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The Climate Beta

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Classical debate on the Discount Rate (DR): CCAPM

- CBA: An action is socially desirable if the discounted value of the flow of expected net benefits is positive.
- Why do we discount the future? Because in a growing economy, investing for the future transfer consumption from the poor (us) to the wealthy (future generations).
- But we are not so sure that future generations will be wealthier, and if they are, by how much.
- Prudence ("$u''' > 0$") justifies using a smaller risk-free DR.
- Decreasing DR: This effect is increasing with maturity.
- Recommendation: Safe DR goes from 2% for short maturities to $0.5 - 1\%$ for extra long ones.

Risk-adjustments

- The practice almost everywhere is to use the same discount rate for all projects. We talk about "*the*" DR.
- This is a catastrophe: Too many projects with a positive NPV when a DR of $1-2\%$ is used! CBA is discredited.
- Most projects increase risk borne by future generations. They should be penalized because of risk aversion.
- Increasing risk premia: Because of the deep uncertainties affecting the distant future, this risk premium is increasing with maturity.
- The DR should be increased by adding a project-specific risk premium $\pi_i = \beta_i \times \pi$.
  - π is the systematic risk premium, which should be around 1% for short maturities, and around 3% for long maturities.
  - β_i is the elasticity of the net benefit to changes in aggregate consumption.

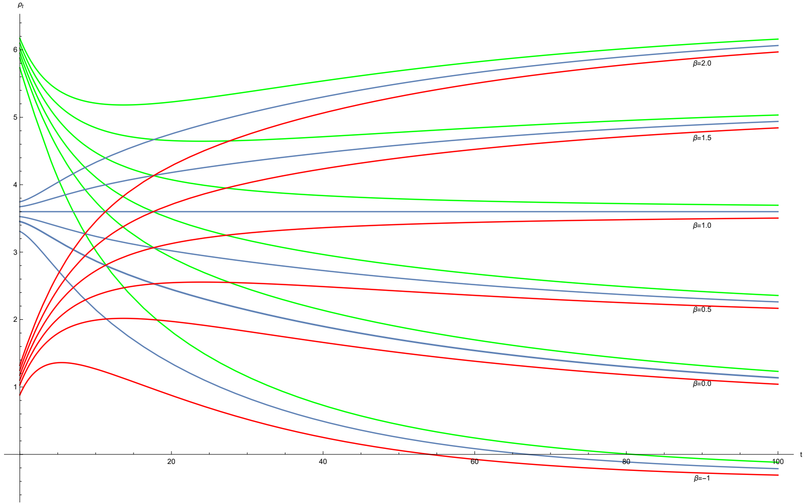
Debating on the climate discount rate

- When estimating the social cost of carbon, which rate should we use to discount marginal climate damages?
- Much of the debate on this question has been based on the Ramsey rule, thereby implicitly assuming that climate damages are certain.
- In reality, if β_t is the elasticity of the marginal climate damage in t years to changes in aggregate consumption at that time, then, one should use the following DR:

$$\rho_t = r_t^f + \beta_t \pi_t.$$

- To debate on the climate DR, one should examine independently the choices of r_t^f, π_t, and β_t.

The choice of the risk-adjusted DR for different maturities and different betas



Climate beta

- What is the beta of investments whose aim is to reduce emission of CO_2?
- Two opposite stories:
  - Positive beta: A growth rate larger than expected raises CO_2 concentration and the marginal damage. There is a positive correlation between future consumption and the future benefit of mitigation.
  - Negative beta (Daniel, Litterman and Wagner (2015)): A larger climate sensitivity raises the marginal damages and reduces consumption.
- This paper: $\beta \simeq 1$.

