Political Competition and Climate Policy: A Dynamic Game of Pollution Control

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Draft: Comments welcome

Motivation & Overview

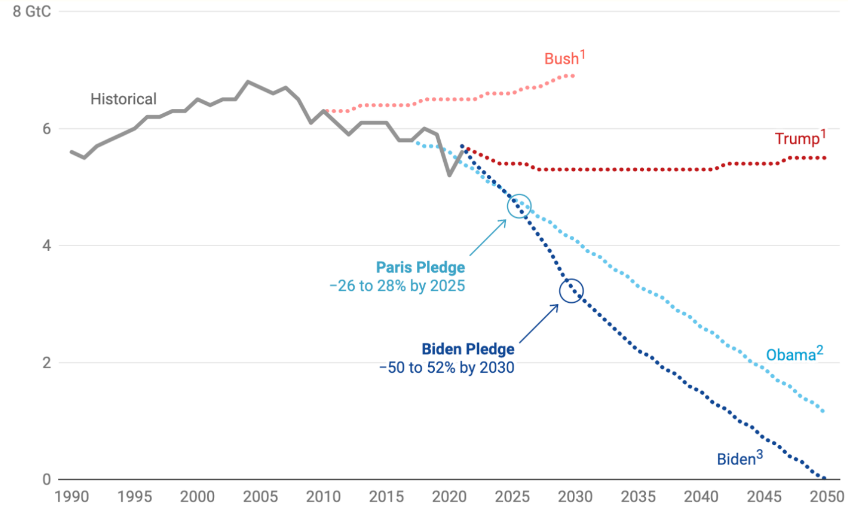


Figure: From Higgins et al. (2024)

Motivation

- Climate policy can switch drastically with changes in administration or leadership
- Political parties differ in ideology on taxation, regulation, and the urgency of environmental protection
- Substantial *long-run* negative externalities from pollution, but electoral incentives tend to be short-run
- **Goal:** Present a *dynamic game* of political pollution control with policy-motivated parties

Research Questions

- How do two *policy-motivated* parties (Green vs. Brown) set emission taxes?
- How does the electorate's **time horizon** (myopic vs. forward-looking) shape equilibrium policies?
- When do outcomes deviate from a *social planner* benchmark, and how large are welfare losses?
- How do **polarization** and **issue salience** affect pollution levels and volatility?

Model Setup

Dynamics

- **Discrete time**: $t = 0, 1, 2, \ldots$
- Pollution stock P_t evolves via:

$$P_{t+1} \;=\; e(\tau_t) \;+\; (1-\delta)\,P_t, \quad \delta \in (0,1)$$

- Two policy-motivated parties: $i \in \{1, 2\}$ (brown vs. green)
- Each period:
  1. Parties propose taxes $(\tau_{t,1}, \tau_{t,2})$
  2. Voters choose which party wins (probabilistically)
  3. Winning party's tax is implemented
  4. Next period pollution depends on that tax

Voter – Utility and Consumption Decisions

- Unit mass of voters, each with susceptibility to climate damages parameter $\gamma_k \sim \mathrm{Uniform}[0, 1]$

- Per-period utility of consumption x_k:

$$U_k(x_k, P) \; = \; \phi(x_k) - \tau \, x_k \; - \; \frac{\gamma_k}{2} P^2 \, ,$$

  with isoelastic utility

$$\phi(x) = \frac{x^{1-\sigma}}{1-\sigma} \, .$$

- Each voter infinitesimally small $\rightarrow$ disregard their impact on pollution

- Each period's utility maximizing pollution level is determined by the period's tax rate

$$x_k^*(\tau) = x^*(\tau) = \tau^{-\frac{1}{\sigma}}$$

Voter – 'Dictatorial' intertemporal problem

- Unit mass of voters with identical benefits implies:

$$\underbrace{x_k^*(\tau)}_{\text{individual emissions consumption}} = \underbrace{e(\tau)}_{\text{aggregate emissions consumption}}$$

- $b(\tau) = B(e(\tau)) = \phi(e(\tau)) - \tau e(\tau)$, net consumption benefit/indirect utility

