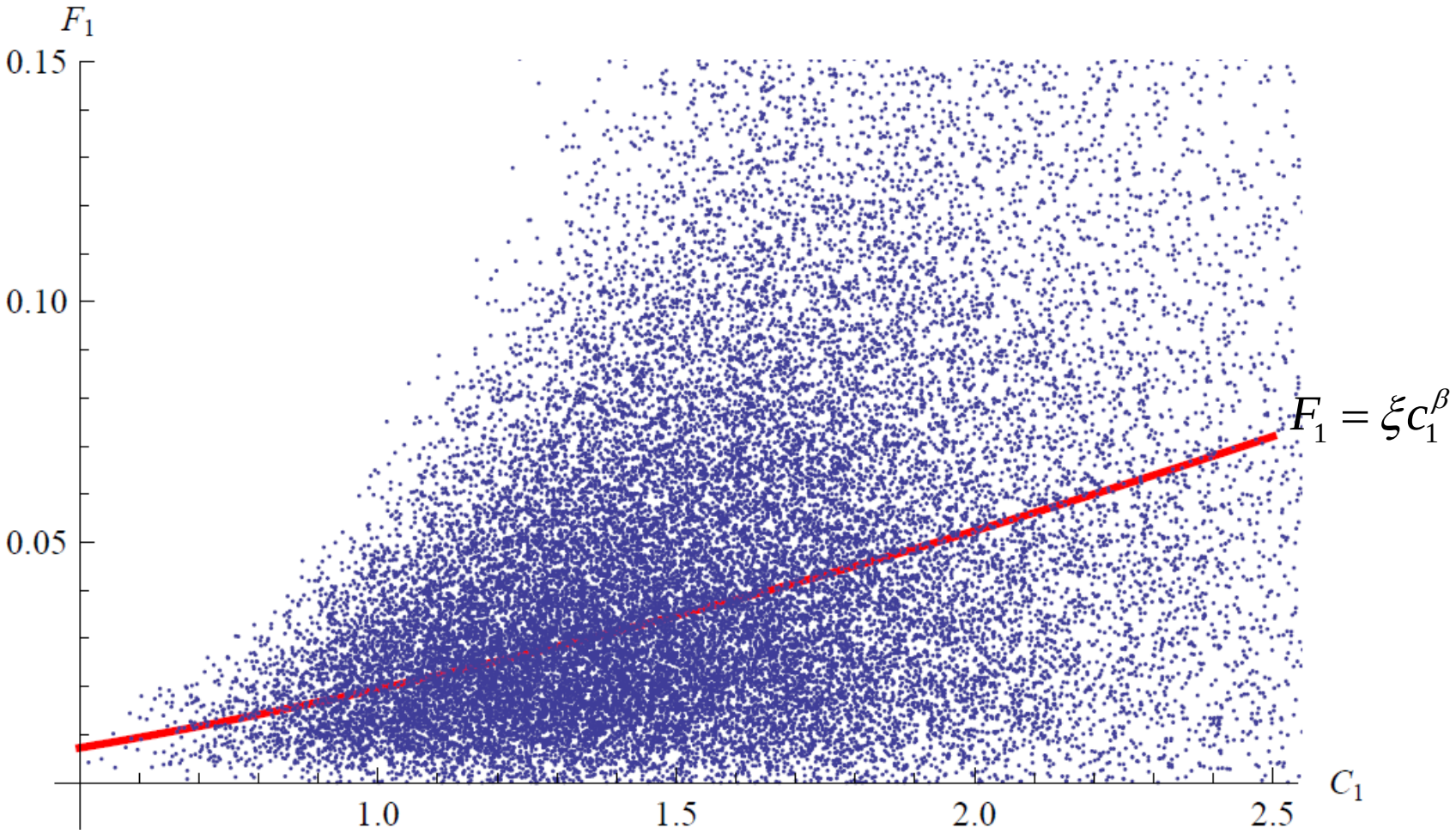
