Too Little Too Late, part II

Clean Innovation as Policy Commitment Device

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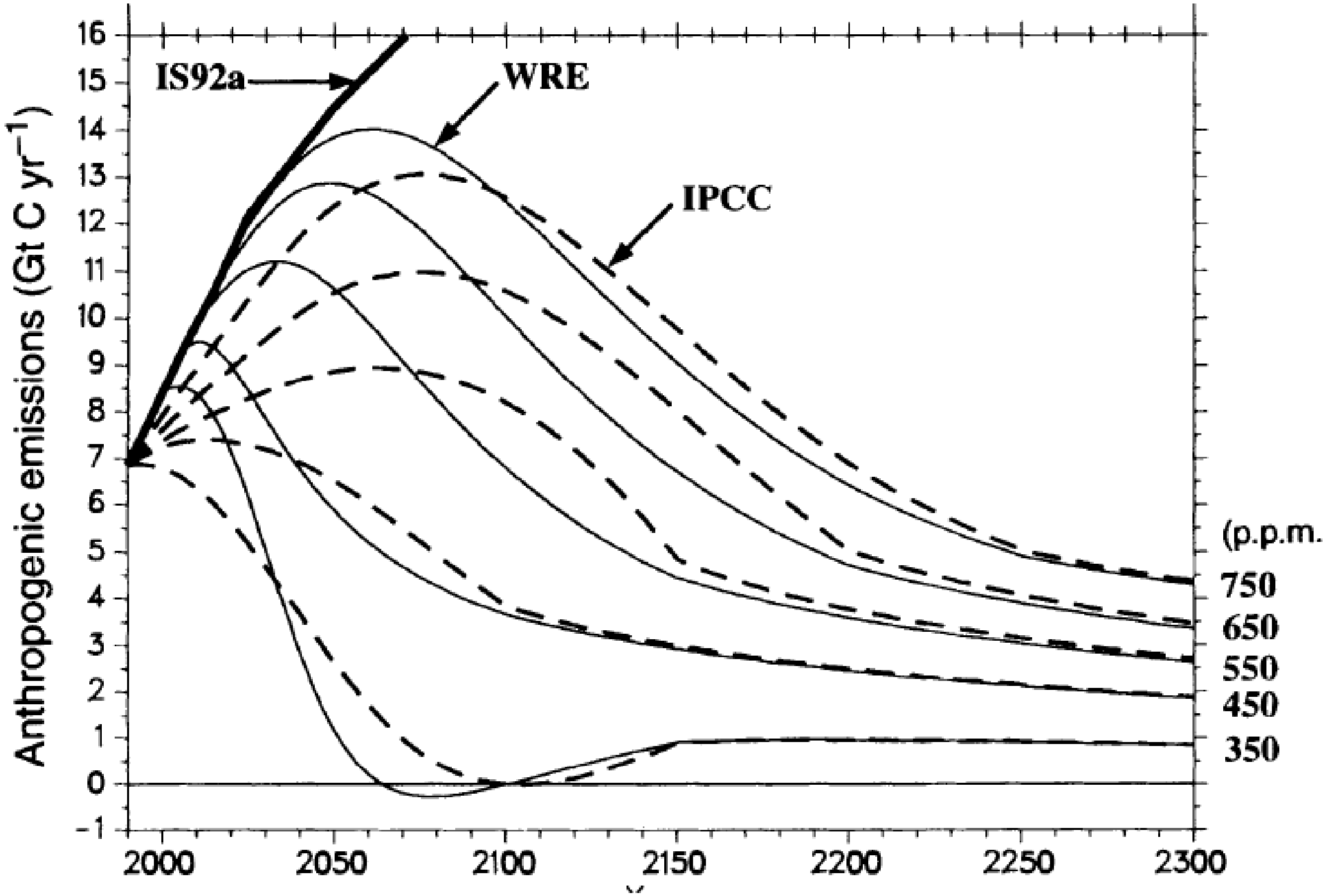
WRE 96: IPCC92 wants too early reductions