- Benchmark dynamic problem of a 'dictator'

$$V_k(P) = \max_{\tau \in \mathcal{S}} \left\{ b(\tau) - \frac{\gamma_k}{2} P^2 + \rho V_k\left(P'\right) \right\}$$

Elections – Probabilistic Voting and Voter Horizons

- Best case: Voters know parties' equilibrium strategies when voting & parties know voters' voting probabilities ⇒ **circularity problem** (Party strategies depend on voter behavior, which depends on party strategies)

- Assumption on voter policy evaluation:

$$W_k(\tau, P; h) = b(\tau) - \frac{\gamma_k}{2}P^2 - \rho\frac{\gamma_k}{2}\Big(e(\tau) + (1-\delta)P\Big)^2 \quad \text{(direct effects)}$$

$$- \rho\frac{\gamma_k}{2}\sum_{t=1}^{h}\rho^t\Big((1-\delta)^t e(\tau) + (1-\delta)P\Big)^2 \text{ (accumulating effects)}$$

Elections – Probabilistic Voting and Voter Horizons

- Voting decisions based on discrete choice framework – probability of voting for party i depends on difference in utilities $\Delta W_k(\tau_i, \tau_j, P; h)$:

$$P_k^i = \frac{1}{1 + \exp\left(-\xi \left[W_k(\tau_i) - W_k(\tau_j)\right]\right)}.$$

Discrete Choice

- Probability of party i being elected: $\theta_i(\tau_i, \tau_j, P) = \int P_k^i \, dF(\gamma_k)$

Intertemporal Party Problem

- **Party** $i \in \{1, 2\}$ characterized by exogenously given damage parameter Γ_i (usually assume $\Gamma_1 < \gamma_{\text{med}} < \Gamma_2$)
    - E.g. due to differences in party platforms and voter bases.

- **Bellman equation**:

$$V_i(P) = \max_{\tau_i \in \mathcal{S}} \Bigg\{ \theta_i(\tau_i, \tau_j, P) \underbrace{\Big(b(\tau_i) + \rho V_i\big(P'(\tau_i)\big)\Big)}_{\text{benefit of winning}}$$

$$+ \Big(1 - \theta_i(\tau_i, \tau_j, P)\Big) \underbrace{\Big(b(\tau_{-i}) + \rho V_i\big(P'(\tau_{-i})\big)\Big)}_{\text{benefit of losing}}$$

$$- \frac{\Gamma_i}{2} P^2 \Bigg\} .$$

Numerical Implementation Sketch

- Discretize $P \in [0, P_{\max}]$
- Guess $V_i^n(P)$ for each i; solve best-response $\tau_i^n\left(\tau_j, P, V_i^n\right)$
- Find Nash equilibria: $(\tau_1, \tau_2) = \left(\varphi_1^n\left(P; V_1^n\right), \varphi_2^n\left(P; V_2^n\right)\right)$
- Update $V_i^{n+1}(P)$ using Nash equilibria policies
- Iterate until convergence. Then:

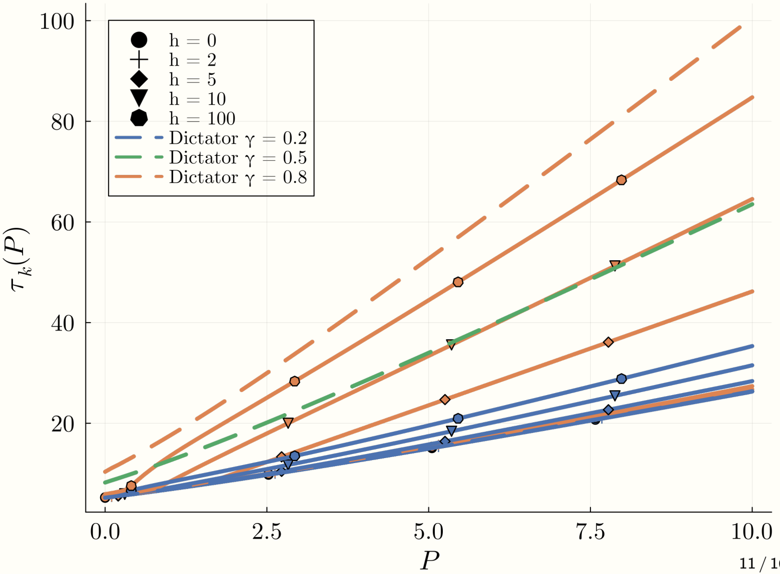
$$\tau_i^*(P),\ \tau_j^*(P) \quad \text{and} \quad V_i^*(P),\ V_j^*(P)$$

define the equilibrium.