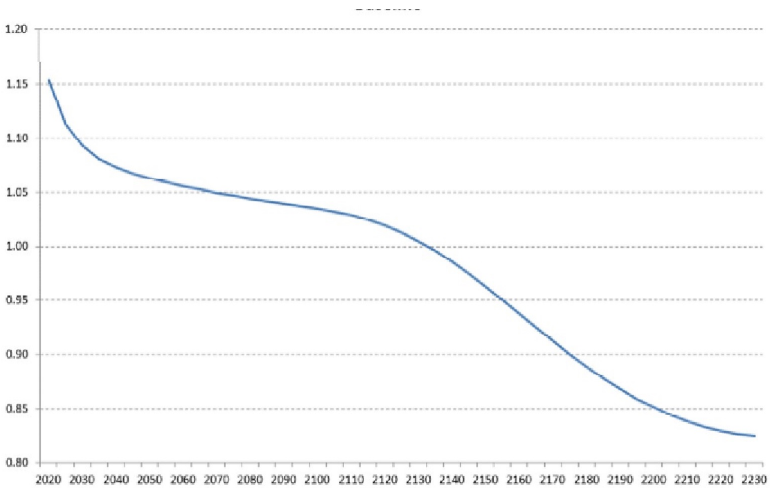
Calibration of DICE

Table 2: Uncertain parameters for simulation of modified DICE-2013R.

Parameter	*Functional form*	*Mean*	*Standard deviation*	*Source*	*Effect on β (likely)*
Initial growth rate of TFP (per year)	Normal	0.0084	0.0059	Maddison project and other sources (see text)	+
Asymptotic global population (millions)	Normal	10854	1368	United Nations (2013)	+
Initial rate of decarbonisation (per year)	Normal	-0.0102	0.0064	IEA (2013)	(+)
Price of back-stop technology in 2050 US$/t$CO_2$(2010 prices)	Log-normal	260	51	Edenhofer et al. (2010)	+
Transfer coefficient in carbon cycle (per decade)	Normal*	0.06835	0.0202	Ciais et al. (2013)	(-)
Climate sensitivity °C per doubling of atmospheric CO_2	Log-logistic**	2.9	1.4	IPCC (2013)	(-)
Damage function coefficient α_2 (% GDP)	Normal	0.0025	0.0006	Tol*** (2009)	(-)
Damage function coefficient α_3 (%GDP)	Normal	0.082	0.028	Dietz and Asheim (2012)	(-)

*Truncated from above at 0.1419. ***Truncated from below at 0.75. ***Including corrigenda published in 2014.

Term structure of the climate beta



Calibration of SCC

$r_f \setminus \pi$	0.00%	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%
0.00%	865.16	443.78	237.16	132.81	78.33	48.78	32.08
0.50%	412.26	223.45	126.90	75.82	47.77	31.71	22.12
1.00%	211.71	121.85	73.70	46.92	31.41	22.05	16.16
1.50%	117.53	71.90	46.22	31.18	22.01	16.19	12.35
2.00%	70.39	45.65	31.01	22.00	16.24	12.41	9.77
2.50%	45.18	30.89	22.02	16.30	12.48	9.84	7.95
3.00%	30.81	22.05	16.37	12.56	9.91	8.01	6.62

Figure: Social Cost of Carbon in $\$/tCO_2$ as a function of the risk-free rate r_f and risk premium π.

Take-home messages

- If we believe in DICE, the climate beta is around 1.
- Focusing on the Ramsey rule, which provides the risk-free DR, is misleading.
- Climate discount rate $= 1 + 1 \times 3 = 4\%$.

Wait a minute! There is a Post-Scriptum...

- The SCC is the discounted sum of the flow of expected damages.
- The climate beta is the elasticity of marginal climate damages to consumption: $D_t = C_t^\beta$.

$$PV = e^{-(r_t^f + \beta\pi_t)t} ED_t$$

$$ED_t = EC_t^\beta = C_0^\beta E e^{\beta \log C_t} = C_0^\beta e^{(\beta\mu + 0.5\beta^2\sigma^2)t}$$

- The larger the climate beta, the larger the expected damage!
- This effect dominates the discounting effect.
- The large climate beta that we obtain is in favor of a large social cost of carbon.