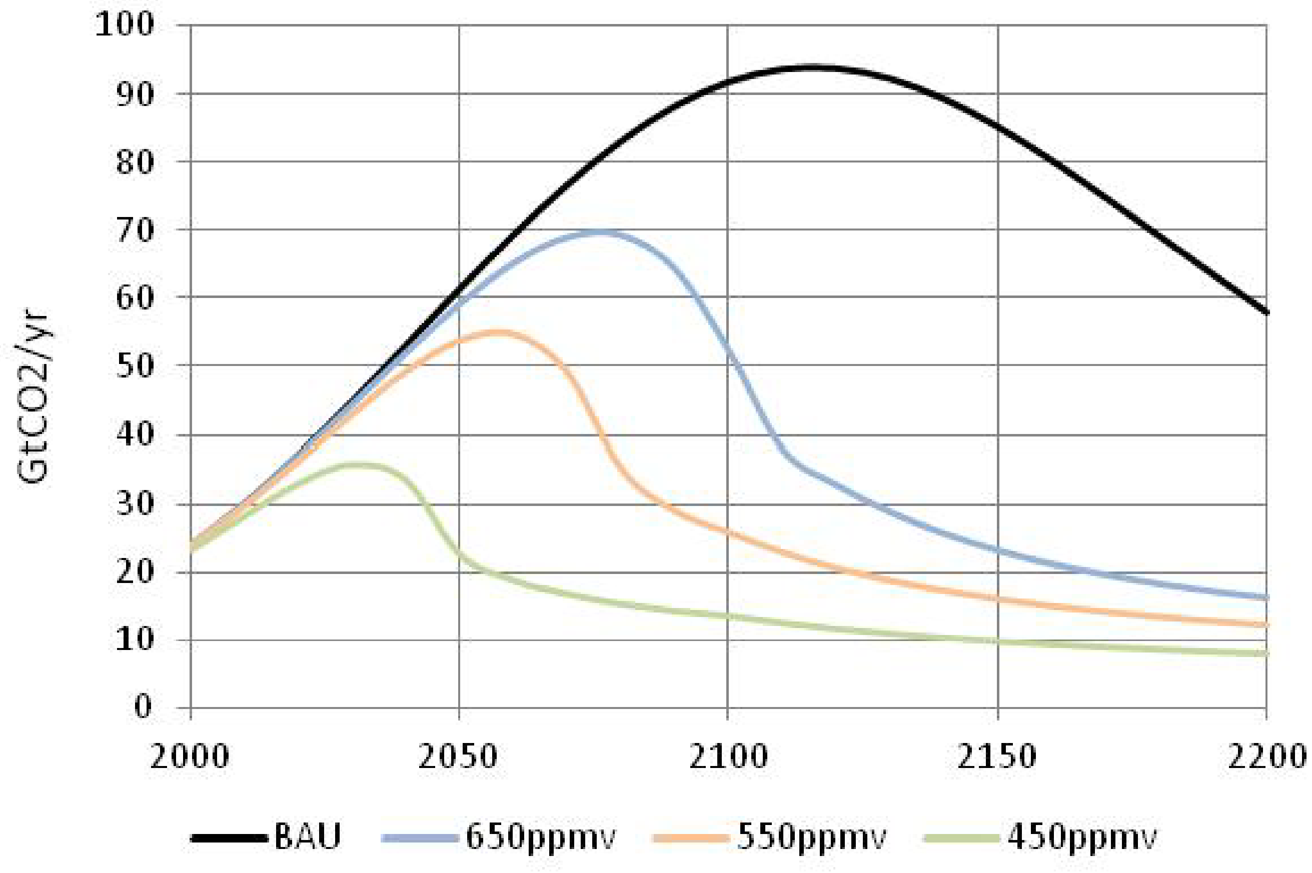
- Wigley, Richels & Edmonds (1996): IPCC92 reduces too early.

Reasons for delay:

- Return on capital (Hicks compensation)
- Vintages of existing dirty capital
- Cheaper future clean technologies
- Atmospheric depreciation (increased carbon budget)

