An International Comparison of Social Discounting for Infrastructure and Regulation: Theory and Practice

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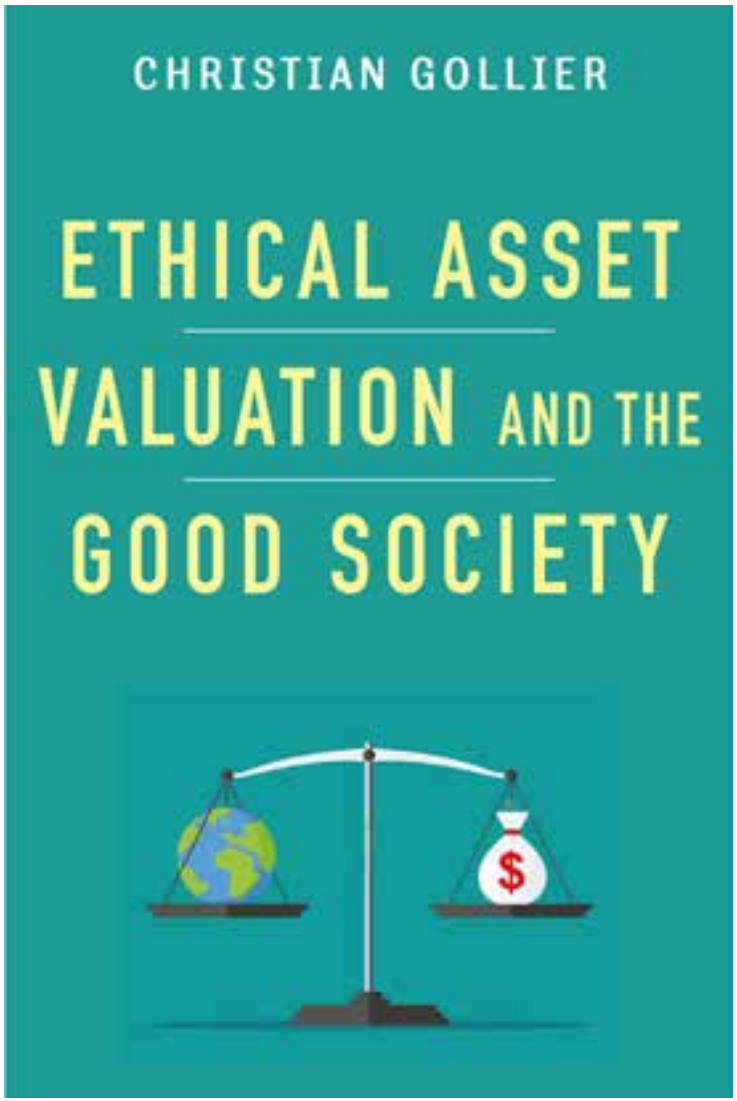
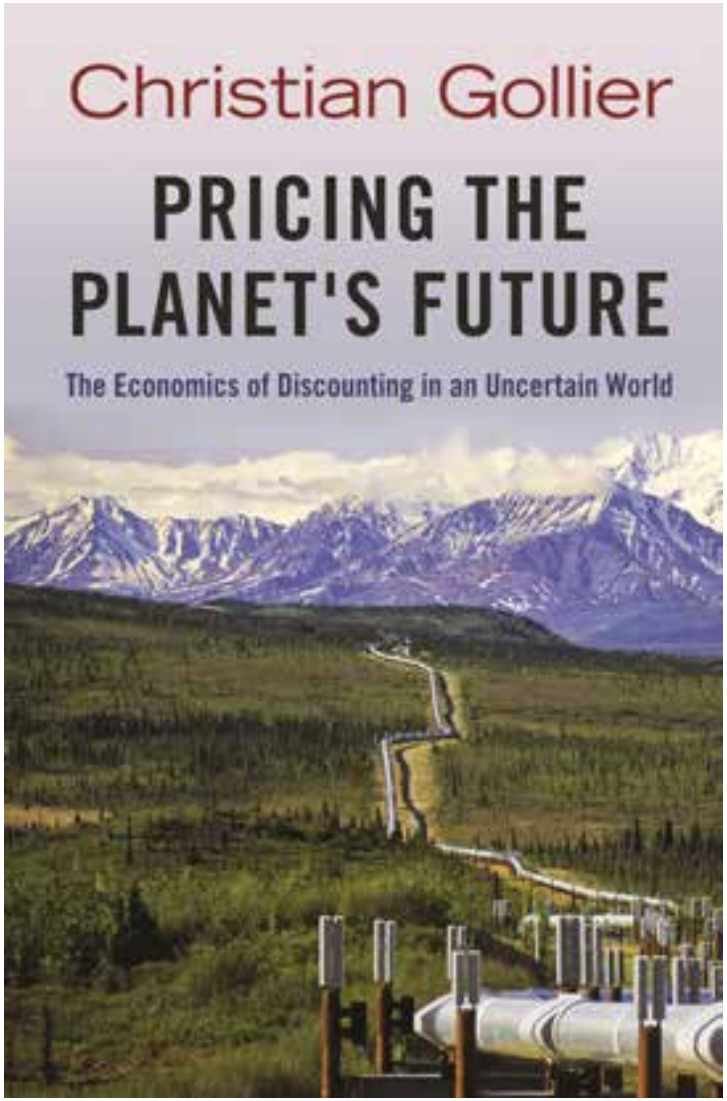
Reference for this talk