Key Numerical Findings

Policy Functions

- With short voter horizons, the green party must propose taxes *very close* to the brown party's to stay competitive
- As horizon increases, green can be more ambitious; brown also raises tax but less so

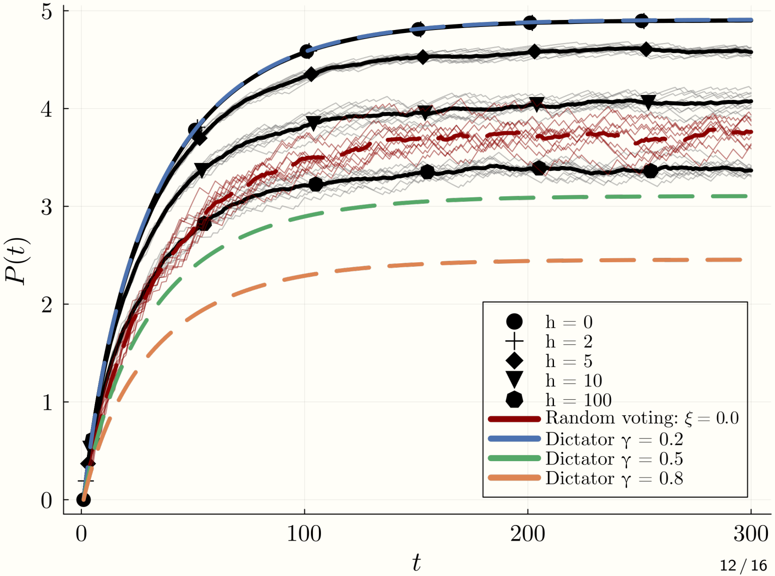


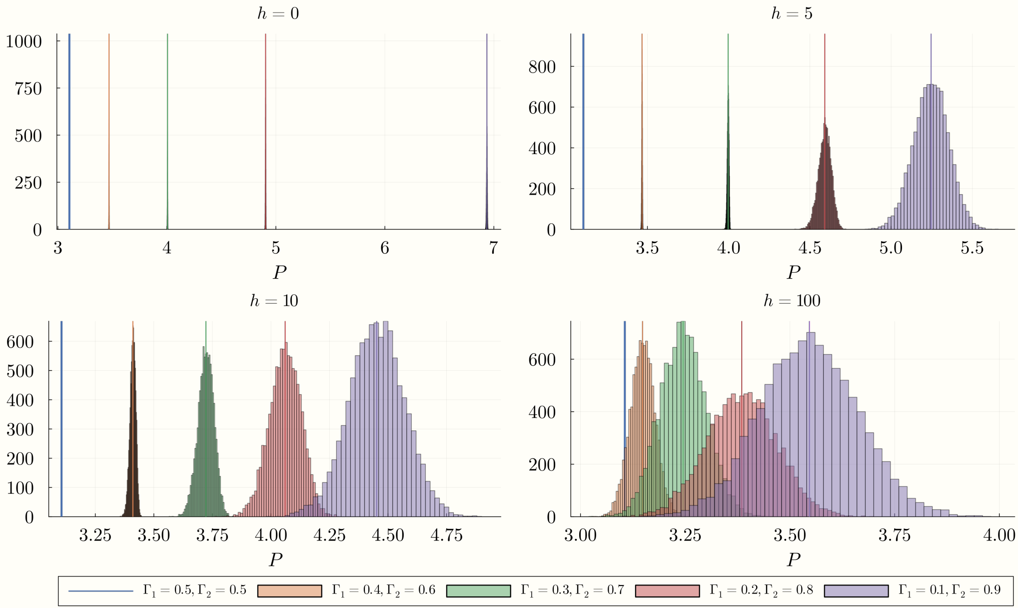
Pollution Dynamics Over Time