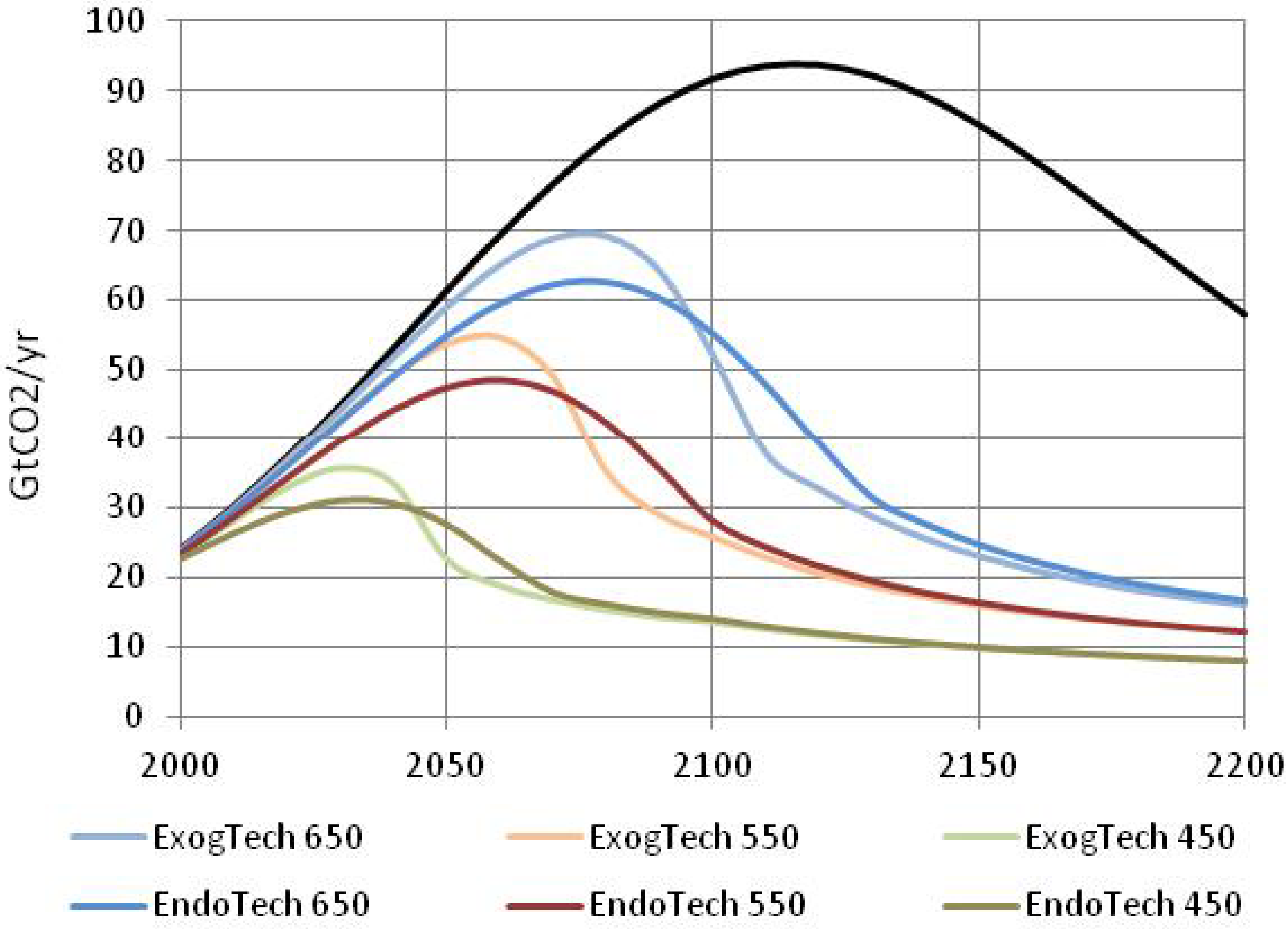
Carbon price goes up with real return on capital + real depreciation

Reproducing WRE 96



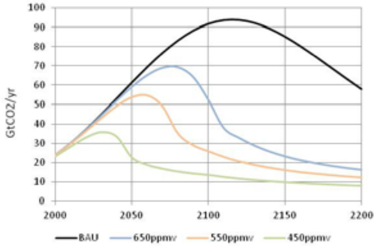
- A simple Ramsey model
- Cobb-Douglas production with capital
- Emissions proportional to output
- Quadratic costs for emissions reductions (linear marginal costs)
  - Decreasing over time
- Emissions – multi-box atmospheric CO2 – ceiling

Critique: Too little too late (ITC)



- Claim: Cheap abatement becomes available only if used -> early abatement is needed
- Ha-Duong et al 1997
- Goulder and Mathai 2000
- Van der Zwaan et al. 2002 2003, … DEMETER
- Manne and Barreto 2004
- Popp 2006, ENTICE
- Bosetti et al. 2006….
- Gerlagh, Kverndokk & Rosendahl 2009, 2014…
- Acemoglu et al. 2012