Columbia UP (2017)



Princeton UP (2013)

Investment theory in practice

- Finance 101 for corporate decisions:
  - NPV rule in which expected cash-flows are discounted at a risk-adjusted Discount Rate (DR);
  - CAPM: The risk-adjusted DR is the sum of a risk-free rate and a project-specific risk premium.
- Public Economics for public decisions:
  - Expected cash-flows are discounted at a social DR;
  - Arrow-Lind Thm: The social DR is equal to the risk-free rate.
- This discrepancy is absurd and inefficient (Law of one price).
- Capital is misallocated in the economy, leading to collosal deadweight losses for the citizens.

Discount rates in practice

- DR for US corporate decisions:
  - Real risk-free rate around 1%;
  - No risk premium for diversifiable risks;
  - Risk premium around 2% for a project whose risk profile is similar to the macroeconomic risk.

- DR for public decisions:
  - Single DR;
  - Positive approach (arbitrage argument): SDR = real return on sovereign bond;
  - Ramsey rule: SDR = 2 times the expected growth rate of GDP/cap - precautionary premium.

The curse of the Arrow-Lind Theorem

- The argument for a risk-neutral government is that the State is so large that it can diversified away all risks.
- The Arrow-Lind Theorem (1972) is a special case of the Consumption-based CAPM (CCAPM, Lucas (1978)) in which all projects generate *independent* future benefits, i.e., are fully diversifiable.
- Let the β of a project be the elasticity of its future benefits to changes in aggregate consumption.
  - Arrow-Lind projects: $\beta = 0$;
  - Projects that increase the aggregate risk: $\beta > 0$;
  - Projects that reduce the aggregate risk: $\beta < 0$.
- Although all projects are marginal, their aggregation generates the macro risk.
- Arrow-Lind ignores the social benefit of investments that hedge the macro risk, and the social cost of investments that raise it.

Term structures in public discount rates

- Public institutions in the U.S. use a single rate of 3% or 7% to discount the future impacts of a policy.
- U.K., Green Book (2013): Decreasing term structure of discount rates
  - from 3.5% (0-30 years)
  - to 1% ($\geq$300 years).
- France: Lebegue report (2005), Gollier report (2011), Quinet report (2013):
  - Risk free rate: 2.5% (less than 50 years) to 1.5% (LT).
  - Risk premium: 1.5% (less than 50 years) to 3% (LT).
- France is the only country which uses an efficient discounting system. But it is currently contemplating the possibility of going back to a single discount rate (Guesnerie-Ourliac Report (2019)).

Related literature

- Public and environmental economics
  - Ramsey (1928): Solve the optimal saving/investment problem under certainty.
  - Weitzman (2001): Gamma discounting under uncertainty
  - Nick Sten (2007), Simon Dietz, Ben Groom, Anthony Millner, David Maddison, Cameron Hepburn,...
- Asset pricing theory
  - Consumption-based CAPM: Lucas (1978), Rubinstein, Breeden, Hansen,...
  - Long-run risk: Bansal and Yaron (2004), ...
- Giglio, Maggiori and Stroebel (2015): The discount rate observed on real estate markets for 100_+-year maturities is 2.6%.

