Discounting over long periods

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Two topics

- Discounting when outcomes are correlated with economic growth
  - Approach proposed by US National Academies of Sciences report on calculating the social cost of carbon (2017)
- Definition & measurement of change in real consumption when relative prices & values change

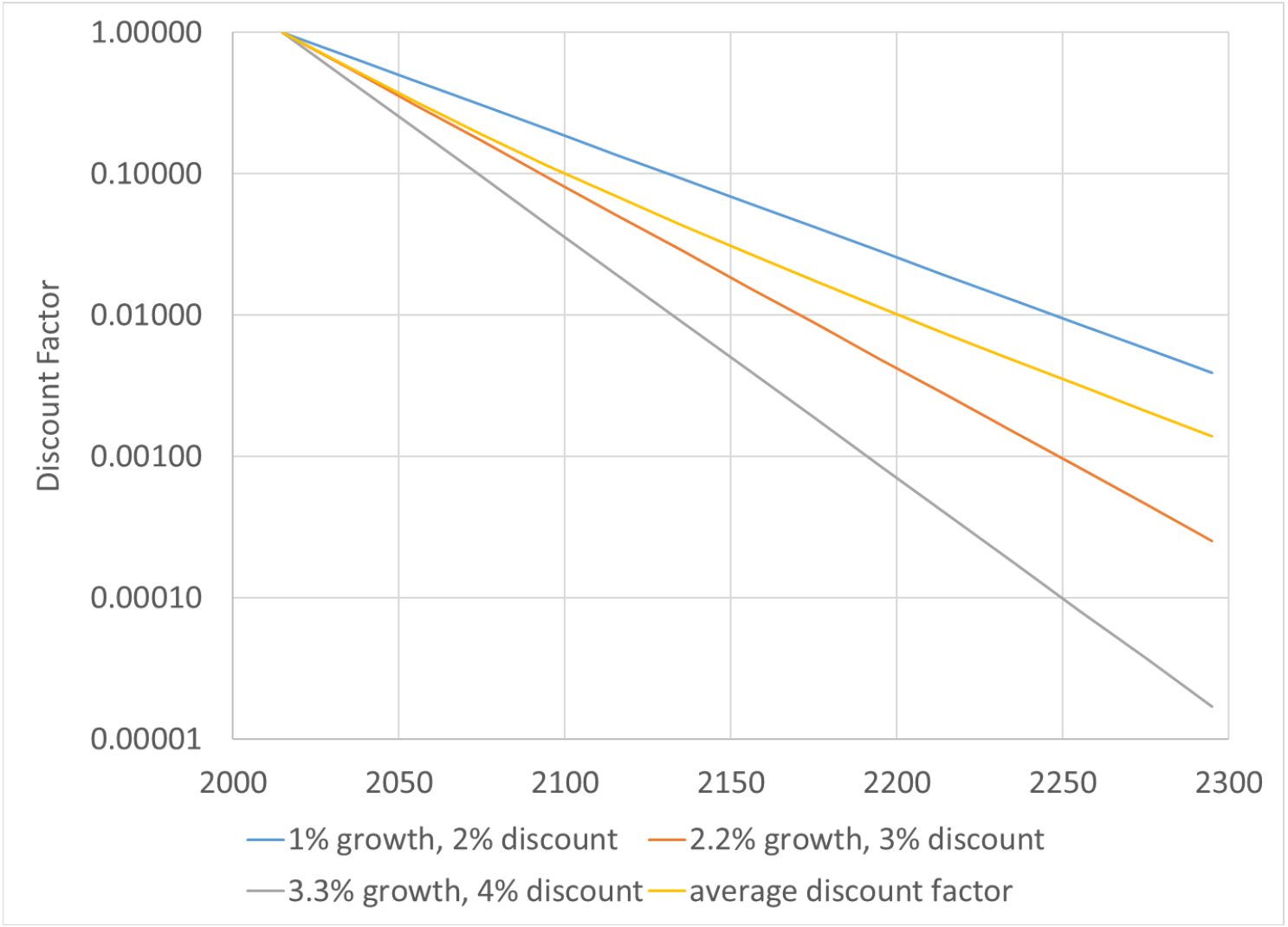
Discounting when outcomes are correlated with economic growth

