Dangers of Abatement Procrastination in a Tipping Climate

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Motivation

- Increased concerned about the presence and distance of tipping point (Seaver Wang et al., 2023)
- Uncertainty too large to predict them (Ben-Yami et al., 2024)
- Recognised importance of tipping points in determining optimal abatement (Dietz et al., 2021; Hambel et al., 2021; Lin and Wijnbergen, 2023; Van den Bremer and Van der Ploeg, 2021)

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This Paper

1. Integrate a tipping point in an IAM
2. Estimate optimal abatement and net present cost of climate change
3. Estimating regret associated with getting the tipping point wrong
4. Implications for a multiple emitters world

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Climate Model

Carbon in sinks N_t and in the atmosphere M_t

$$\xi_m \,\mathrm{d}N_t = \delta_m(N_t) M_t \,\mathrm{d}t \tag{1}$$

$$\frac{\mathrm{d}M_t}{M_t} = (\gamma_t - \alpha)\,\mathrm{d}t + \sigma_W \,\mathrm{d}W_{m,t} \tag{2}$$

γ^t calibrated using SPSS5 BaU scenario (Kriegler et al., 2017)

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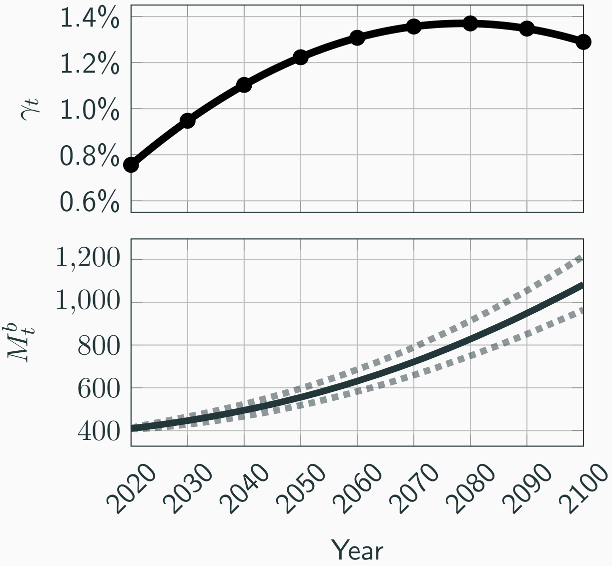
BaU calibration



Temperature dynamics

$$\mathrm{d}T_t = r(T_t)\,\mathrm{d}t + g(M_t)\,\mathrm{d}t + \sigma_T\,\mathrm{d}W_{T,t} \tag{3}$$

- Greenhouse gas effect

$$g(M_t) = G_0 + G_1 \log(M_t/M_t^p) \tag{4}$$

- Radiative forcing

$$r(T_t) = S_0 \underbrace{\Big(1 - \lambda(T_t)\Big)}_{\text{Positive feedback}} - \eta\sigma T_t^4 \tag{5}$$

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Positive feedback

When temperature deviations from pre-industrial levels $T_t - T^p$ cross a tipping point T^c, the function λ smoothly transitions from a high to a low value. (Ashwin and Von Der Heydt, 2020; McGuffie and Henderson-Sellers, 2005)

Consider two scenarios

- a remote tipping point $T^c = 2.5^\circ$
- an imminent tipping point $T^c = 1.5^\circ$

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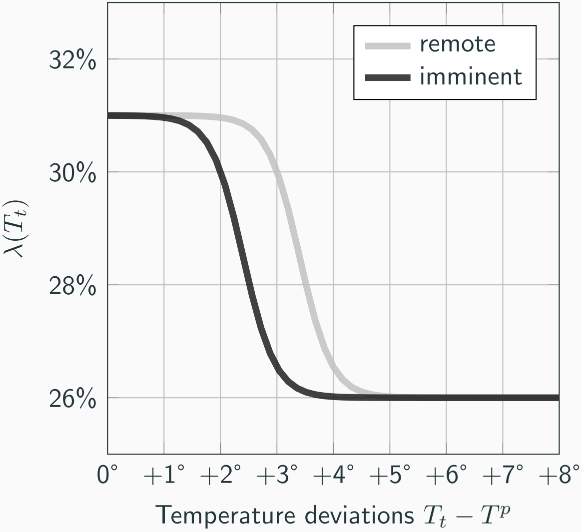
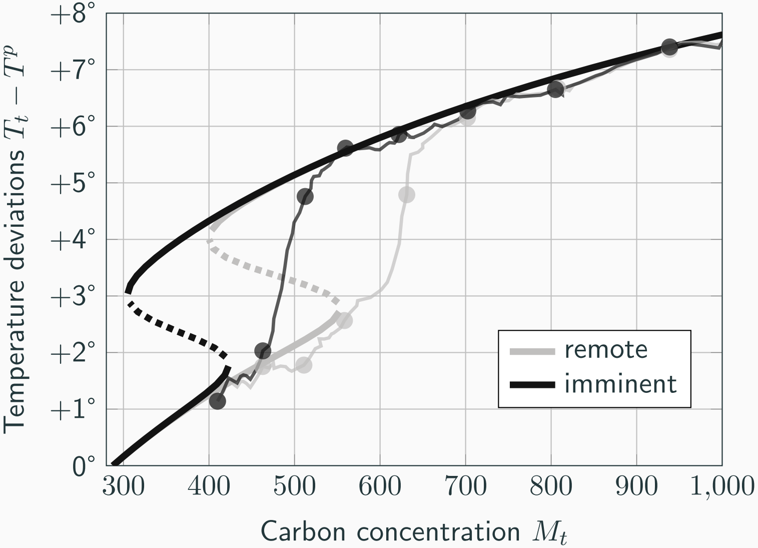