A normative model for discounting: CCAPM

- Social welfare function:

$$V_0 = \sum_{t=0} e^{-\delta t} E_0 U(C_t)$$

- Suppose that $U(C) = C^{1-\gamma}/(1-\gamma)$ and C_t follows a geometric brownian process with trend μ and volatility σ.
- Consider a project that generates a single benefit C_T^{β} at date per dollar invested today.
- At the margin, investing in this project if its NPV is positive, with the following DR:

$$R = r^f + \beta\pi \text{ (CCAPM rule)}$$

$$rf = \delta + \gamma\mu - 0.5\gamma^2\sigma^2 \text{ (Ramsey rule)}$$

$$\pi = \gamma\sigma^2$$

Why do we discount safe projects?

- In a growing economy, investing has the adverse effect to increase intertemporal inequalities.
- The DR is the minimum IRR that is necessary to compensate for this adverse effect.
- If growth is certain, this DR is equal to $\gamma\mu$, where γ is an index of intertemporal inequality aversion.
- If growth is uncertain, it is prudent to implement precautionary investments by reducing the DR by $0.5\gamma^2\sigma^2$.
- "Risk-free rate puzzle" of financial economics: This provides a prediction for the interest rate which is too large. Markets have been very long-termist for safe projects.

Measure of inequality aversion: The experts' view

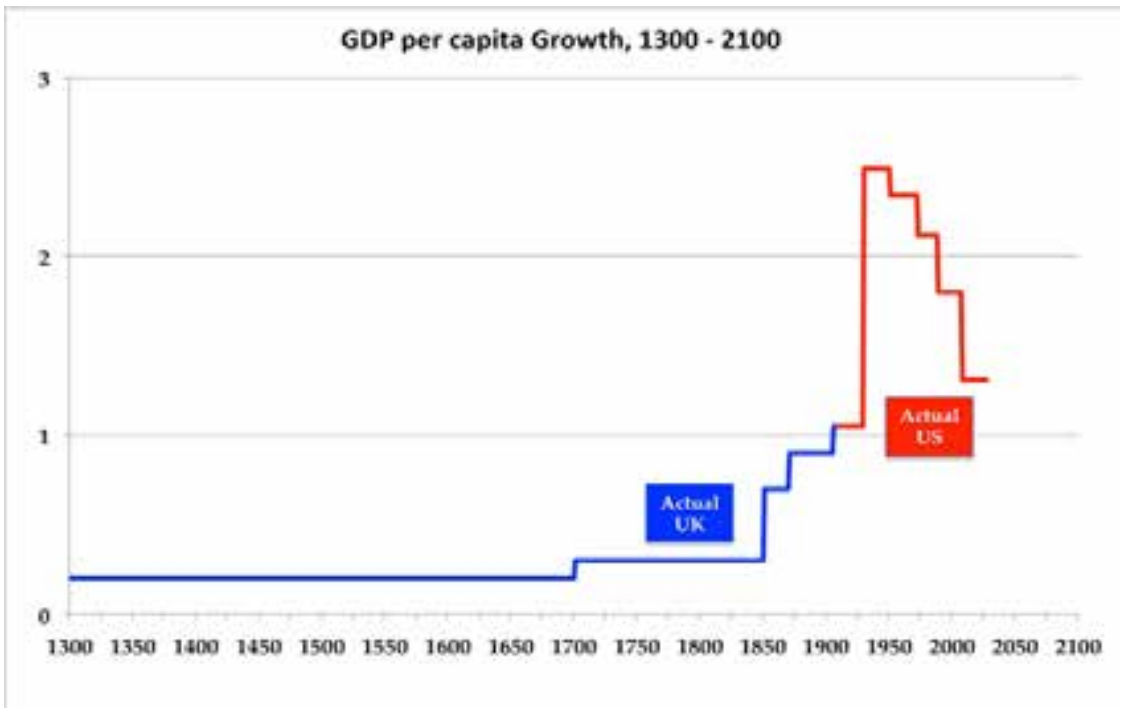
author	inequality aversion	growth rate	discount rate
Stern (1977)	2		
Cline (1992)	1.5	1%	1.5%
IPCC (1995)	1.5-2	1.6%-8%	2.4% - 16%
Arrow (1995)	2	2%	4%
UK: Green Book (2003)	1	2%	2%
Stern (2007)	1	1.3%	1.3%
Arrow (2007)	2-3		
Dasgupta (2007)	2-4		
Weitzman (2007)	2	2%	4%
Nordhaus (2008)	2	2%	4%

CCAPM risk premium and market short-termism

- By how much should we penalize projects that raise the macro risk? How should we value the benefit of the mitigation/hedging of the aggregate risk borne by our fellow risk-averse citizens?
- CCAPM: $\pi = \gamma\sigma^2$, which is small: Equity premium puzzle.
- Financial markets have been very short-termist for the pricing of risky projects.
- Solving the asset pricing puzzles (reduce r^f, raise π):
  - Extreme events and macroeconomic catastrophes (Barro, Weitzman, Martin);
  - Epstein-Zin preferences and long-run risks (decreasing term structure);
  - Deep uncertainties (Weitzman, Gollier, Weitzman-Gollier).