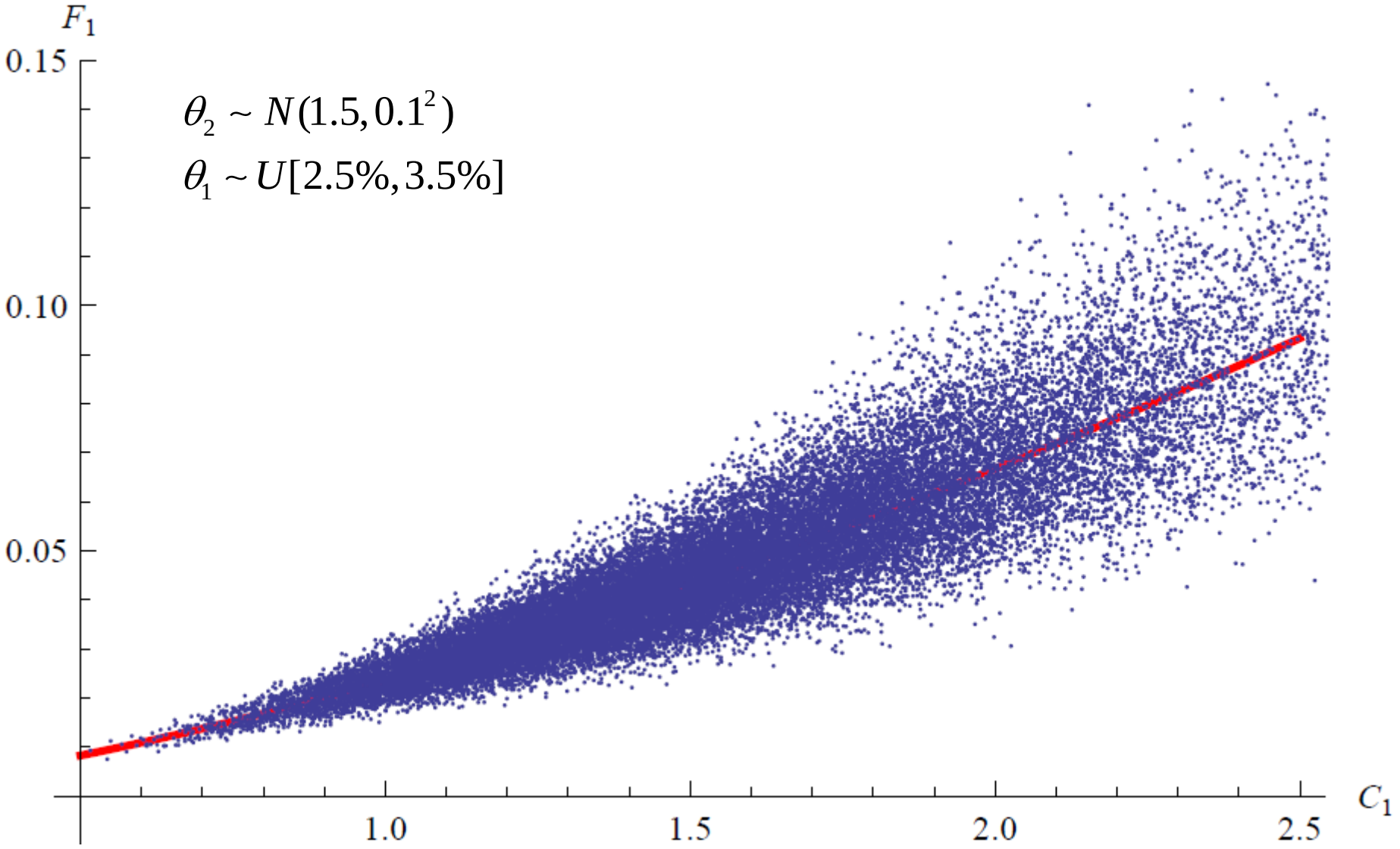
Monte-Carlo (n=30 000)