Scientific uncertainty: stochastic targets

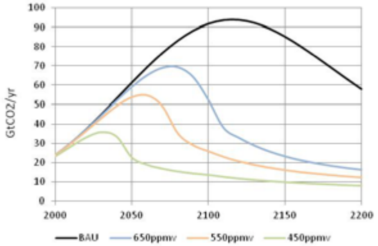


- Scientific uncertainty → don't know climate threshold … yet
- Assume climate threshold is known at some future date *T* → Hedging (act-learn-act)

- Theory: Ulph and Ulph 1997 and Webster 2000
- IAMs: Manne and Richels 1995, Nordhaus and Popp 1997, Yohe, Andronova, Schlesinger 2004, Bosetti et al. 2009, Gerlagh and van der Zwaan 2011

- What if objective targets 'never' arrive? If they need to be derived endogenously, each period again?
  - Assume International Cooperation is reached

Project Part I: Cost-Effective Scenarios = TLTL

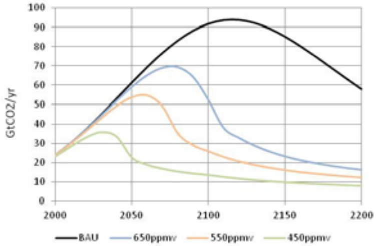


- Research question 1A: how will climate targets develop dynamically, if they are endogenous?

- Frame: Scientific uncertainty → no clear climate threshold → negative welfare as function of expected consequences
- i.e. preferences over consumption stream + long-term climate outcomes
- Result: preferences are time-inconsistent
- Climate change targets are not credible.
  - Assume in 2013: we find 450ppm too costly, so we go for 550ppm.
  - In 2030: Achieving 550ppm is equally costly, as was achieving 450 in 2013.

- Result: Sequence of climate plans deviates from naive plans

Project Part I: Cost-Effective Scenarios = TLTL



- Research question 1B: how big is the gap between committed and naive climate target outcome?

- Result: if we aim for 450ppm (2K) by 2000, we naively reach 570ppmv (>3K)
  - Sensitive to all details of model

Project Part II: Sophisticated policies

- Research question 2A: what are characteristics of a sophisticated policy
  - Sophisticated policy = Markov equilibrium: each regulator predicts correctly future response to current policies, and maximizes its own objectives (that are different from future objectives)
- How to calculate a sophisticated scenario in an IAM?
- Does the sophisticated policy perform better/worse vis-a-vis the naive policy
  - Irrelevance theorem (Iverson 2012): future climate policies don't affect current optimal climate policies

Project Part II: Innovation as commitment device

- Research question 2B: Can clean innovation act as commitment device to to overcome the time-inconsistency problem?

- If so: clean energy innovation deserves support *in excess of* carbon price.

Cost-effective with objective threshold

- UNFCC: “Stabilization of greenhouse gases that would prevent dangerous anthropogenic interference with the climate system”
- Conceptual framework:

$$\max W = \sum_{t=\tau}^{\infty} \beta^{t-\tau} U(t)$$

$$s.t.$$

$$Z(t) \leq \bar{Z}$$

- Where $Z(t)$ is (set of) climate-variables (temperature, atmospheric CO_2, ocean acidification, cumulative emissions), and $\bar{Z}$ is the ‘dangerous’ threshold

Cost-effective with subjective threshold

$$\max W = \sum_{t=\tau}^{\infty} \beta^{t-\tau} U(t) - D(\overline{Z})$$

$$Z(t) \leq \overline{Z}$$

- τ is the time of perspective (when planner decides on optimal path)
- $U^*(t;\tau)$ is the optimal utility at time t envisaged at τ
- $Z^*(\tau)$ is the optimal target envisaged at τ

Numerical model

- Basic Ramsey growth model
- Capital, population growth, CD production function
- Calibrated 3-box atmosphere-ocean-biosphere model
- Quadratic emission reduction costs (loss of output)
- Social costs of atmospheric ppmv quadratic, such that in 2000 a 450 ppmv target is optimal

- ETC1 (current version): transition costs: reducing emissions by 1% more per year (relative to BAU) adds 1% GDP costs
- ETC2 (in progress): endogenous growth choice between TFP & emission intensity