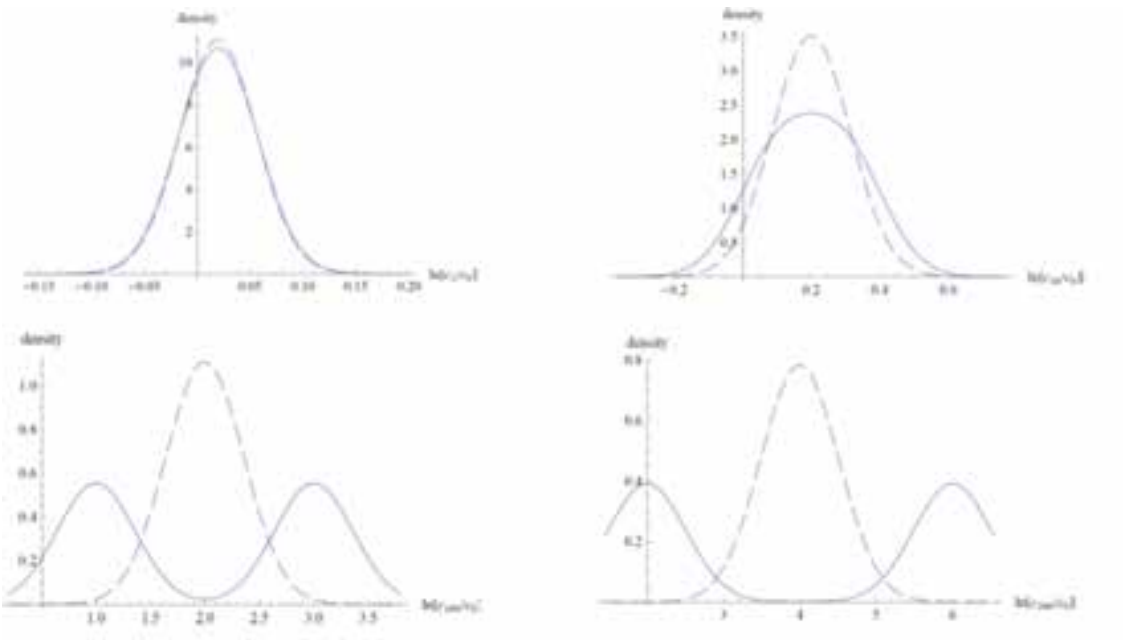
Deeper uncertainties surround the distant future

- The LT trend of the economy is uncertain: Secular stagnation?



