Dynamics of Environmental Policy

Hülya Eraslan
Rice University

Adriana Piazza
Universidad Adolfo Ibáñez

Institute for Mathematical Sciences, NUS
June 6, 2018

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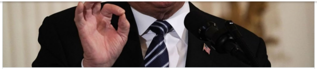

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Introduction

> *John Adams left the White House in a flurry of paperwork, working till midnight to fortify the United States against the next president, his political nemesis and friend, Thomas Jefferson. Each founder's legacy was bound up in the other's, setting a precedent for every president who followed them.*
>
> The Guardian, January 10, 2017

Policy reversals are especially prevalent in U.S. environmental policy.

Main questions:

Under what conditions policy reversals arise?

What are the efficiency implications of policy reversals?

Introduction

We present a model with two parties deciding on environmental policy each period over an infinite horizon.

A randomly selected party is chosen to decide the level of environmental stock $x \in [0, 1]$.

Higher x corresponds to tighter policies that improve the environment but reduce flexibility of the individuals and businesses.

Marginal benefit of environmental stock is different for the two parties.

Reducing x is costless but increasing x is costly for both parties.

Introduction: main results

Pareto efficient allocations cannot involve policy reversals except at the initial date.

Markov Perfect Equilibrium exists. Depending on the parameter values, the equilibrium is either unique, or its structure is unique.

When polarization is high, equilibrium is inefficient due to perpetual policy reversals.

When favoritism is high, equilibrium is inefficient due to an "overshooting" effect.

When neither polarization nor favoritism is high, equilibrium is efficient in the long run.

Related literature (incomplete)

Transaction cost politics: Coase (1960), Peltzman (1976), Williamson (1979), North (1990)

Political economy of environmental policy: Maloney and McCormick (1982), Oates and Portney (2003), Harstad (2012a, 2012b, 2016)

Dynamic political economy with endogenous status quo: Baron (1996), Kalandrakis (2004), Duggan and Kalandrakis (2012), Bowen, Chen, Eraslan (2014), Dziuda and Loeper (2016), Kalandrakis (2016), Zapal (2016), Bowen, Chen, Eraslan, Zapal (2017).

Model

Two parties B and G.

Infinite horizon, time indexed by $t = 0, 1, \dots$

The party in power at time t decides the level of environmental stock $x_t \in [0, 1]$ taking as given x_{t-1}.

Increasing the environmental stock by an amount z costs cz to the party in power, and $c'z$ to the out-of-power party.

The utility for party i from environmental stock x is $u_i(x)$

- u_i strictly concave and continuously differentiable
- $u'_B(x) < u'_G(x)$ for all $x \in [0, 1]$.

Parties discount the future at a rate δ.

Benchmark: dictatorship

Dictator i's problem is a single agent dynamic programming problem where the value function satisfies

$$V_i(x) = \max_{x' \in [0,1]} u_i(x') - c \max\{x' - x, 0\} + \delta V_i(x')$$

and the policy function satisfies

$$\sigma_i(x) \in \arg\max_{x' \in [0,1]} u_i(x') - c \max\{x' - x, 0\} + \delta V_i(x')$$

for all $x \in [0, 1]$.

Benchmark: dictatorship

Definition

The minimum acceptable level of environmental stock for party i, denoted by α_{1i}, is the solution to

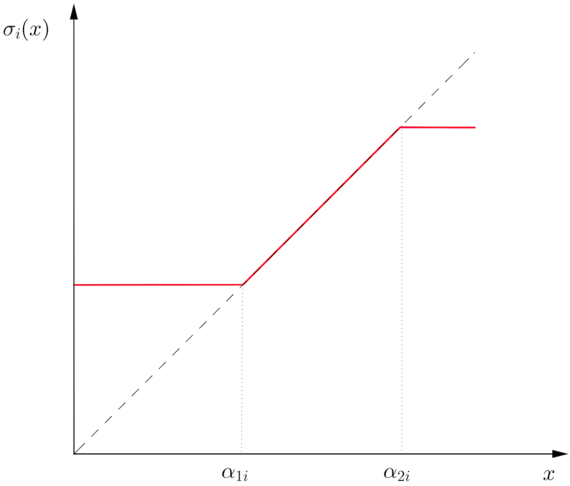
$$u_i'(x) = c(1 - \delta).$$

The maximum acceptable level of environmental stock for party i, denoted by α_{2i}, is the solution to

