Web Appendix to The Dynamics of Environmental Politcs and Values: A More General Framework

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1 Basics

There are three main elements: (i) policy setting, (ii) politics with probabilistic voting, two parties, and swing/loyal voters, and (iii) value adaptation over time.

Time and types Time is infinite and labelled by s. In each time period, a government policy vector denoted by x, is chosen. This could be quite a complex object, including taxes, regulations and spending commitments.

Following the paper's notation, there are only two types of individuals in the population denoted by $\tau \in \{m, e\}$ (although these could be different types than materialists and environmentalists). Let μ_s be the proportion of type-e individuals in the population at date s. As in the paper, this share can evolve over time.

Payoffs from policy Types affect agents' payoffs, which are denoted by:

$$u(\tau, x, \mu). \tag{1}$$

Any private decisions – due to, say, consumption, savings, or labor supply – are embodied in this payoff function, which takes the form of an indirect-utility function. Note that we allow the composition of the population, μ, to directly affect the payoffs of agents, aside from any indirect effect via the policy vector x. For example, the direct effect could represent a desire by individuals to engage in social signalling (as it does in the paper).

Denote by function $X(\mu)$ feasible policies that respect all the constraints due to incentive compatibility and the government budget constraint. This function depends naturally on μ, as the composition of the population may affect behavior and hence tax revenues or public spending.

Each type has a preferred policy outcome:

$$x^*(\tau, \mu) = \arg \max_{x \in X(\mu)} \{u(\tau, x, \mu)\}.$$

Political competition will determine which policies are actually implemented and how close they are to the preferred policy of a specific type.

2 Politics

In this section, we specify the policy process for fixed preferences in the population. This part of the model is standard. We think of the model as portraying two cleavages in politics: party politics and identity politics. The conflicts in party politics reflect a fixed cleavage dimension, such as class or religion, and creates loyalty to a particular party among some groups of voters. Identity politics is imperfectly correlated with party politics and helps shape policy preferences. In particular, conflicts in this dimension run across the cleavage between types τ. As the type distribution will evolve dynamically over time, so will the conflicts in identity politics.

Parties and policy responses Our basic model of politics is based on two-party competition with probabilistic voting. Which party holds office is determined by competition for voters. We label the two parties, A and B, and suppose they compete by choosing policies. Each party cares only about winning. Let $\{x^A, x^B\}$ denote the policy platforms on offer in an election.

We choose this probabilistic-voting formulation for two reasons. The first is pure convenience. The second is transparency: the formulation makes clear how our model differs from standard models, where the population types are not allowed to evolve over time.

However, similar effects to those described below will follow from any kind of political model, where greater numerical strength of some type moves policy in favor of the preferred policy of that type. In the model here, this policy response is smooth due to the probabilistic-voting approach. In a model with strict majority rule, a small change in types could instead generate either no response or a discontinuous response of policy, neither of which is very realistic. But the same key results would apply.

Voters We consider two kinds of voters: swing voters, who cast their ballot for a party depending on policy, and loyal voters, who always support the same party. This split follows a long-standing tradition in political science based on the Michigan-voting surveys. Party loyalty is best thought of as reflecting policy concerns on a fixed policy dimension. Swing voters weigh up the pros and cons of what is on offer from a party. We assume that loyal voters are split equally between the two parties.

There are $\gamma\mu$ type-e swing voters and $(1-\gamma)(1-\mu)$ type-m swing voters. Thus $\gamma > (<)\ 1/2$ reflects a disproportionate tendency for type-e (type-m) voters to be swing voters. For analytical convenience, we assume an equal split of loyal voters across parties. By adding up, a fraction $\gamma+\mu-2\gamma\mu$ are then loyally attached with equal shares to each one of the two parties.