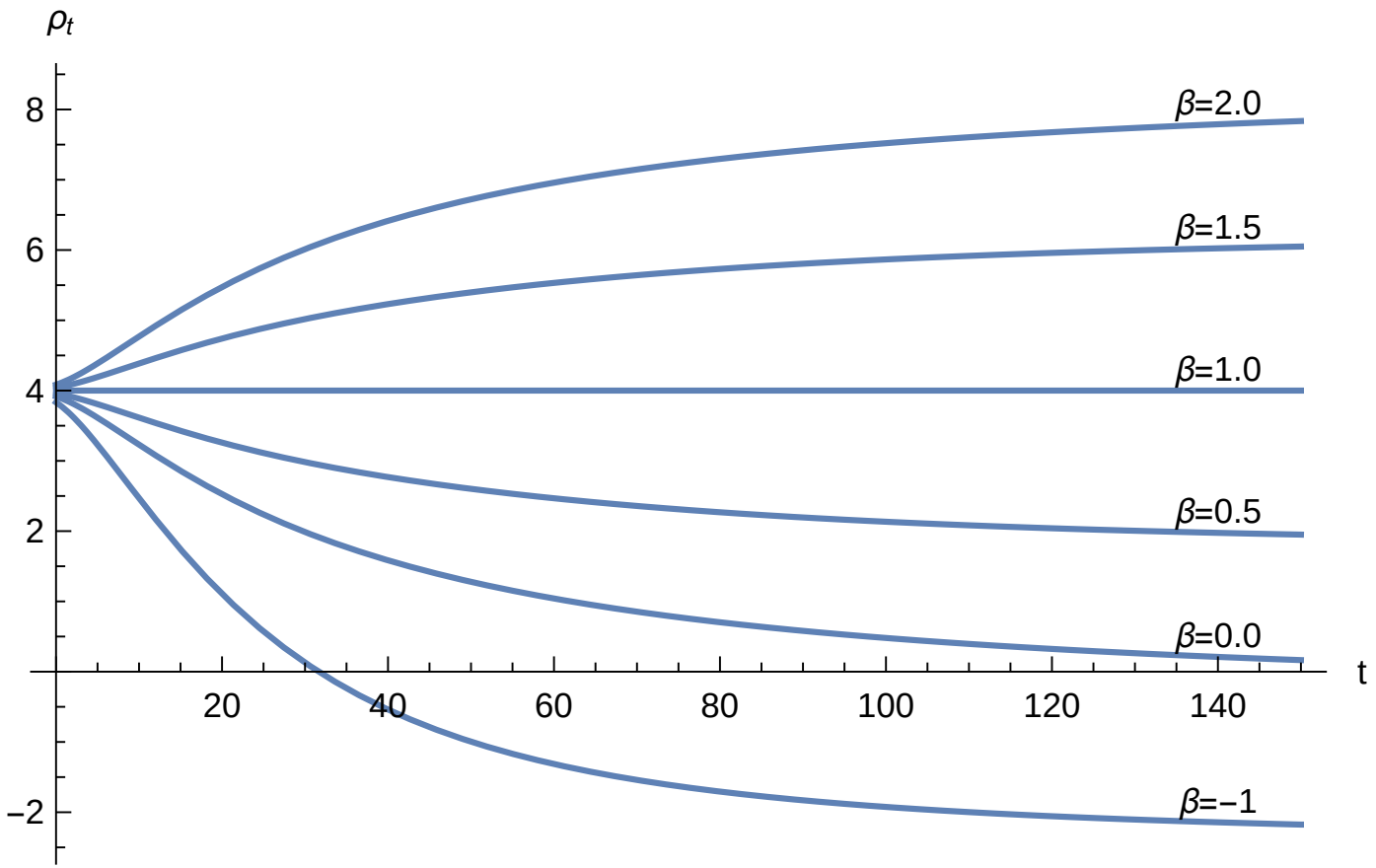
Uncertain trend and LT uncertainty

- Parametric uncertainty generates an increasing term structure of risk on future consumption.
- Example with $\mu \sim (1\%, 1/2; 3\%, 1/2)$ and $\sigma = 3.6\%$.