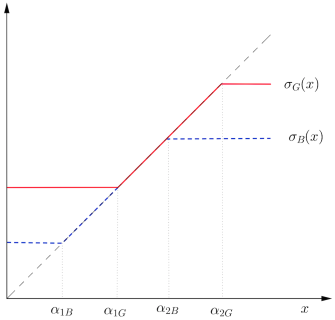
$$u_i'(x) = 0.$$

Benchmark: dictatorship

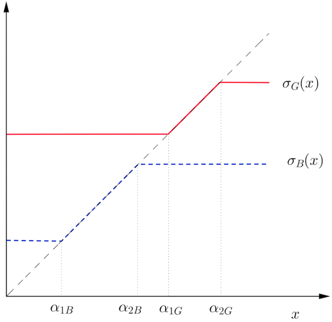
Optimal policy for dictator i:



Polarization



Low polarization



High polarization

Benchmark: pareto efficiency

Cost of preservation to i when κ is the incumbent:

$$c_{i,\kappa} = 1_\kappa(i)c + (1 - 1_\kappa(i))c'$$

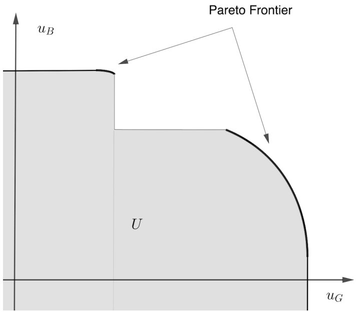
A *Pareto efficient* **deterministic allocation** *given an initial status quo* x_0 solves:

$$\max_{\mathbf{x}\in[0,1]^\infty, \boldsymbol{\kappa}\in\{B,G\}^\infty} \sum_{t=1}^{\infty} \delta^t [u_i(x_t) - c_{i,\kappa_t} \max(x_t - x_{t-1}, 0)]$$

$$\text{s.t. } \sum_{t=1}^{\infty} \delta^t [u_j(x_t) - c_{j,\kappa_t} \max(x_t - x_{t-1}, 0)] \geq \overline{u}$$

for some $\bar{u} \in \mathbb{R}$, $i, j \in \{B, G\}$ and $i \neq j$.

Pareto frontier with deterministic power allocation



Benchmark: pareto efficiency

A *Pareto efficient* **stochastic allocation** *given an initial status quo* x_0 solves:

$$\max_{\mathbf{x}\in[0,1]^\infty,\boldsymbol{\pi}\in[0,1]^\infty} \sum_{t=1}^{\infty} \delta^t [u_i(x_t) - c_{i,\pi_t} \max(x_t - x_{t-1}, 0)]$$

$$\text{s.t.} \sum_{t=1}^{\infty} \delta^t [u_j(x_t) - c_{j,\pi_t} \max(x_t - x_{t-1}, 0)] \geq \overline{u}$$

for some $\bar{u} \in \mathbb{R}$, $i, j \in \{B, G\}$ and $i \neq j$.

Lemma

The utility possibility set is convex.

Benchmark: pareto efficiency

Let

$$U_i(\mathbf{x}, \boldsymbol{\pi}; x_0) = \sum_{t=1}^{\infty} \delta^t [u_i(x_t) - c_{i,\pi_t} \max\{x_t - x_{t-1}, 0\}].$$

An allocation $(\mathbf{x}^*, \boldsymbol{\pi}^*)$ is Pareto optimal given x_0 iff there exists $\lambda \in [0, 1]$ such that

$$(\mathbf{x}^*, \boldsymbol{\pi}^*) \in \underset{\mathbf{x} \in [0,1]^\infty, \boldsymbol{\pi} \in [0,1]^\infty}{\arg\max} \lambda U_B(\mathbf{x}, \boldsymbol{\pi}; x_0) + (1 - \lambda) U_G(\mathbf{x}, \boldsymbol{\pi}; x_0). \tag{PE-λ}$$