Effect on Temperatures



Stochastic Tipping

$$\mathrm{d}T_t = r(T_t)\,\mathrm{d}t + g(M_t)\,\mathrm{d}t + \sigma_T\,\mathrm{d}W_{T,t} + q(T_t)\ \mathrm{d}N_t\,(T_t) \qquad (6)$$

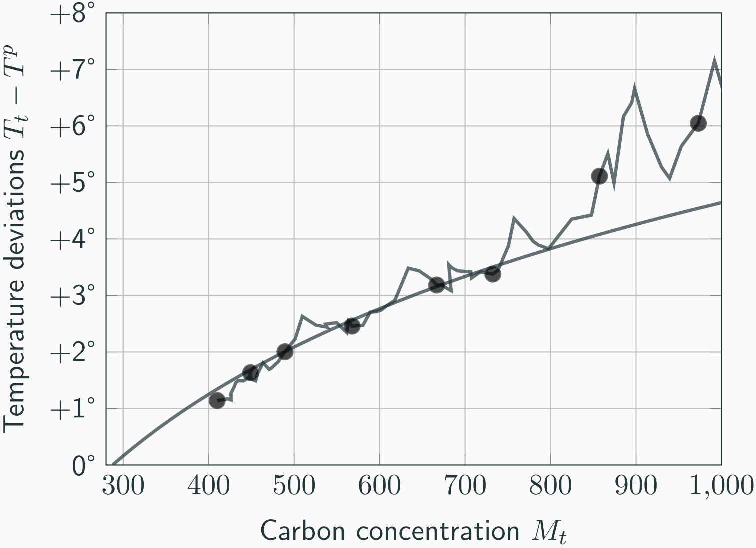
- Greenhouse gas effect

$$g(M_t) = G_0 + G_1 \log(M_t/M_t^p) \qquad (7)$$

- Radiative forcing

$$r(T_t) = S_0\Big(1 - \lambda\Big) - \eta\sigma T_t^4 \qquad (8)$$

Effect on Temperatures



Economy

Social Planner Problem

Maximise net present value of consumption

$$V_t(T_t, M_t, Y_t) = \sup_{\chi,\alpha} \mathbb{E}_t \int_t^\infty f(\underbrace{\chi_s Y_s}_{\text{consumption}}, V_s)\ \mathrm{d}s \tag{9}$$

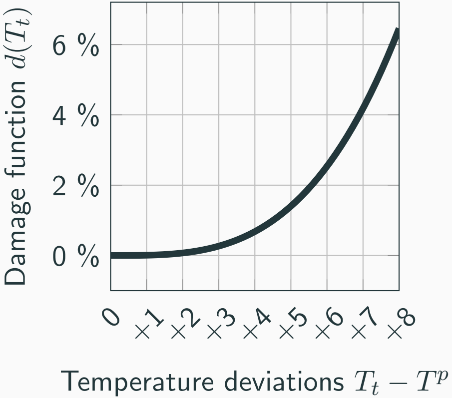
where f is an Epstein-Zin aggregator, subject to

$$\frac{\mathrm{d}Y_t}{Y_t} = \phi_t(\chi_t) - d(T_t) - \omega_t c_t(\alpha_t). \tag{10}$$

Updated calibration by Hambel et al., 2021.