Shocks and vote shares In the probabilistic-voting tradition, party choices by swing voters are subject to shocks. These are of two kinds: idiosyncratic (i.e.. voter-specific) and aggregate (i.e., affecting all swing voters). A swing voter of type τ supports party A if

$$u\left(\tau, x^A, \mu\right) + \varepsilon + \zeta \geq u\left(\tau, x^B, \mu\right),$$

where ε is the idiosyncratic shock and ζ is the aggregate shock. To obtain simple solutions, we assume that both shocks are uniformly distributed, ε on $[-1/\epsilon, 1/\epsilon]$ and ζ on $[-1/\psi, 1/\psi]$.

Integrating over ε, the share of type-τ swing voters who vote for party A is

$$\frac{1}{2} + \epsilon\left[u\left(\tau, x^A, \mu\right) - u\left(\tau, x^B, \mu\right) + \zeta\right]. \tag{2}$$

This assumes an interior solution, i.e., that (2) lies between zero and one which will be the case if ϵ is small enough.

Winning probabilities Elections are decided by plurality rule. Party A thus wins the election if it gets more than half of the votes. This requires

$$\left(1-\gamma-\mu+2\gamma\mu\right)\zeta + \Omega\left(x^A, x^B, \mu, \gamma\right) \geq 0, \tag{3}$$

where

$$\Omega\left(x^{A}, x^{B}, \mu, \gamma\right)=\begin{array}{c}\left[\gamma\mu\left[u\left(e, x^{A}, \mu\right)-u\left(e, x^{B}, \mu\right)\right]\right. \\ \left.+(1-\gamma)(1-\mu)\left[u\left(m, x^{A}, \mu\right)-u\left(m, x^{B}, \mu\right)\right]\right]\end{array}.$$

The sign of the first term in (3) depends on whether the realization of the aggregate shock ζ favors party A or not, while the sign of the second depends on whether its policy is more popular among the swing voters than the policy of party B.

Integrating over ζ gives the probability that party A wins the election (assuming an interior solution):

$$q^{A}=\frac{1}{2}+\psi\left[\frac{\Omega\left(x^{A}, x^{B}, \mu, \gamma\right)}{(\gamma\mu+(1-\gamma)(1-\mu))}\right]. \tag{4}$$

Party B wins with the complementary probability $q^{B}=1-q^{A}$. Given that parties choose x^{A} and x^{B}, these probabilities are fully mediated in terms of election outcomes via $\Omega\left(x^{A}, x^{B}, \mu, \gamma\right)$.

Equilibrium policies and payoffs To study equilibrium policy choices, we look for a Nash equilibrium where each party optimizes its policy, given the decision of the other. Choosing an optimal policy is equivalent to maximizing the winning probability q^{J}. Given (4), the optimal choice boils down to:

$$x^{J}(\mu, \gamma)=\arg\max_{x\in X(\mu)}\left\{\gamma\mu u(e, x, \mu)+[(1-\gamma)(1-\mu)]\, u(m, x, \mu)\right\}$$

for $J\in\{A, B\}$. This objective is a weighted average of the preferences of the two groups of swing voters, where the weights depend on μ and γ. For example, as μ or γ increases, a greater weight is placed on preferences of type-e citizens. At $\gamma=1/2$, only the shares of each type matter for policy. With $\gamma>1/2$ $(\gamma<1/2)$, type-e (type-m) voters are favored as they have a "swing" advantage.

Parties will make identical decisions, as they care only about courting the swing voters. We can use $\hat{x}(\mu)$ to denote this common policy choice, given μ. In this equilibrium, each party has the same probability of winning: $q^{A}=q^{B}=\frac{1}{2}$.

The key aspect of this equilibrium is that, for any $\gamma\in(0,1/2)$, policy responds to the share of type τ with a larger share gaining more policy weight. As we show,below, this is true in a wide variety of settings as a natural consequence of democratic politics. Thus the specific political model does not matter too much for the logic developed below. But for some policy issues, non-majoritarian institutions – e.g., courts, the EU, independent agencies or pressure groups – may enter the picture. This will weaken the link with (average) voter preferences.

