Discounting over long periods

James K. Hammitt
Two topics

• Discounting when outcomes are correlated with economic growth

• Definition & measurement of change in real consumption when relative prices & values change
Discounting when outcomes are correlated with economic growth

• Ramsey formula: \( \tilde{r} = \delta + \gamma \tilde{g} \)
  — \( \delta \) = utility discount rate
  — \( \gamma \) = inequality aversion
  — \( \tilde{g} \) = growth rate (uncertain)
  — \( \tilde{r} \) = discount rate (uncertain)

• Future value = \( \tilde{v}_t \) (uncertain)

• Expected present value = \( E \) [discount factor x future value]
  — \( EPV = E \left[ e^{-\tilde{r}t} \cdot \tilde{v}_t \right] \)
  — \( = E \left[ e^{-\tilde{r}t} \right] \cdot E \left[ \tilde{v}_t \right] \)
  — \( = E \) [discount factor] \( \cdot E \) [future value]
    o if and only if \( \tilde{r} \) and \( \tilde{v}_t \) are independent

• If \( \tilde{r} \) and \( \tilde{v}_t \) 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 $\bar{g} = 1.0\%, 2.2\%, 3.3\%$ (equally likely)
  - $\delta = 1.1\%; \gamma = 0.88$
- 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

![Graph showing discounted future damages over time for different growth rates. The x-axis represents years from 2000 to 2300, and the y-axis represents discounted future damages in dollars. Three lines are plotted for 1.0%, 2.2%, and 3.3% growth rates.]
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