- **Myopic voters** ($h = 0$): high long-run pollution, no green policy

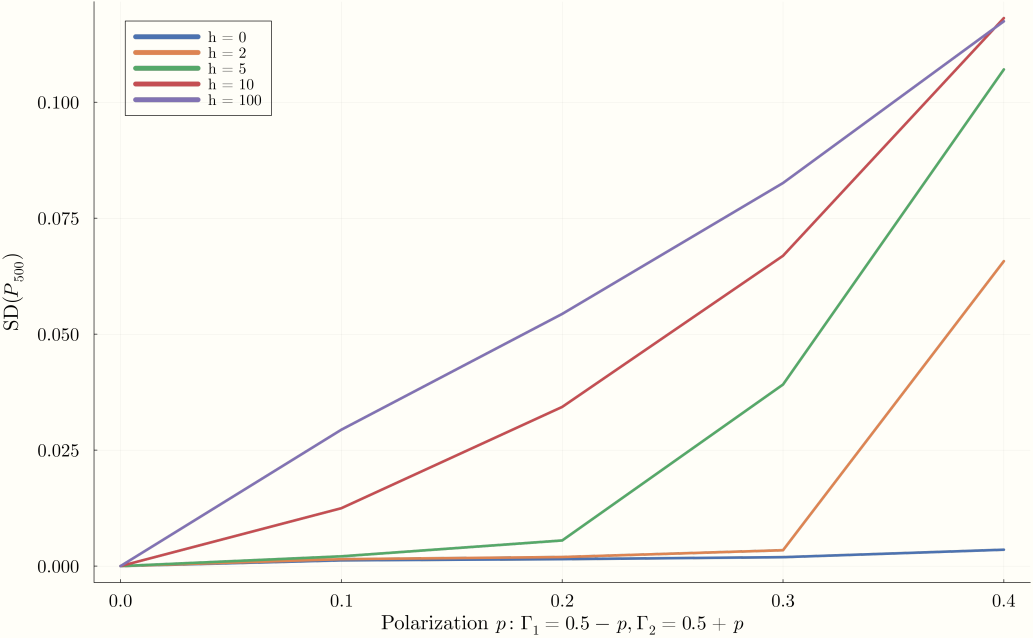
- **Forward-looking voters**: lower pollution steady-state, more "green" taxation

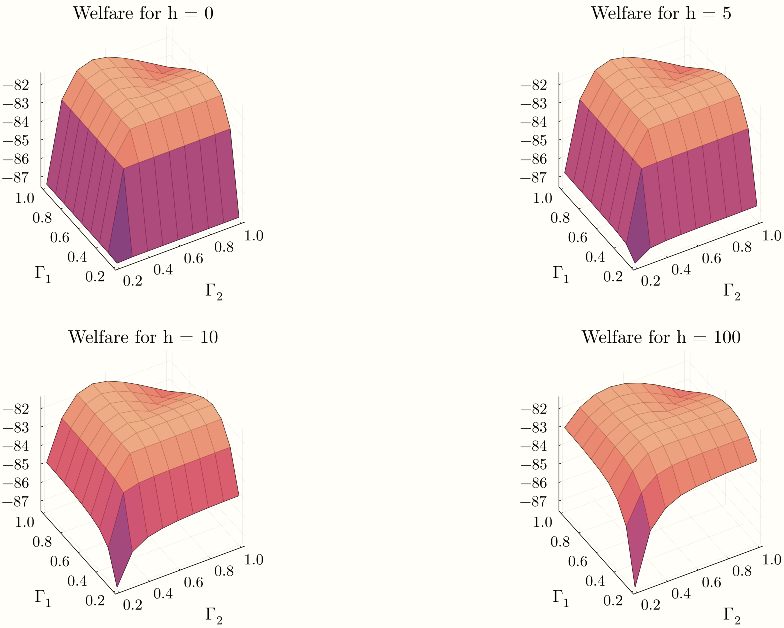
- **Paradox of salience**: if voters are myopic, not making pollution salient can help green propose higher taxes ‣ Policy Functions





