Charge Questions 2:

Uncertainty and Discount Rates over Long Time Horizons

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Weitzman (2001) "Gamma Discounting"

- PDV of project benefits in year t = $Z(t) \exp(-rt)$
- r is uncertain due to disagreement among experts
- Expected value of net benefits = $Z(t)A(t) = Z(t)E(\exp(-rt))$
- If r follows a Gamma distribution with mean μ and variance σ^2

The certainty equivalent discount rate $R(t) \equiv -(dA/dt)/A$ is

$$R(t) = \mu/[1 + t\sigma^2/\mu]$$

- Next slide shows R(t) based on $\mu = 4$; $\sigma = 3$ (2160 experts)

Discount Rate Schedule Weitzman (2001)

Time period	Name	Marginal discount rate (Percent)
Within years 1 to 5 hence	*Immediate* Future	4
Within years 6 to 25 hence	*Near* Future	3
Within years 26 to 75 hence	*Medium* Future	2
Within years 76 to 300 hence	*Distant* Future	1
Within years more than 300 hence	*Far-Distant* Future	0

The Declining Discount Rate Literature

- Theoretical literature has been advanced by Gollier and Weitzman (2010) and Weitzman (2010) (Risk-adjusted Gamma discounting)
- How should this theoretical literature be used in cost-benefit analyses?
  - Could do simulations, illustrative calculations?
- Problem is framed as irreducible uncertainty about r; decision maker must choose a policy before uncertainty is resolved
  - The fact that uncertainty will be resolved obviates the problem of time inconsistency
  - But, if uncertainty were not resolved and decision revisited using same distribution over r, could have time inconsistent decisions
- Work on expert elicitation by Freeman and Groom (2010) deals with how expert preferences should be aggregated and interpreted
- Empirical literature—Newell and Pizer (2003); Groom et al. (2007); Hepburn et al. (2009) has examined the distribution over r using historical data

The Empirical Discount Rate Literature

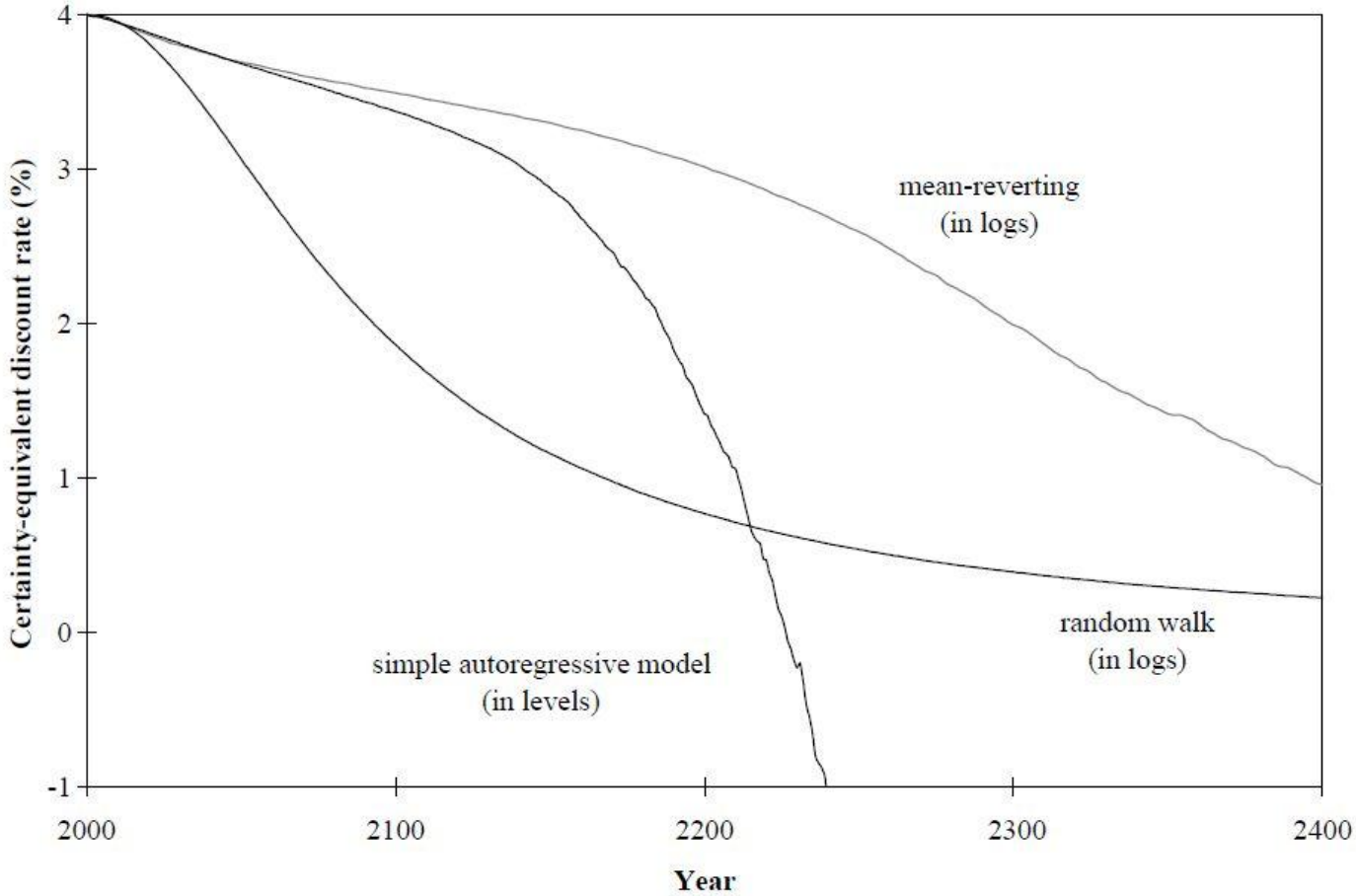
- Newell and Pizer (2003) use two decades of data on Treasury bonds to estimate a reduced-form model of bond yields

$$r_t = \eta + \varepsilon_t, \quad \eta \sim N(\mu, \sigma^2) \quad \text{and} \quad \varepsilon_t = \rho\varepsilon_{t-1} + u_t$$

and use the results to compute certainty-equivalent interest rates over time.

- Subsequent literature has used different econometric models to describe interest rates and data from different countries
- Should a similar empirical approach be used by analysts in conducting cost-benefit analyses?

Forecasts of Certainty-Equivalent Discount Rates (Newell & Pizer 2003)



Uncertainty and Discount Rates over Long Time Horizons

- **Question 2.** How should the results of the declining discount rate (DDR) literature be reflected in benefit-cost analyses? Should a schedule of discount rates be derived from theoretical principles and/or simulation models, should discount rates be estimated empirically or should both approaches be used?
- **Question 2a.** If an empirical approach is taken, what should it be? What datasets should be used, for what countries, and which empirical models should be used? What difficulties do you foresee in implementing this approach practically?
- **Question 2b:** Will the use of time-declining discount rates lead to time inconsistent decisions? How much of a concern is this?

Uncertainty and Discount Rates over Long Time Horizons

- **Question 2c:** If future benefits in a regulatory impact analysis represent expected values (rather than certainty equivalents), the appropriate discount rate will not equal the risk-free rate. How should the appropriate discount rate be determined, allowing for correlation between benefits and market returns?