Finally, define

$$U(\tau,\mu) = u(\tau, \hat{x}(\mu), \mu)$$

as the equilibrium payoff of type τ, when a fraction μ of the population belongs to type e. The fact that policy $\hat{x}(\mu)$ responds smoothly to μ, by adapting policy to the preferences of type e, means that $U(e,\mu)$ will tend to be increasing in μ and $U(m,\mu)$ decreasing. While this is strictly true with the assumptions in the paper, this property is not generally guaranteed without further assumptions – such as $u(e,x,\mu)$ $(u(m,x,\mu))$ being increasing (decreasing) in μ, or the effect through policy change being large enough to dominate any direct effect.

Policy-motivated parties It would be straightforward to introduce policy-motivated parties due to different fractions of each type in each party. The payoff for party $J \in \{A, B\}$ would then be:

$$W\left(x, \varphi^J\right) = \varphi^J \mu u(e,x,\mu) + (1-\mu)\left(1-\varphi^J\right) u(m,x,\mu),$$

where φ^J is the fraction of type-e in party J. This would predict policy divergence between parties. For example, with the same representation of the voter side, party A would have the objective function:

$$\begin{aligned}&\left[\frac{1}{2}+\psi\left[\frac{\Omega\left(x^A,x^B,\mu,\gamma\right)}{(\gamma\mu+(1-\gamma)(1-\mu))}\right]\right] W\left(x^A,\varphi^A\right)\\ &+\left[\frac{1}{2}-\psi\left[\frac{\Omega\left(x^A,x^B,\mu,\gamma\right)}{(\gamma\mu+(1-\gamma)(1-\mu))}\right]\right] W\left(x^B,\varphi^A\right).\end{aligned}$$

Party platforms would then change over time, if μ changes over time (for fixed φ^J). Nevertheless, in any given period equilibrium payoffs would still have the form $U(\tau,\mu)$ with the same properties as with purely opportunistic parties.

Citizen-candidates Suppose instead that two candidates compete in every election: one from each type. If a candidate of $\tau \in \{e, m\}$ wins, she implements her preferred policy $x^*(\tau, \mu)$. Let $P(\mu)$ be the probability of type e winning with P increasing in μ.

This probability may reflect an aggregate shock ζ, which (as before) is uniformly distributed on $[-1/\psi, 1/\psi]$. In particular, the election is majoritarian, so the group-e candidate wins if and only if $\mu + \zeta > (1 - \mu)$, or $(2\mu - 1) > \zeta$. This implies that

$$P(\mu) = \begin{cases} 1 & \text{if } \psi(2\mu - 1) > 1 \\ \frac{1+\psi(2\mu-1)}{2} & \psi(2\mu - 1) \in [-1, 1] \\ 0 & \psi(2\mu - 1) < -1. \end{cases}$$

It follows that $P(\mu)$ is (weakly) increasing in μ. If $\psi < 1$ the probability is always interior and strictly increasing in μ.

The winning candidate for each group will implement their preferred policy: $x^*(\tau, \mu)$. Hence the expected payoff of type τ, with share μ e-types in the population, is:

$$U(\tau, \mu) = P(\mu) u(\tau, x^*(e, \mu), \mu) + (1 - P(\mu)) u(\tau, x^*(m, \mu), \mu).$$

As before, there are reasonable conditions for $U(e, \mu)$ increasing and $U(m, \mu)$ decreasing in μ, but it is not guaranteed without further model structure.

Comments This section show that the analysis can handle a rich policy space, so the reduction of x to a single issue in the paper is just for convenience. It also shows that we could motivate the analysis with different political models. These would all give rise to static equilibrium payoffs $U(\tau, \mu)$. The effect of politics always pushes towards $U(e, \mu)$ being increasing in μ, and $U(m, \mu)$ decreasing in μ. However, the details of any direct dependence of payoffs on μ will also matter. In the text, the social-signalling model gives such a micro-foundation.