$h = 0$
$h = 5$
$h = 10$
$h = 100$
P
$\Gamma_1 = 0.5, \Gamma_2 = 0.5$
$\Gamma_1 = 0.4, \Gamma_2 = 0.6$
$\Gamma_1 = 0.3, \Gamma_2 = 0.7$
$\Gamma_1 = 0.2, \Gamma_2 = 0.8$
$\Gamma_1 = 0.1, \Gamma_2 = 0.9$


h = 0
h = 2
h = 5
h = 10
h = 100
0.000
0.025
0.050
0.075
0.100
SD(P_{500})
0.0
0.1
0.2
0.3
0.4
Polarization p: $\Gamma_1 = 0.5 - p, \Gamma_2 = 0.5 + p$


Welfare for h = 0
Welfare for h = 5
Welfare for h = 10
Welfare for h = 100
−82
−83
−84
−85
−86
−87
1.0
0.8
0.6
0.4
0.2
Γ_1
0.2
0.4
0.6
0.8
1.0
Γ_2

Conclusions

Main Takeaways

- **Voter myopia** yields weak green policies; brown party almost completely dictates the tax

- **Longer horizons** foster more ambitious environmental policy (both parties shift upward)

- **Polarization** amplifies policy swings
  - Longer voter horizons reduce median pollution in polarized environments

  - But **volatility** remains high $\rightarrow$ **Policy uncertainty** may affect firm investment decisions

- **Issue salience** paradox:
  - High salience can help push green policy if voters also think ahead
  - Very low salience sometimes lets green propose higher taxes without electoral backlash

Thank you!

Backup / Appendix

Discrete Choice Model

- Each voter k's preferences are described by a random utility model:

$$U_k^i(\tau_i, P) \ = \ \xi W_k(\tau_i, P) \ + \ \varepsilon_k^i, \quad i \in \{1, 2\},$$

  where:
  - $W_k(\tau_i, P)$ is the deterministic component (e.g. net consumption benefit minus expected pollution damages),
  - ε_k^i is a random error term (Gumbel distribution), describing unobserved (or unmodelled) factors.
  - ξ denotes how much the deterministic component influences the choice.

- The voter chooses party i if $U_k^i(\tau_i, P) > U_k^j(\tau_j, P)$.

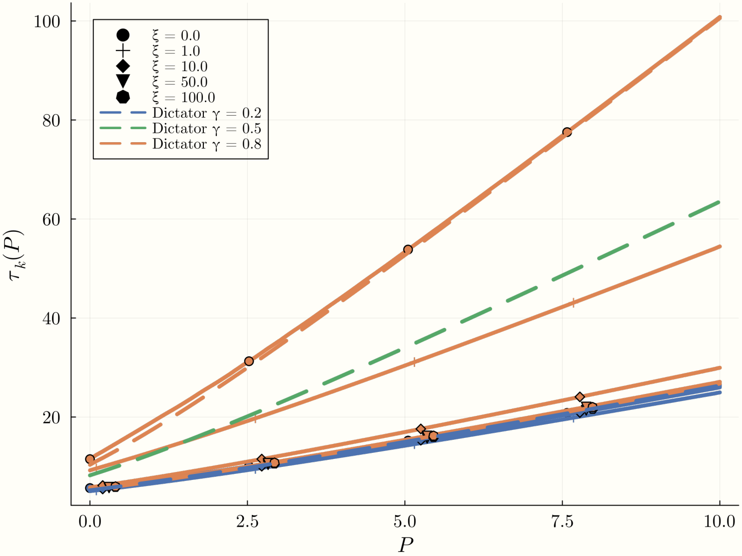
- As the error term is a random variable, this gives a probability of voting for party i

Back

Salience – Policy Functions

- With lower salience, green can propose higher taxes without losing votes

- $\xi = 0$ means random voting



Salience – Pollution Dynamics

- Lower salience leads to lower pollution levels

‣ Back