Damage function

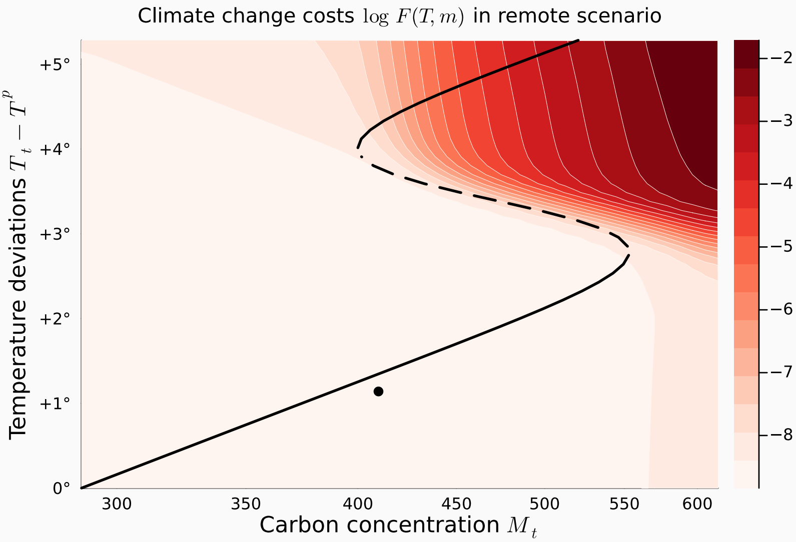
Weitzman, 2012



Results

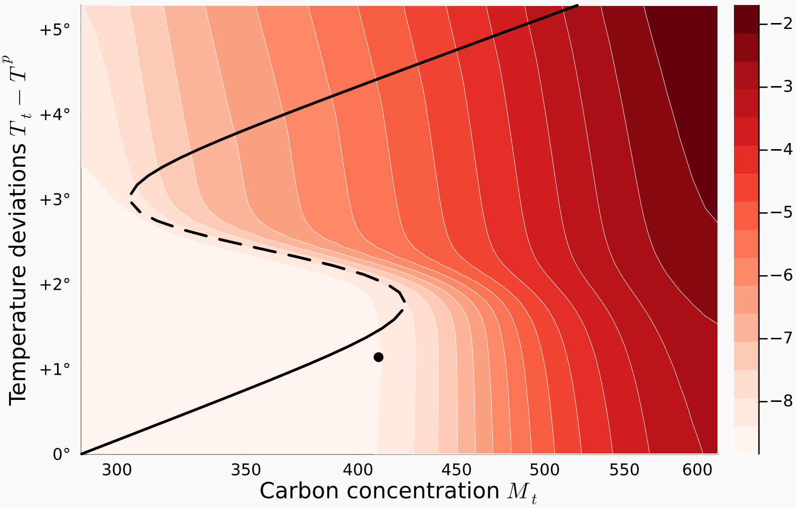
Costs of Climate Change

$$V_t(T_t, M_t, Y_t) \equiv \frac{Y_t^{1-\theta}}{1-\theta} \underbrace{F_t(T_t, M_t)}_{\text{Cost of climate change}} \tag{11}$$

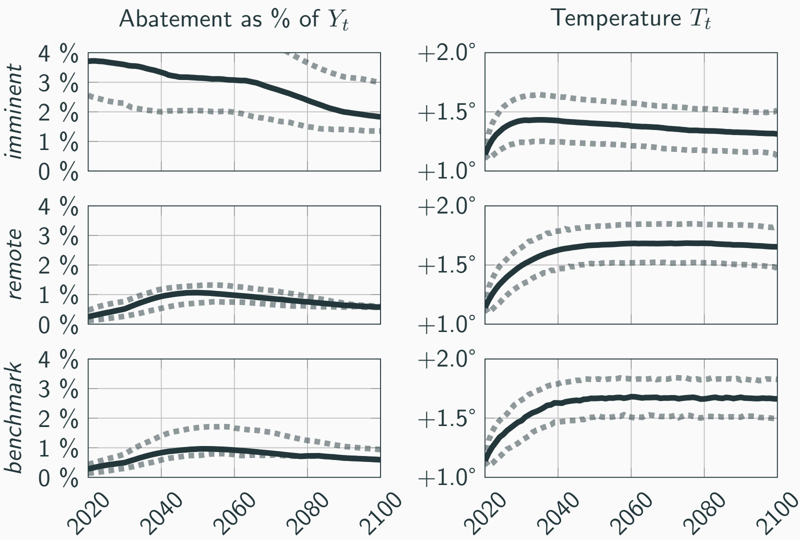


Climate change costs $\log F(T, m)$ in remote scenario
Temperature deviations $T_t - T^p$
+5°
+4°
+3°
+2°
+1°
0°
300
350
400
450
500
550
600
Carbon concentration M_t
−2
−3
−4
−5
−6
−7
−8

Climate change costs $\log F(T, m)$ in imminent scenario



Optimal Abatement



Conclusion

1. Stochastic and bifurcation tipping prescribe **qualitatively** different optimal abatement paths
2. Costs of regret can be extremely large and dwarf first order results

Thank you!