Model: technology

$$W_\tau = \left[\sum_{t=\tau}^{\infty} (1+\rho)^{-(t-\tau)} L_t \ln(C_t / L_t) \right] - \frac{1}{2} \Delta \left(\max\{ppm_t\} - 275 \right)^2$$

$$C_t + K_{t+1} - (1-\delta) K_t = Y_t$$

$$X_t = K_t^{\alpha} \left(A_t L_t \right)^{1-\alpha}$$

$$Y_t = \Omega(Temp_t)(1 - \frac{1}{2} \vartheta_t \mu_t^2 - \varphi \left(\mu_t - \mu_{t-1} \right)^2) X_t$$

$$Z_t = (1-\mu_t) \sigma_t X_t$$

$$Temp_t = f(Z_0; \ldots Z_{t-1}; Z_t)$$

Committing regulator

- Two decision variables: investments (*K*) & abatement (*μ*)
- Assume that regulator controls all future decisions
- Calculate optimal path at time 2000 (or 2020)

$$W_\tau = \left[\sum_{t=\tau}^{\infty} (1+\rho)^{-(t-\tau)} L_t \ln(C_t / L_t) \right] - \frac{1}{2} \Delta \left(\max\{ppm_t\} - 275 \right)^2$$

$$MRT(C^*_{\tau,\tau};(\max ppm_t)^*_\tau) = MRS(C^*_{\tau,\tau};(\max ppm_t)^*_\tau;\tau) = \Delta \left((\max\{ppm_t\})^*_\tau - 275 \right) / C^*_{\tau,\tau}$$

Time-inconsistency of regulator

- Regulator at time *τ*, looking at current consumption:

$$MRT(C^*_{\tau,\tau};(\max ppm_t)^*_\tau) = MRS(C^*_{\tau,\tau};(\max ppm_t)^*_\tau;\tau) = \Delta\left((\max\{ppm_t\})^*_\tau - 275\right)/C^*_{\tau,\tau}$$

- Regulator at time *τ*, looking at future consumption

$$MRT(C^*_{\tau+1,\tau};(\max ppm_t)^*_\tau) = MRS(C^*_{\tau+1,\tau};(\max ppm_t)^*_\tau;\tau) = \Delta\left((\max\{ppm_t\})^*_\tau - 275\right)/(1+\rho)C^*_{\tau+1,\tau}$$

- Regulator at time *τ*+1 (looking at previous plan):

$$MRT(C^*_{\tau+1,\tau};(\max ppm_t)^*_\tau) \neq MRS(C^*_{\tau+1,\tau};(\max ppm_t)^*_\tau;\tau+1) = \Delta\left((\max\{ppm_t\})^*_\tau - 275\right)/C^*_{\tau+1,\tau}$$

Naive regulator

- Regulator assumes that it controls all future decisions
- But each subsequent regulator re-optimizes
- Calculate optimal paths for all times 2000, 2020, 2030, …
- Naive path is sequence of first periods

Sophisticated regulator (Markov equilibrium)