Benchmark: pareto efficiency

Can express (PE-λ) as a nested optimization problem:

$$\max_{\mathbf{x}\in[0,1]^\infty} \left[\sum_{t=1}^{\infty} u_\lambda(x_t) - \big(\min_{\pi_t\in[0,1]} c_{\lambda,\pi_t} \big) \max\{x_t - x_{t-1}, 0\} \right]$$

where

$$u_\lambda(x) = \lambda u_B(x) + (1-\lambda) u_G(x)$$

and

$$c_{\lambda,\pi} = (1-\lambda)c + \lambda c' - \pi(c - c')(1-2\lambda).$$

Benchmark: pareto efficiency

Optimal $\boldsymbol{\pi}^*$ that solves the above nested optimization problem:

$$\pi_t^* = \begin{cases} 1 & \text{if } (c - c')(1 - 2\lambda) > 0, \\ 0 & \text{if } (c - c')(1 - 2\lambda) < 0. \end{cases}$$

Let c_λ denote the value c_{λ,π_t^*}.

The nested optimization problem becomes:

$$\max_{\mathbf{x} \in [0,1]^\infty} \sum_{t=1}^{\infty} u_\lambda(x_t) - c_\lambda \max\{x_t - x_{t-1}, 0\}.$$

Identical to the optimization problem faced by a dictator with utility function u_λ facing cost c_λ.

Benchmark: pareto efficiency

Define $\alpha_{1\lambda}$ and $\alpha_{2\lambda}$ by

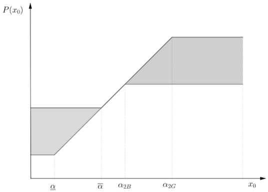
$$u_\lambda'(\alpha_{1\lambda}) = c_\lambda(1-\delta) \quad \text{and} \quad u_\lambda'(\alpha_{2\lambda}) = 0.$$

Let

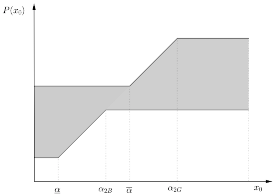
$$\underline{\alpha} = \min_{\lambda \in [0,1]} \alpha_{1\lambda} \quad \text{and} \quad \overline{\alpha} = \max_{\lambda \in [0,1]} \alpha_{1\lambda}.$$

Benchmark: pareto efficiency

Define the correspondence $P(.)$:



$P(x_0)$ when $\overline{\alpha} \leq \alpha_{2B}$



$P(x_0)$ when $\overline{\alpha} > \alpha_{2B}$

Benchmark: pareto efficiency

Proposition (Efficiency requires no policy reversals.)

Any Pareto efficient allocation $\mathbf{x} = \{x_t\}_{t=1}^{\infty}$ *given any initial environmental stock* x_0 *must have a constant environmental stock with* $x_t = k$ *for some* $k \in P(x_0)$.

Political system

Policy is determined by the party in power.

Each period a party is randomly selected to be in power.

Probability that party i is in power in period t conditional on being in power in period $t-1$ is given by $p_i \in [0, 1]$.

Strategies

Focus on stationary Markov strategies, i.e. strategies that depends only on the payoff-relevant state.

The payoff relevant state in period t is the level of environmental stock x_{t-1} at the beginning of the period.

Pure strategies: $\sigma_i : [0,1] \to [0,1]$

> $\sigma_i(x)$ is the level of environmental stock at the end of the current period when i is in power and the environmental stock at the beginning of the current period is x.

Markov Perfect Equilibrium

An equilibrium is a pair of strategy profiles $\sigma = (\sigma_B, \sigma_G)$ and the associated value functions (V_B, W_B, V_G, W_G) such that

(E1) Given (V_B, W_B, V_G, W_G),

$$\sigma_i(x) \in \arg\max_{x' \in [0,1]} u_i(x') - c \max\{x' - x, 0\} + \delta[p_i V_i(x') + (1 - p_i) W_i(x')]$$

for all $x \in [0, 1]$ and for all $i \in \{B, G\}$.