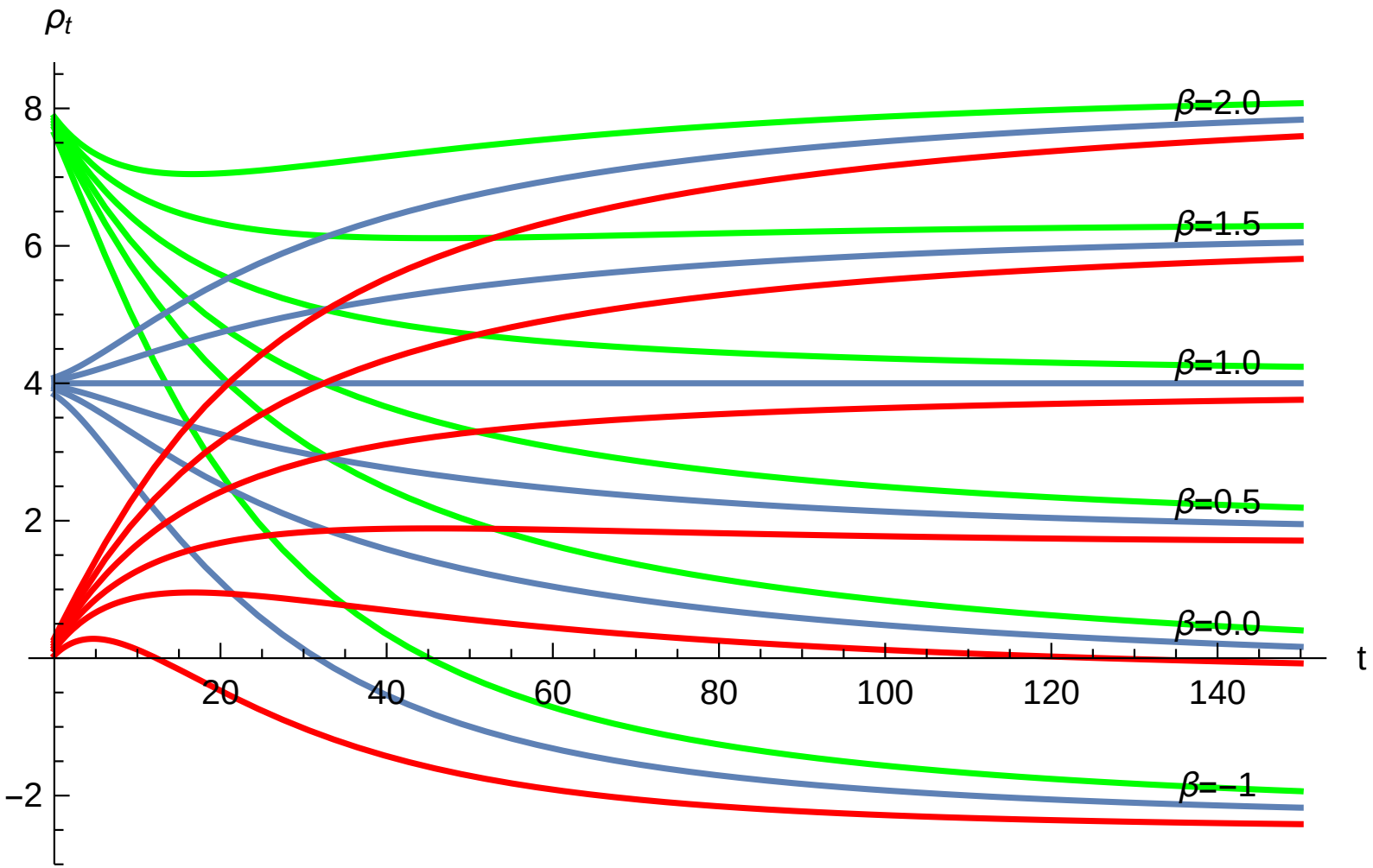


Deep uncertainty: Uncertain trend

- $\delta = 0$, $\gamma = 2$, $\sigma = 2\%$, and $\mu \sim (0.8\%, 1/2; 3.2\%, 1/2)$



Surimposing mean-reversion



International comparison (Gollier-Mahul (2017) with Epstein-Zin preferences and mean-reversion

Country	μ	σ	k	$\overline{r}^f_{0,1}$	$\overline{r}^f_{0,20}$	$\pi_{0,1}$	$\pi_{0,20}$
China	7.48	4.37	0.37	3.27	2.17	2.99	4.74
European Union	2.25	1.54	0.48	2.08	1.83	0.44	0.83
France	2.11	1.55	0.57	1.85	1.43	0.53	1.20
Latin America	1.73	2.10	0.40	1.49	1.20	0.72	1.19
ME & North Africa	1.76	3.20	0.46	0.43	-0.54	1.83	3.37
Nicaragua	0.47	5.49	0.36	-2.76	-4.32	4.53	7.00
Sub-Saharan Africa	0.86	2.42	0.49	0.52	-0.11	1.09	2.08
United Kingdom	2.01	1.92	0.37	1.83	1.62	0.57	0.89
United States	2.08	1.89	0.31	1.94	1.80	0.51	0.73
World	1.85	1.35	0.37	1.98	1.88	0.28	0.45
Zimbabwe	0.02	6.08	0.40	-4.40	-6.82	5.91	9.75

Estimation of beta

- The beta of a project is the elasticity of its benefit to change in GDP/cap. It can be estimated by regressing $\log(B_t)$ with respect to $\log(C_t)$.

- Typical large β projects:
  - Fast train lines;
  - Projects whose output has a high income-elasticity of demand (energy?).

- Typical low (negative) β projects:
  - Prevention of macro risk (wind and flood protection in Haiti);
  - Export infrastructures (transfrontier electricity transportation).

Take-home messages

- The tradition to use a single discount rate to evaluate public policies is wrong. It is based on a flawed Arrow-Lind Theorem, as demonstrated 40 years ago by the CCAPM.
- This persistent tradition leads to overinvestment in too risky activities, and to underinvestment in activities which have the benefit to reduce the macroeconomic risk.
- This also makes the debate on the efficient discount rate unintelligible.
- This should be changed.

I need your help...