- Regulator forecasts future response
- Calculate equilibrium path

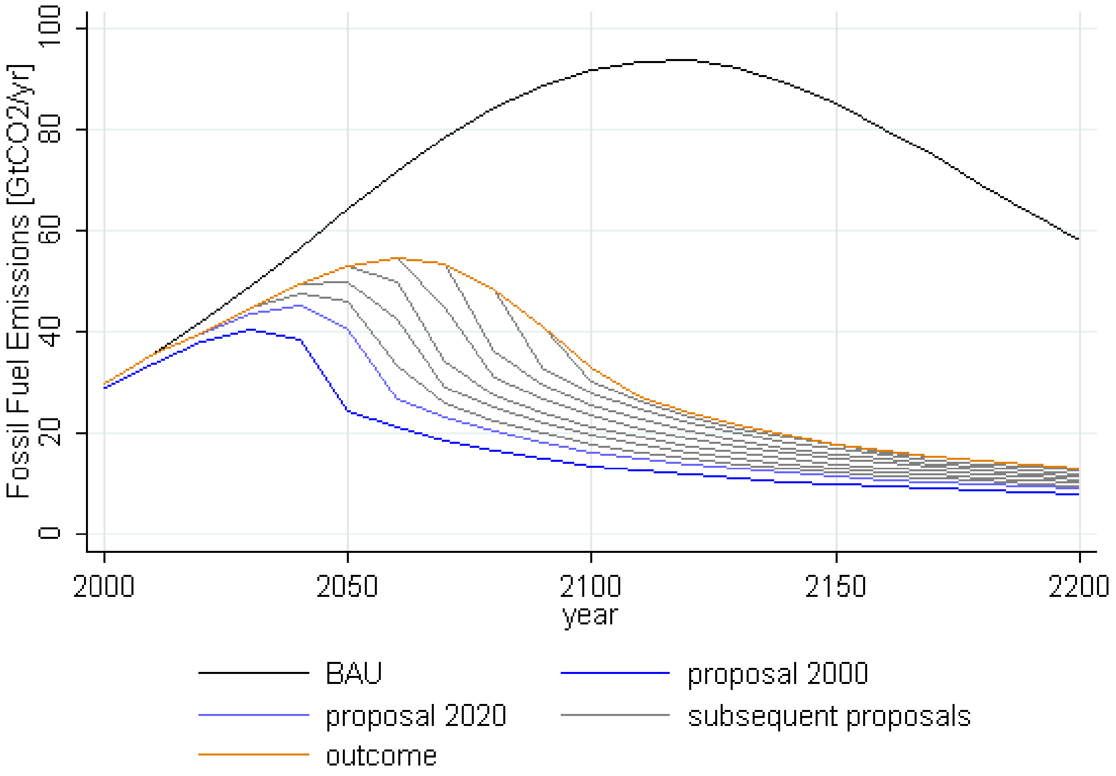
$$\max_{\Theta_{\tau+1}} W_\tau = U_\tau(\Theta_\tau, \Theta_{\tau+1}) + \frac{\Upsilon_{\tau+1}(\Theta_{\tau+1})}{1+\rho} - \frac{1}{2}\Delta\Gamma_{\tau+1}(\Theta_{\tau+1})^2$$

- Backwards recursively estimate functions:

$$\Upsilon_\tau(\Theta_\tau) = U_\tau + \frac{\Upsilon_{\tau+1}(\Theta_{\tau+1})}{1+\rho}$$

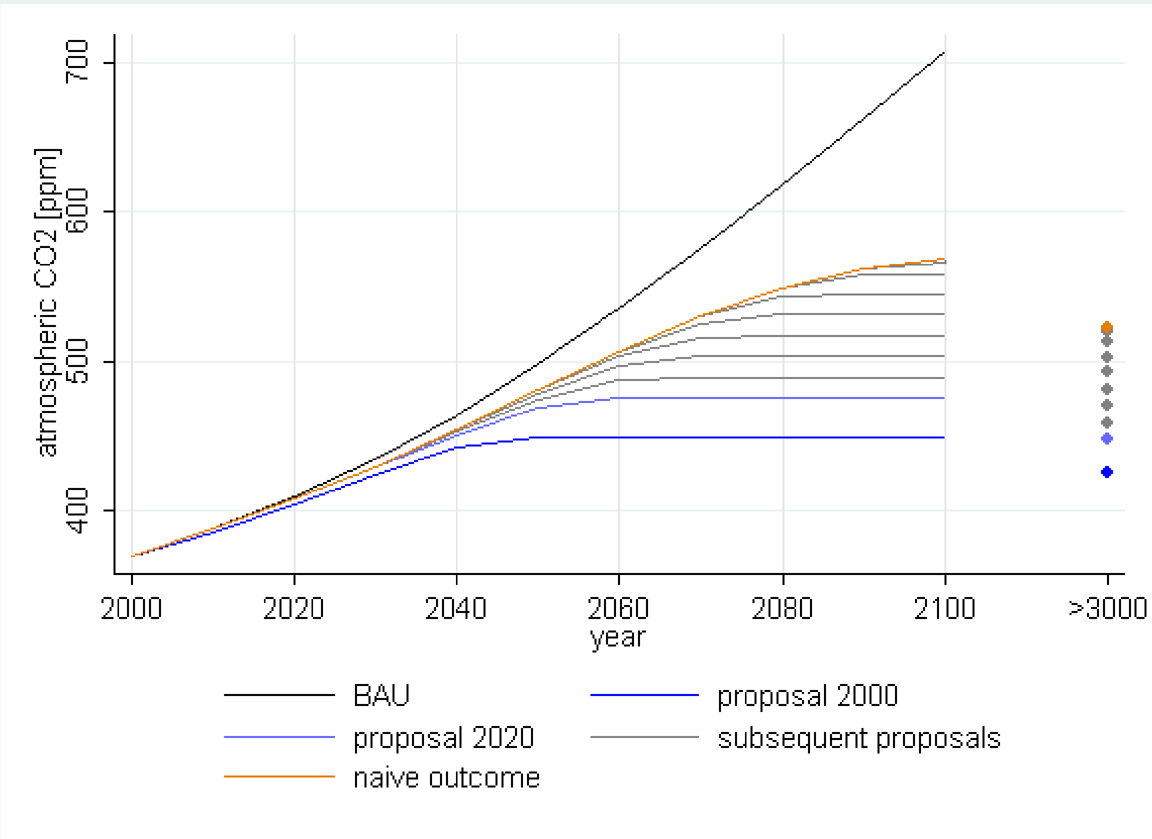
$$\Gamma_\tau(\Theta_\tau) = \max\{ppm_\tau; \Gamma_{\tau+1}(\Theta_{\tau+1})\}$$