- Ramsey formula: $\tilde{r} = \delta + \gamma \tilde{g}$
  - δ = utility discount rate
  - γ = inequality aversion
  - $\tilde{g}$ = growth rate (uncertain)
  - $\tilde{r}$ = discount rate (uncertain)
- Future value = $\widetilde{v_t}$ (uncertain)
- Expected present value = E [discount factor x future value]
  - $EPV = E\left[e^{-\tilde{r}t} \cdot \widetilde{v_t}\right]$
  - $= E\left[e^{-\tilde{r}t}\right] \cdot E[\widetilde{v_t}]$
  - = E [discount factor] • E [future value]
    - if and only if $\tilde{r}$ and $\widetilde{v_t}$ are independent
- If $\tilde{r}$ and $\widetilde{v_t}$ are dependent,
  - Different values of v_t are discounted at different rates
  - Can evaluate using Monte Carlo simulation

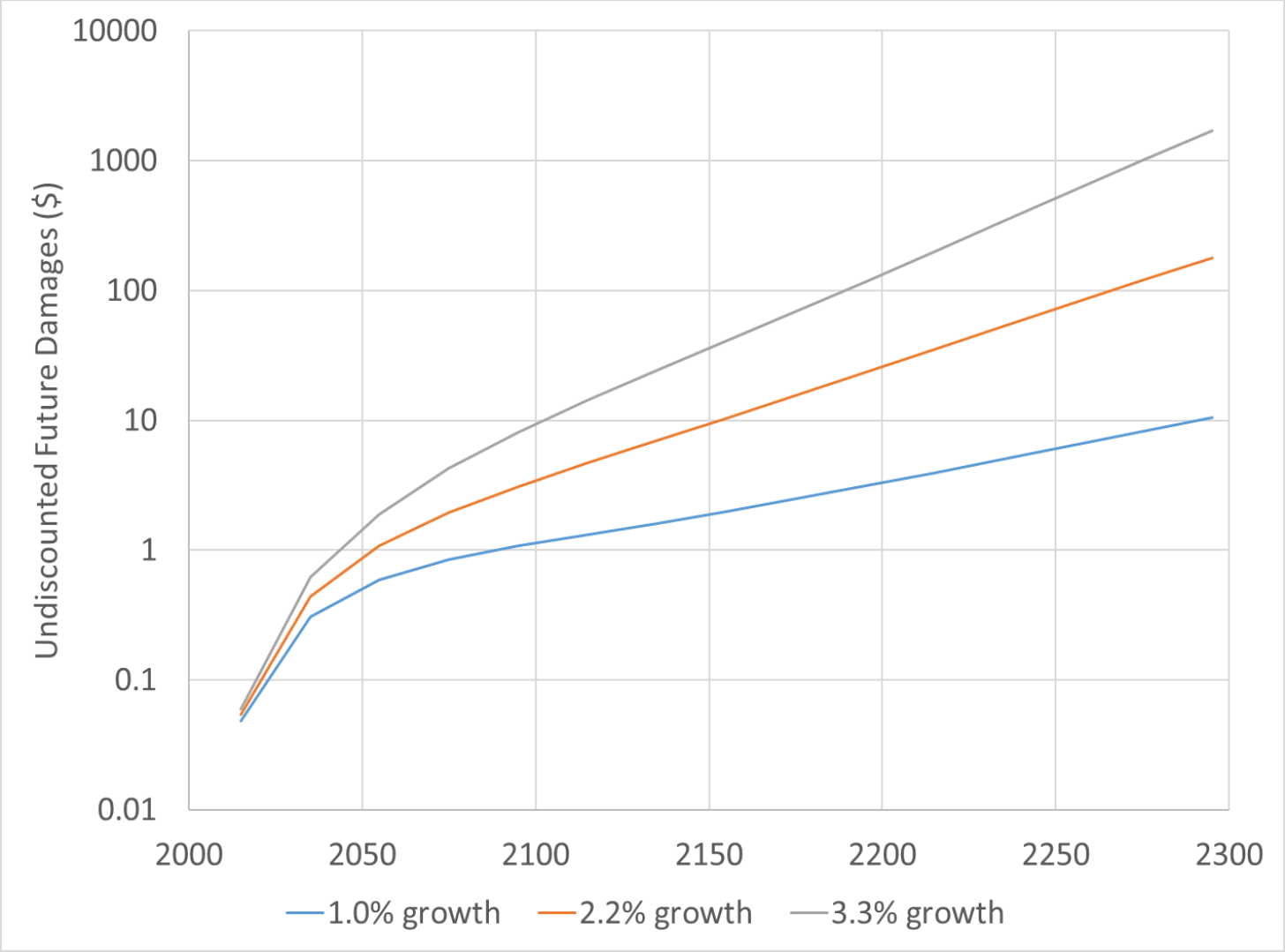
Example: EPV of marginal future climate damages

