THE POLITICAL ECONOMICS OF GREEN TRANSITIONS*

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Reducing the emissions of greenhouse gases may be almost impossible without a green transition—a substantial transformation of consumption and production patterns. To study such transitions, we propose a dynamic model, which differs from the common approach in economics in two ways. First, consumption patterns reflect not just changing prices and taxes, but changing values. Transitions of values and technologies create a dynamic complementarity that can help or hinder a green transition. Second, and unlike fictitious social planners, policy makers in democratic societies cannot commit to future policy paths, as they are subject to regular elections. We show that market failures and government failures can interact to prevent a welfare-increasing green transition from materializing or make an ongoing green transition too slow. *JEL Codes:* D72, D91, Q58.

I. Introduction

Many believe that limiting the risk of an environmental disaster requires a radical structural transformation of production and consumption. We refer to such a process as a green transition, where firms gradually switch toward producing goods with green technologies while households switch toward consuming these alternatives. Despite an emerging consensus on the need for such transformative change, different observers hold a variety of views on how to best achieve it.

However, among economists there is a dominant view—with roots in Pigou (1920)—that sees the solution as implementing a carbon tax, the only issue being the optimal level and time path of that tax. Two postulates underpin this view. First, the feasible

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route to a green transition goes solely through extrinsic incentives, specifically mediated by a change in prices.[1] Second, the analysis is normative and reflects the optimal dynamic choices of a social planner who is able to commit to an entire policy path. Our article reconsiders these postulates and shows how the standard static Coase theorem (Coase 1960) and the political Coase theorem (Acemoglu 2003) may simultaneously fail.

I.A Changing Values

We explore an alternative route to a green transition that goes (partly) via values and hence via intrinsic incentives. Almost 50 years ago, commentators like Ernst Friedrich Schumacher exhorted Western countries to change lifestyles due to their environmental consequences (Schumacher 1973). Concerns about climate change have reinvigorated such debates in light of apparent inertia among households, firms, and governments.[2]

It is useful and plausible to think about demand patterns as reflecting both prices and values, where some consumers care intrinsically about the environmental effects of their choices. This allows us to characterize a green transition as a process whereby the share of those who hold green values endogenously rises over time, and this raises the profitability of using green technologies.

Although we emphasize endogenous values, we model them as (partly) related to underlying economic incentives. In our basic model, few people acquire green values or more people abandon such values when they are costly to hold—thus the share espousing green values evolves over time. These cost calculations reflect decisions by firms about which technologies to use and which prices to charge. We also consider an extension where values have an important moral component.

I.B Politics and Limited Commitment

We question the standard policy approach based on an omnipotent social planner, who maximizes a social-welfare function with full commitment to a future policy path. Instead, we model policies determined by political forces. Those who make political decisions can rarely commit their successors to future policies. This was vividly illustrated when President Donald Trump

1. The next section relates our approach to existing research on this and several other dimensions.

2. See Peattie (2010) and O'Rourke and Lollo (2015).

decided to pull out of the Paris Climate Agreement signed by President Barack Obama.

We ask if sequentially chosen policies will support a green transition. Our basic framework focuses on electoral politics. But two extensions incorporate organized lobbying by firms and private political activism. Whether they emanate from lobbyists at climate Conferences of the Parties (often shortened to COP), or from movements like Extinction Rebellion in the United Kingdom, such activities are an important part of the climate policy landscape.

Refocusing the analysis from normative to positive shifts the perspective on the role that policy can realistically play in a green transition. Rather than being the main driver, policy becomes more like a facilitator of a process that has its roots in interdependent private actions by households and firms as both political and economic actors.

I.C Central Modeling Assumptions

The main theoretical contribution of the article is to formulate a tractable model where values and technologies coevolve and where policy makers cannot commit. The framework lays bare the challenges posed by a green transition. Four aspects of the framework are key to gaining clean analytical insights.

First, there are forward-looking choices of values and technologies that generate a two-way complementarity akin to that found for platform technologies (Rochet and Tirole 2003). If more firms go green, then more households go green, and vice versa. This articulates what it means to have a green transition based on joint dynamics of consumption and production.