Naive policies: Emissions



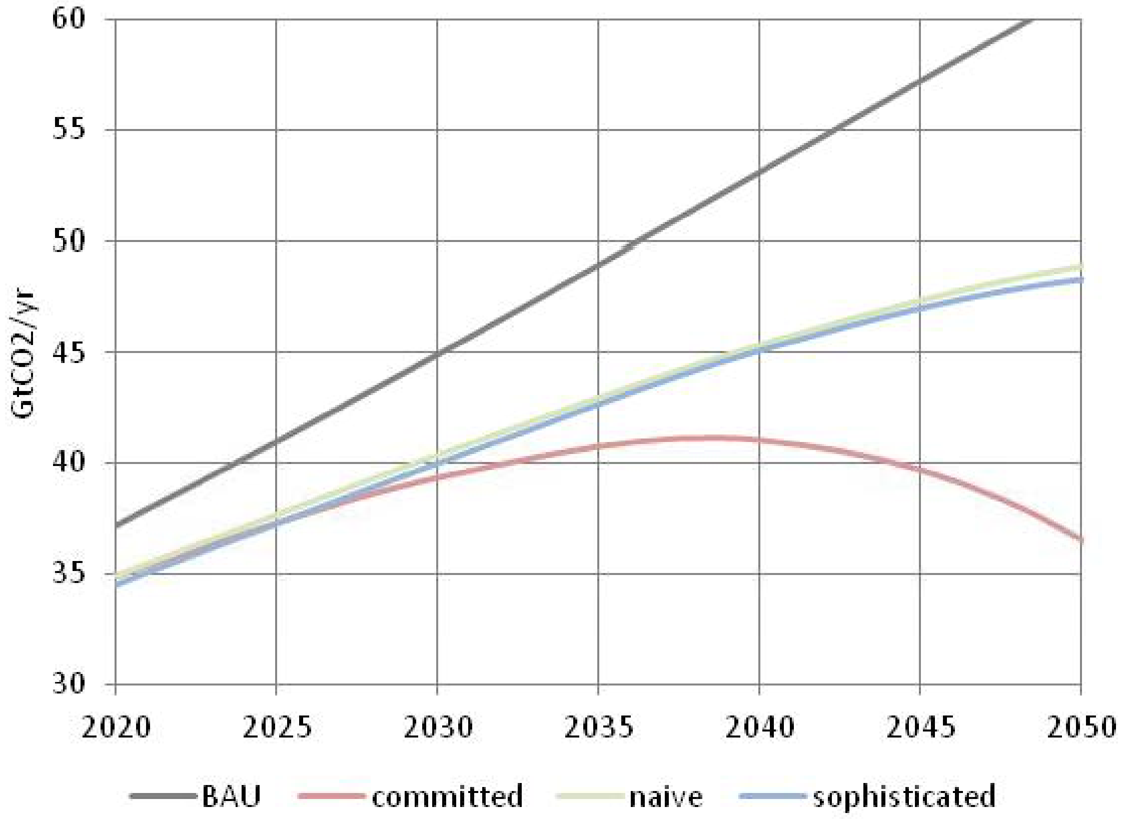
- 2000 proposal: raise carbon prices quickly so that emissions reduce quickly after 2030.
- 20 years of BAU (inaction)
- 2020 proposal: delay action by about 15 years, relative to 2000-proposal.
- 2030 proposal: delay action by another 5 years
- etcetera