(E2) Given $\sigma = (\sigma_B, \sigma_G)$, the value functions V_B, W_B, V_G, W_G satisfy the following functional equations for any $x \in [0, 1]$, $i, j \in \{B, G\}$ with $j \neq i$:

$$V_i(x) = u_i(\sigma_i(x)) - c \max\{\sigma_i(x) - x, 0\} + \delta[p_i V_i(\sigma_i(x)) + (1 - p_i) W_i(\sigma_i(x))],$$

$$W_i(x) = u_i(\sigma_j(x)) - c' \max\{\sigma_j(x) - x, 0\} + \delta[(1 - p_j) V_i(\sigma_j(x)) + p_j W_i(\sigma_j(x))].$$

Precautionary levels

Definition

G's precautionary minimum level of environmental stock α_{0G} is the solution to

$$u'_G(x) = c(1 - \delta p_G).$$

Definition

B's precautionary maximum level of environmental stock α_{3B} is the solution to

$$u'_B(x) = -c'\delta(1 - p_B).$$

We have

$$\alpha_{1B} < \alpha_{2B} < \alpha_{3B} \qquad \text{and} \qquad \alpha_{0G} < \alpha_{1G} < \alpha_{2G}.$$

No partisan favoritism: $c = c'$

Proposition (Low polarization equilibrium strategies.)

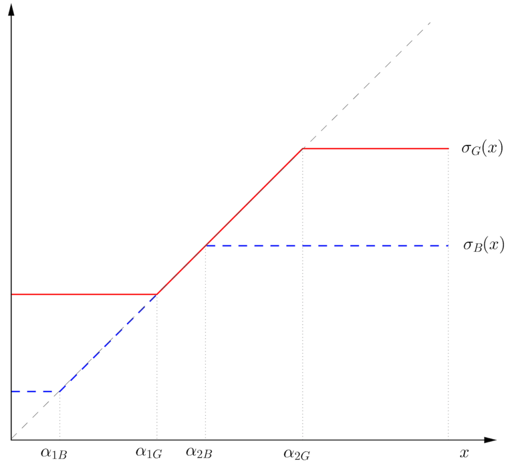
If $\alpha_{1G} \leq \alpha_{2B}$, then the equilibrium strategy for party $i = B, G$ is given by

$$\sigma_i(x) = \begin{cases} \alpha_{1i} & \text{if } x < \alpha_{1i}, \\ x & \text{if } \alpha_{1i} \leq x \leq \alpha_{2i}, \\ \alpha_{2i} & \text{if } x > \alpha_{2i}. \end{cases}$$

At most one policy reversal.

Efficient in the long run.

No partisan favoritism



Equilibrium strategies when polarization is low

No favoritism

Proposition (Moderate polarization equilibrium strategies.)

If $\alpha_{0G} \leq \alpha_{3B}$ *and* $\alpha_{2B} \leq \alpha_{1G}$*, then a strategy profile* $(\sigma_B(.), \sigma_G(.))$ *is an equilibrium strategy profile iff there exists* $\alpha \in [\max\{\alpha_{2B}, \alpha_{0G}\}, \min\{\alpha_{3B}, \alpha_{1G}\}]$ *such that*

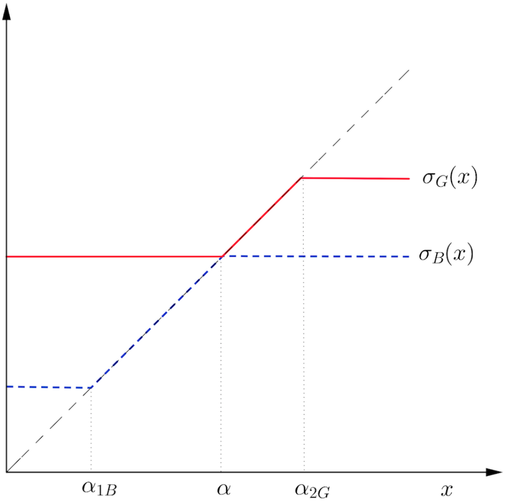
$$\sigma_B(x) = \begin{cases} \alpha_{1B} & \text{if } x \leq \alpha_{1B}, \\ x & \text{if } \alpha_{1B} \leq x \leq \alpha, \\ \alpha & \text{if } x \geq \alpha, \end{cases}$$