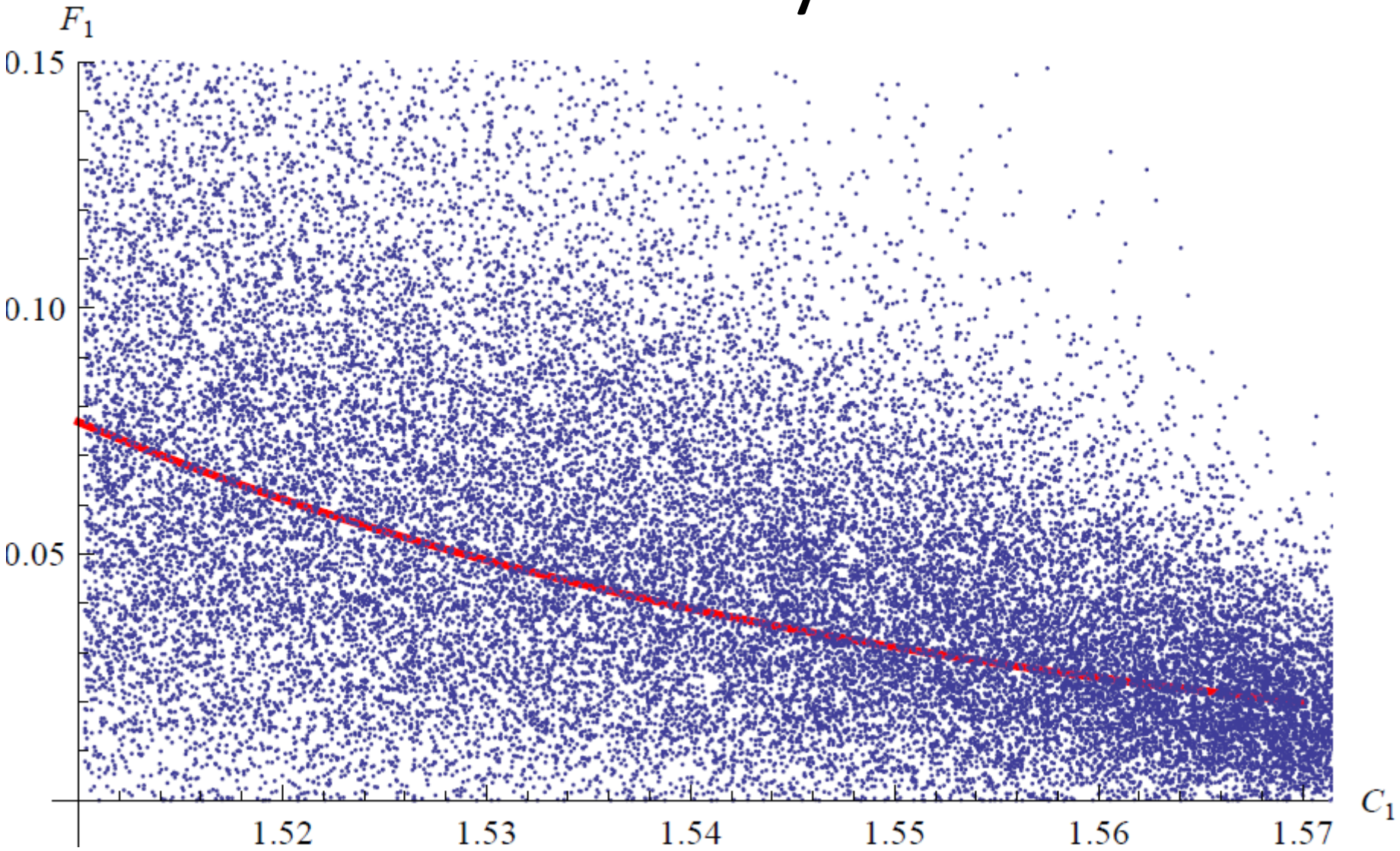
- Estimation of beta: $\hat{\beta} = 1.4$