Naive policies: Atmospheric CO2 concentrations



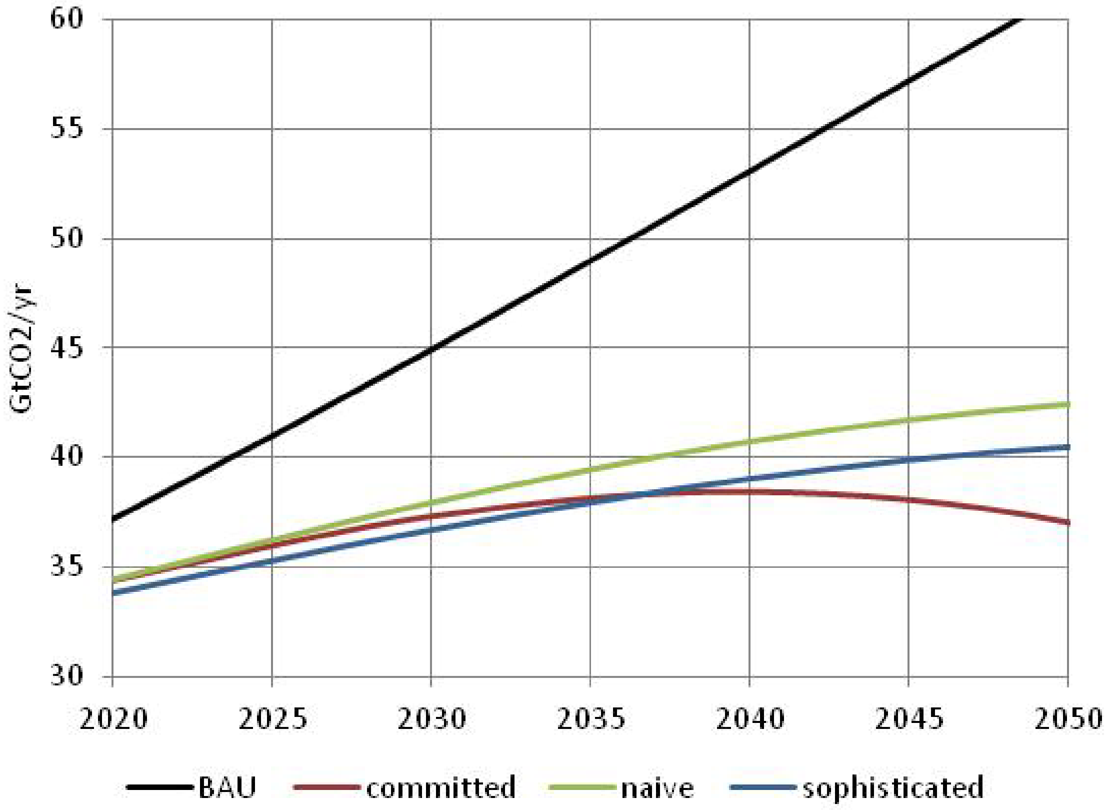
- 2000 proposal: stabilize atmospheric CO2 at 450 ppm.
- 20 years of BAU (inaction)
- 2020 proposal: stabilize at 475 ppm
- 2030 proposal: stabilize at 490 ppm
- Ultimately reached: 570 ppm

Sophisticated policies: virtually no difference



- Sophisticated policy does *not* deviate (much) from Naive policy!
  - Irrelevance theorem (Iverson)

Commitment through 'technology'



- Assume Transition Costs (very rudimentary ETC)
- More abatement now = cheaper future abatement
- Abatement = commitment device
- Sophisticated policy abates more compared to Naive policy!
- TU-SSB project: endogenous growth specification

I. Too little too late

- Our paper specifies climate target as an endogenous variable dependent on preferences for climate stabilization, in addition to preferences for consumption streams
- Time-inconsistency of preferences is fundamental property of sustainability concerns? (Gerlagh & Liski 2012)
- Climate targets tend to erode over time both in naive and sophisticated policies

II. Clean innovation as commitment device

- Moving targets: Need to think about commitment mechanisms.
- Pledges don't commit.
- Clean energy technologies can work as commitment device
- Transition costs induce commitment device: sophisticated abatement effort > naive abatement effort
- Is cheap clean technology a good commitment device / do we need to support clean technology beyond carbon price ?