- Growth rate $\tilde{g}$ = 1.0%, 2.2%, 3.3% (equally likely)
  - δ = 1.1%; γ = 0.88
- Implies $\tilde{r}$ = 2%, 3%, 4% (equally likely)

Expected discount factor starts at average discount rate & approaches smallest rate

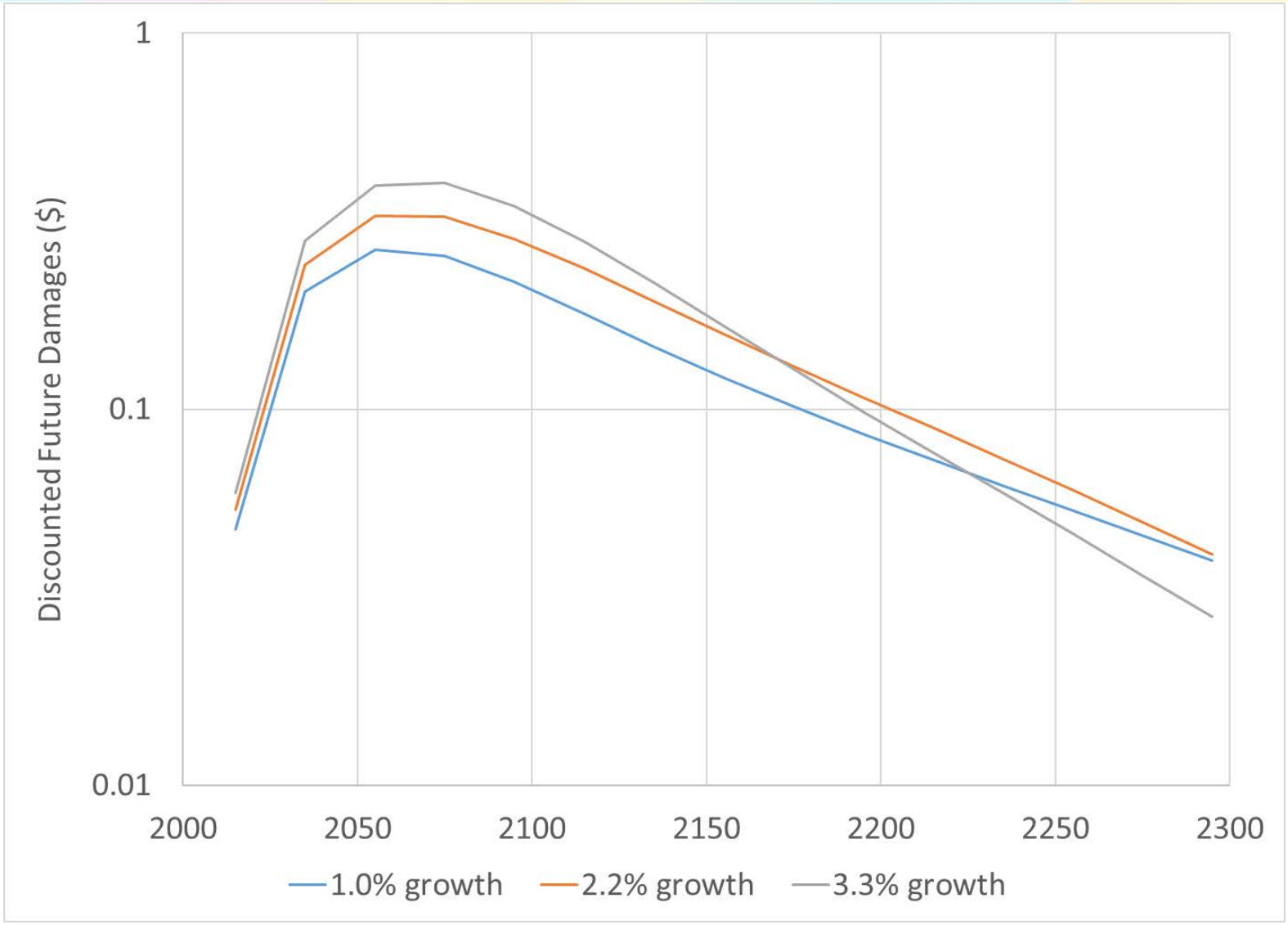


Illustrative marginal climate damages (positively correlated with growth)



Discounted marginal damages very similar

Expected present value = average discounted damages



Definition & measurement of real consumption when relative prices & values change

- When relative prices/values of goods change, effective discount rates differ
- Example: Monetary value of health grows roughly in proportion to income
  - Measure health in life years (LY)
  - Assume value of one LY now = V €
- Let
  - Discount rate on consumption = r
  - Growth rate of income = g
  - Then value of health increases at rate g
- PV of one LY in T years $= e^{-rT}[V \cdot e^{gT}] = V \cdot e^{-(r-g)T}$
- Effective discount rate for health = r – g
  - Rate of substitution between current & future health

Components of real consumption change radically

- Constant real consumption implies constant wellbeing (utility)
- But basket of goods & services changes radically over time
  - Airliners, mobile telephones, electronic calculators did not exist 100 years ago
    - Prices of the services these goods provide decreased from infinity
  - Price of domestic lighting relative to conventional basket of consumer goods decreased > 1000 fold from 1800 to 1990 (Nordhaus 1997)
- Health and other non-market goods have changed radically
- Lifetime wellbeing in US, 1900 – 1995
  - Life expectancy at birth increased from 48 to 76 years = 60%
  - Consumption increased from $3,000 to $18,000 = 6x (1990$)
  - Annual increase in consumption: 2.1%
  - Value of annual increase in longevity: 2.2 – 3.0% of consumption
  - Value of longevity gain ≈ value of consumption gain

Discounting depends on multiple components of real consumption

- For single good (consumption), discount rate depends on
  - Future growth in consumption
  - Uncertainty about future growth
- When wellbeing depends on consumption, health, environmental quality, … (as complements or substitutes), then consumption discount rate depends on
  - Future growth in consumption, health, other components
  - Uncertainty about growth in consumption, health, other components
- In general, discount rate for any component of real consumption depends on growth and uncertainty about growth for all components
  - What is effect of growing health & longevity on consumption discount rate?

Conclusion

- Need to incorporate dependence between future consequences and economic growth
  - Simulation, risk premium, etc.
- Real consumption includes many components
  - Changes in relative prices (& uncertainty about changes) affects discount rate