$$\sigma_G(x) = \begin{cases} \alpha & \text{if } x \leq \alpha, \\ x & \text{if } \alpha \leq x \leq \alpha_{2G}, \\ \alpha_{2G} & \text{if } x \geq \alpha_{2G}. \end{cases}$$

At most one policy reversal.

Efficient in the long run.

No favoritism



Equilibrium strategies when polarization is moderate

No favoritism

Proposition (High polarization equilibrium strategies.)

If $\alpha_{3B} \leq \alpha_{0G}$, then the equilibrium strategies are given by

$$\sigma_B(x) = \begin{cases} \alpha_{1B} & \text{if } x \leq \alpha_{1B}, \\ x & \text{if } \alpha_{1B} \leq x \leq \alpha_{3B}, \\ \alpha_{3B} & \text{if } x \geq \alpha_{3B}, \end{cases}$$

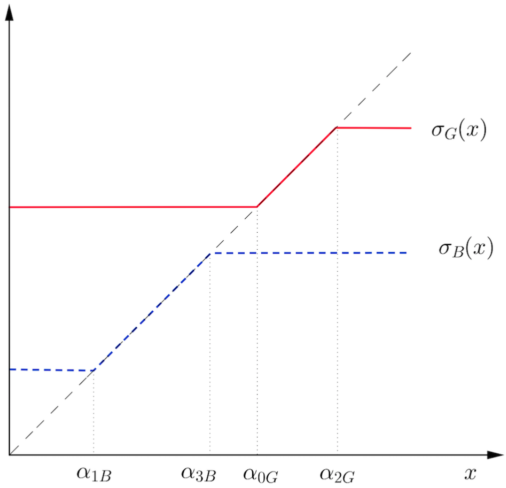
and

$$\sigma_G(x) = \begin{cases} \alpha_{0G} & \text{if } x \leq \alpha_{0G}, \\ x & \text{if } \alpha_{0G} \leq x \leq \alpha_{2G}, \\ \alpha_{2G} & \text{if } x \geq \alpha_{2G}. \end{cases}$$

Perpetual policy reversals.

Inefficient even in the long run.

No favoritism



Equilibrium strategies when polarization is high

Partisan favoritism: $c' > c$

Definition

B's precautionary minimum level of environmental stock $\tilde{\alpha}$ is the solution to

$$u_B'(x) = c(1 - \delta p_B) - c'\delta(1 - p_B).$$

Note: $\alpha_{1B} \leq \tilde{\alpha} \leq \alpha_{3B}$.

Low favoritism ($\tilde{\alpha}$ low)

Equilibrium characterization is almost identical to those in the no favoritism case.

The only difference is when the environmental stock x is "low", party B now increases it to $\tilde{\alpha}$ instead of α_{1B}, and what party B considers "low" itself is determined by the new cutoff $\tilde{\alpha}$ instead of α_{1B}.

Party B's optimal policy for higher levels of x, and party G's optimal policy for any x remains unchanged compared that in the no favoritism case.

High polarization case does not depend on favoritism.