Second, the policy tools we consider include the classically studied instruments for mitigating pollution externalities, namely, taxes/subsidies on brown (polluting) and green (nonpolluting) goods. This mirrors contemporary debates about the roles of carbon taxes and green subsidies.

Third, the externality is tied to immediate (flows of), rather than cumulated (stocks of) pollution.

Fourth, intergenerational altruism drives the forward-looking decisions made by voters, implying that politicians also care about future generations. The limiting factor is that politicians cannot commit to future policy and hence can only hope to indirectly influence future outcomes. But in effect they have to take drivers of future welfare as given, with policy choices focused on current welfare.

In Section V, we show how to widen the set of policy instruments to those that do influence future outcomes. In that section, we also consider the implications of a stock externality. These extensions also allow us to apply the model to more general issues.

I.D Outline of Our Analysis

Our baseline model in Section III assumes laissez-faire. Citizens hold either green or brown values. Value transitions via socialization reflect forward-looking assessments of the expected-utility difference between green and brown consumers. Firms use either green or brown technologies with the technology choice depending on expected future profit. Value and technology transitions are interdependent, as green technologies are more profitable with more green consumers and green values are more attractive with more green producers. This complementarity can result in a market-driven green transition. But it can also result in a “trap” where welfare would be higher on an alternative path.

In Section IV, we consider the classical policies that researchers have stressed as tools to avoid such market failures: corrective (Pigouvian) taxes on brown and green goods. In each period, these taxes are set by the electoral platforms of two office-motivated parties, given the policy preferences held by green and brown consumers/voters. Policies affect production and consumption decisions and also influence the dynamics. However, the incentive-compatible policy path generated by politics may not lead to a green transition in cases when this is socially desirable. Moreover, in an economy that has embarked on a green transition, policy makers would like to alter future policies to speed up the transition but cannot do so in the absence of commitment.

Section V includes richer modeling of values, politics, and economic dynamics. The extensions serve two purposes: to derive additional results from genuinely new elements and/or check that the conclusions from our baseline framework are robust in more general settings. Our first substantive extension allows for richer values in that green consumers hold moral concerns for the environment, and not just an additional taste for green consumption. Moral voters contribute to higher taxes on polluting activities. In a second substantive extension, we allow for richer politics in the form of lobbying by (coalitions of) firms or private (individual) activism by households. In a robustness analysis, we allow green technologies to have adoption costs that fall or rise with the fraction of adopters—through learning by doing or through crowding. We also relax one of the key assumptions of the baseline model, allowing for an additional policy tool: a direct subsidy for adopting a green technology. Finally, we relax another key model assumption by relating the externality to pollution stocks rather than flows. Together, these six (seven) extensions also serve as a proof of concept by showing that our framework is quite easily adaptable in different directions.

Before we embark on these three steps, Section II relates our analysis to prior research.

II. Forerunners

The article relates to a number of different research fields in economics and other social sciences.

II.A Green Consumers and Values

Our baseline model of values in Sections III and IV links to growing economics research on green consumer demands. Some of that work posits that consumers express green values due to prosocial or self-image motives (e.g., Nyborg, Howarth, and Brekke 2006), and find that this helps us better understand demands for electric vehicles and solar panels (e.g., Delmas, Kahn, and Locke 2017). Among our extensions in Section V, we discuss a moral component of values recently emphasized by several scholars such as Enke (2020) and Enke, Polborn, and Wu (2022). Surveying a representative sample of 8,000 U.S. adults, Andre et al. (2021) find that social norms raise the individual willingness to take actions that limit global warming. A recent worldwide survey of 40,000 people in 20 countries reports large and systematic—cross-country and within-country—differences in attitudes to climate policy (Dechezleprêtre et al. 2022). Besley and Persson (2019a) consider a proxy for green values in individual-level data from the World Values Survey and likewise find large differences across and within countries. Mattauch, Hepburn, and Stern (2018) consider policy implications of endogenous values.