Reduction of climate change



- Estimation of beta: $\hat{\beta} = 1.49$

Growth uncertainty switched off

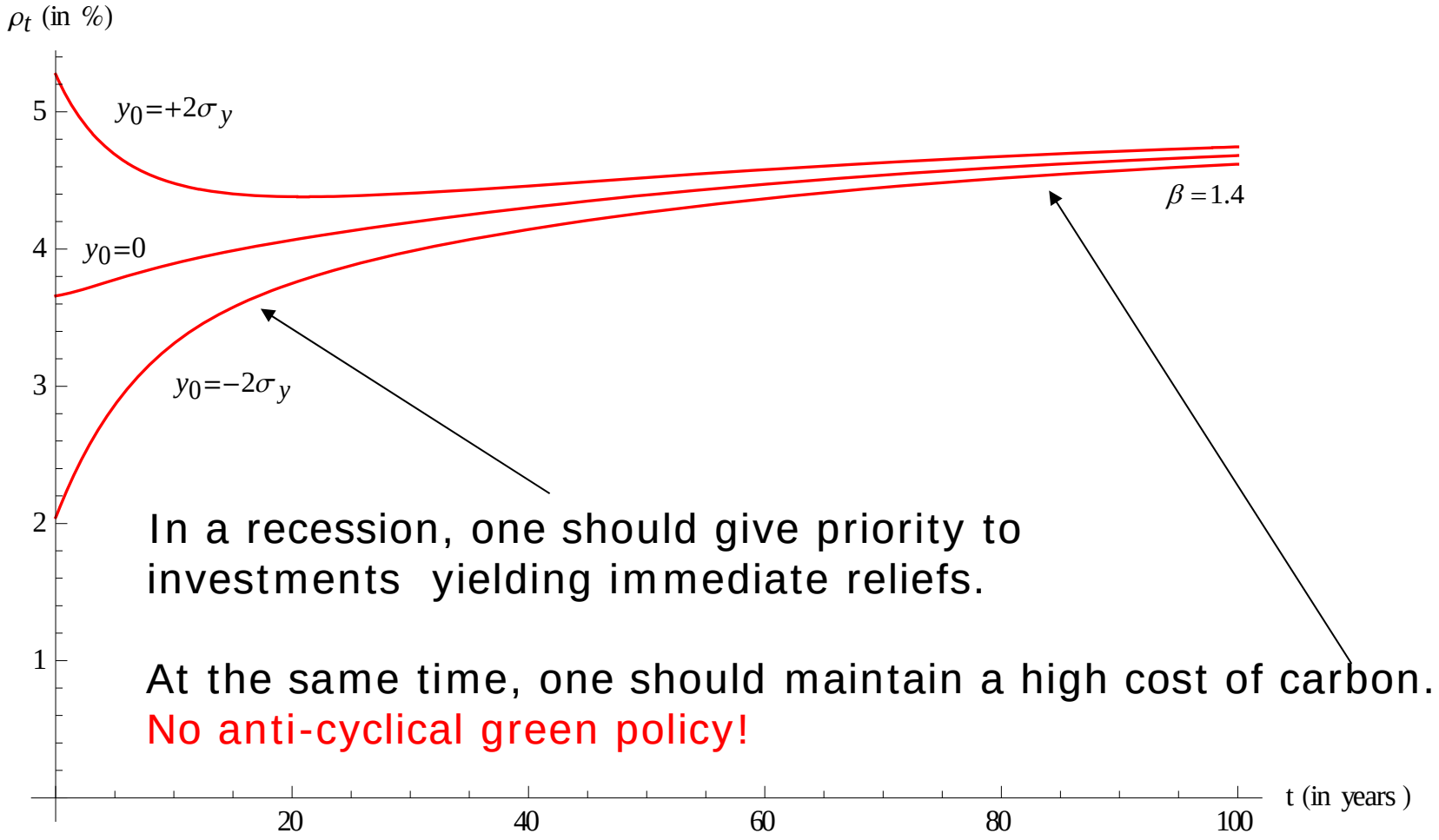


- Estimation of beta: $\hat{\beta} = -36$

Climate beta and the climate DR

- Suppose that the LT risk-free rate is 1%, and the LT risk premium is 3%.
- One should discount climate damages at a rate around 1% + 1.4 x 3% = 5 %.
- Nordhaus looks right, but he has a problem: Double counting:
  - He uses a large discount rate implicitly justified by a large equity premium (and β =1);
  - His certainty equivalent climate benefits include a risk premium.

Fighting climate change along the business cycle



In a recession, one should give priority to investments yielding immediate reliefs.

At the same time, one should maintain a high cost of carbon.

No anti-cyclical green policy!

Challenges

- No extreme event in this valuation exercise: Dismal Theorem, …
- More fundamental uncertainties and uncertainty aversion?

Irreversibilities, adaptation and option value to wait

Uncertainty, learning and dynamic decisions

- In the DEU model, the timing of resolution of uncertainty (green innovations, climate sensitiveness,…) does not affect welfare.
- But it can affect the sequence of decisions.
- In the absence of irreversibility, the effect of the anticipation of learning has an ambiguous effect on the optimal sacrifice that one should do for the future.

Two types of irreversibility

- “If CC is dramatic, one will not be able to remove CO2 from the atmosphere as it would desirable”.
  - An argument to fight CC immediately.
- “If CC is innocuous (cheap green tech), one will not be able to undo the unnecessary green infrastructures”.
  - An argument to delay actions.

Conclusion

Risk and uncertainty: The last frontier?

- Crucial role of uncertainties, in particular if fat tails.
  - Benchmark scenarii can be misleading, with a wrong feeling of perfect foresight.
  - Standard deviation is a good measure of risk *only* in the Gaussian case.
  - Global changes could bring us back to Stone Age.
- However, outside these low-probability events, climate damages arise mostly in the good states of nature.

Thank you !

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SEVENTH FRAMEWORK
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Estimation of RRA

- You are indifferent between
  - 50-50 chance to live with a daily income of 80 or 120;
  - A sure daily income of X.

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γ	Certainty equiv (80,1/2;120,1/2)	Certainty equiv (50,1/2;150,1/2)
0	100,00	100,00
0,5	98,99	93,30
1	97,98	86,60
1,5	96,98	80,38
2	96,00	75,00
4	92,44	62,24

- Risk aversion or aversion to inequality (veil of ignorance).