Moderate favoritism and low polarization

Proposition

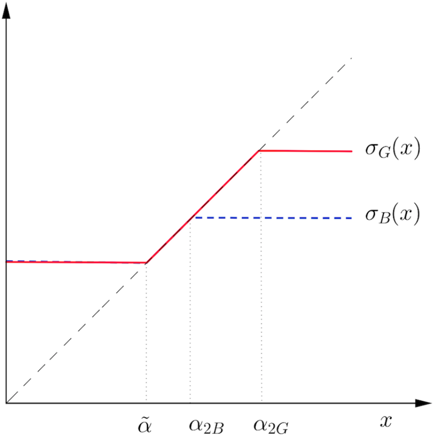
If $\alpha_{1G} \leq \tilde{\alpha} \leq \alpha_{2B}$*, then a strategy profile* $(\sigma_B(.), \sigma_G(.))$ *is an equilibrium strategy profile if and only if there exists* $\alpha \in [\alpha_{1G}, \tilde{\alpha}]$ *such that, for all* $i = B, G$,

$$\sigma_i(x) = \begin{cases} \alpha & \textit{if } x \leq \alpha, \\ x & \textit{if } \alpha \leq x \leq \alpha_{2i}, \\ \alpha_{2i} & \textit{if } x \geq \alpha_{2i}. \end{cases}$$

At most one policy reversal.

Efficient in the long run.

Moderate favoritism and low polarization



Equilibrium strategies when favoritism moderate and polarization is low

High favoritism and low or moderate polarization

Proposition

If $\alpha_{2G} < \tilde{\alpha}$*, then a strategy profile* $(\sigma_B(.), \sigma_G(.))$ *is an equilibrium strategy profile if and only if there exists* $\alpha \in [\alpha_{2G}, \tilde{\alpha}]$ *such that, for all* $i = B, G$*,*

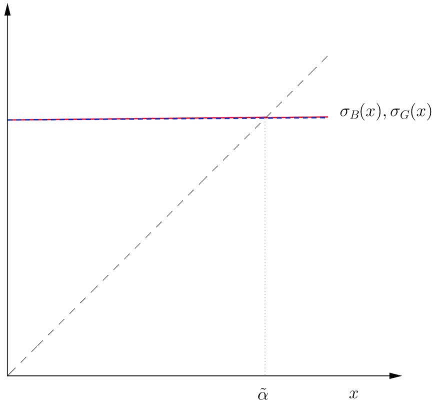
$$\sigma_i(x) = \alpha \; \forall x.$$

Inefficient even in the long run due to an *overshooting* effect.

Each party increases the environmental stock to an undesirably high level fearing that otherwise the other party will when there is political turnover resulting in an even higher cost.

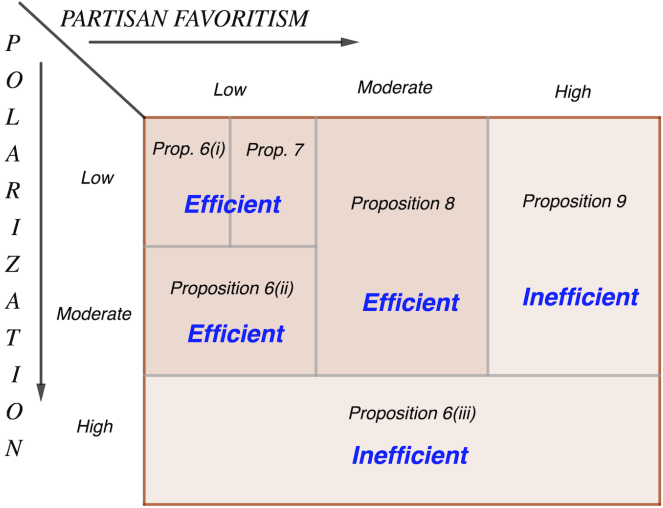
These fears are in turn justified by the equilibrium strategy of the other party which itself is sustained by the same fear!

High favoritism and low or moderate polarization



Equilibrium strategies when favoritism is high

Summary


PARTISAN FAVORITISM
POLARIZATION
Low
Moderate
High
Low
Moderate
High
Prop. 6(i)
Prop. 7
Efficient
Proposition 8
Efficient
Proposition 9
Inefficient
Proposition 6(ii)
Efficient
Proposition 6(iii)
Inefficient

Extensions

Free riding effect when $c > c'$

Extensions:

- Technological innovation
- Endogenous turnover
- Weak political power / bargaining over policy