3 Dynamics

The dynamics of values (types) is straightforward and follows the formulation in the paper.

Evolution of types (values) Let values evolve according to

$$\mu_{s+1} - \mu_s = 2\mu_s (1 - \mu_s)(1 - \beta)\left[G(\Delta(\mu_{s+1})) - \frac{1}{2}\right], \tag{5}$$

where

$$\Delta(\mu_{s+1}) = U(e, \mu_{s+1}) - U(m, \mu_{s+1})$$

and G is the symmetric c.d.f of a family-specific shock with $G(0) = 1/2$ and with density g. As we have seen, functions $U(\tau, \mu)$ can subsume expected equilibrium payoffs in a probabilistic-voting model – with opportunistic or policy-motivated parties – or a citizen-candidate model. Under a range of reasonable conditions, $\Delta_\mu \geq 0$, with strict inequality for all $\mu \in [0, 1]$ when policy (or the probability of winning) responds smoothly to type shares, as in the example studied in the paper. As in the paper, additional assumptions about the direct dependence of $u(\tau, x, \mu)$ are needed to guarantee this.

If we assume that $\Delta_\mu(\mu) \geq 0$ and that

$$1 - 2\mu(1 - \mu)(1 - \beta)\, g(\Delta(\mu))\, \Delta_\mu(\mu) > 0 \tag{6}$$

for all $\mu \in [0, 1]$, the model will only have extremal equilibria.

A more general formulation This is only one specific socialization protocol where cultural fitness is based on payoff differences. We could also have followed the formulation in Sandholm (2010), where individual types evolve sporadically (with inertia), and where switches depend on current behavior and opportunities (myopia). This approach is underpinned by a revision protocol $\varsigma_s^{i,j} \in [0, 1]$ for $i, j \in \{e, m\}$ that specifies a time-varying conditional switch rate from type i to j given the payoffs and proportion of types in the population. In our forward looking model this would yield:

$$\mu_{s+1} - \mu_s = (1 - \mu_s)\varsigma_s^{e,m} - \mu_s \varsigma_s^{m,e},$$

where

$$\varsigma_s^{m,e} > 0 \Longleftrightarrow \Delta(\mu_{s+1}) > 0 \quad \text{and} \quad \varsigma_s^{e,m} > 0 \Longleftrightarrow \Delta(\mu_{s+1}) < 0.$$

The model that we have above is a special case of this with

$$\varsigma_s^{m,e} = -\mu_s (1 - \beta)\left[G(\Delta(\mu_{s+1})) - \frac{1}{2}\right]$$

and

$$\varsigma_s^{m,e} = (1 - \mu_s)(1 - \beta)\left[G(\Delta(\mu_{s+1})) - \frac{1}{2}\right].$$

Timing As in the paper, the timing is as follows

1. There is an initial stock of type e individuals in the population represented by μ_s.
2. Parties choose policy platforms and compete for office, which determines x_s.
3. Payoffs of citizens are realized.
4. Citizens match, a new generation is born and children are socialized leading to μ_{s+1}.

Equilibrium dynamics The model has clear implications for steady states, at least in the monotone case where $\Delta(\mu)$ is increasing in μ throughout its domain.

As stated above, when $\Delta(\mu)$ is increasing for $\mu \in [0,1]$, there can be no interior steady state. Hence, three possibilities remain: (i) with $\Delta(0) > 0$, the unique steady state has $\mu = 1$, (ii) with $\Delta(1) < 0$, the unique steady state has $\mu = 0$, and (iii) with $\Delta(0) < 0$ and $\Delta(1) > 0$, there is a critical value of μ defined by $\Delta(\widehat{\mu}) = 0$ and the endogenously evolving values converge to steady state $\mu = 1$ for initial value $\mu > \widehat{\mu}$ and to $\mu = 0$ for $\mu < \widehat{\mu}$.