II.B Cultural Evolution

Our approach to evolving values has roots in a literature on cultural evolution emanating from Boyd and Richerson (1985) and Cavalli-Sforza and Feldman (1981). Following Akerlof and Kranton (2000), we think about adoption of values as formation of identities. This approach has a long history in sociology and social psychology, but is more recent in economics—Bisin and Verdier (2011) review economic applications.[3] Our extension in Section V with a moral component of values is linked to recent research on universalist cultures (Enke 2020). We extend the dynamic approach to green-values formation in Besley and Persson (2019a) by allowing a dual transition of values and technologies.

II.C Endogenous and Directed Technical Change

The switch from green to brown technology links to work on endogenous technical change (Romer 1986, 1990) and directed technical change (Acemoglu 2002 on theory, Popp 2002 on empirics) especially from green to brown technologies (Acemoglu et al. 2012). Unlike that research, we model consumer switching via changing values, on top of the standard incentives via prices and taxes. Related contributions on how innovation and values may interact include Bezin (2015, 2019).

II.D Environmental Policy

Our approach to environmental policy in Section IV is tied to work on policies for fighting pollution and global warming. Dasgupta and Heal (1979) is a classic exposition of the Pigouvian approach. Seminal applications to climate change, such as Nordhaus and Boyer (2000) and Golosov et al. (2014), add a carbon-cycle *cum* global-warming bloc to a neoclassical growth model. These authors consider Pigouvian taxes set by a social planner, who can commit to an entire future policy path (see Hassler and Krusell 2018 for an overview). Damages are related to cumulative emissions, which we discuss in the last part of Section V.

II.E Political Mechanisms

Our baseline political model in Section IV relies on probabilistic electoral competition between parties, as in Lindbeck and Weibull (1987) and Persson and Tabellini (2000). In Section V, the extension to lobbying uses an approach

3. See Bowles (1998) for a general discussion of preference change in economic models. Persson and Tabellini (2021) draw on lessons from several existing literatures when surveying research on the coevolution of values and institutions.

that is similar to Baron (1994), whereas the extension to "private politics" directed against firms relies on an approach extensively surveyed in Abito, Besanko, and Diermeier (2019). Other extensions in Section V use settings with "strategic policy making" when policy makers try to influence future outcomes by changing future state variables, as in Persson and Svensson (1989) or Alesina and Tabellini (1990).

III. A Laissez-Faire Benchmark

In this section, we outline our baseline laissez-faire framework, which abstracts completely from policy interventions. This allows us to isolate the key economic forces at work and to show how a complementarity between technologies and values may shape a green transition.

1. *Basics.* Each citizen has an exogenous endowment I of a numeraire consumption good. The numeraire can be turned into a continuum of varieties with mass one, indexed by $i \in [0, 1]$. Each variety can be produced in a polluting "brown" way and a nonpolluting "green" way. Firms indexed $i \in [0, \gamma]$ are green and those with $i \in [\gamma, 1]$ are brown. This ordering will follow from their endogenous technology choices, where $\gamma \leqslant \bar{\gamma} < 1$ with $\bar{\gamma}$ set by the green technology frontier. The share of green firms γ can change from one period to the next, due to forward-looking technology adoption by firms.

In a given time period, a unit mass of citizens can hold one of two identities, $\Gamma \in \{0, 1\}$ where $\Gamma = 1$ denotes green and $\Gamma = 0$ brown consumers, with μ denoting the green share. These identities determine preferences over consumption. Green-consumer share μ can change over time, due to forward-looking socialization by (cultural or biological) parents.

2. *Timing.* Time is infinite, discrete, and indexed by s. When no risk of confusion arises, we use short-hand notation: z for z_s and z' for z_{s+1}. Each period has four stages:

(i) Shares of green consumers μ and green firms γ are inherited from the previous period.
(ii) Price-setting, production, and consumption decisions are made.
(iii) Technology transitions among firms determine γ'.

(iv) Value transitions among consumers determine μ'.[4]

The next task is to solve the model in detail.

III.A. Statics

We now discuss preferences and demands of consumers, together with the pricing and production decisions of producers.

1. *Preferences and Consumption*. Consumer preferences are given by

$$\frac{1}{1-\sigma}\left[\int_0^\gamma \left[\Gamma(1+g)^\sigma+(1-\Gamma)\right]y(i)^{1-\sigma}di+\int_\gamma^1 \left[\Gamma(1-g)^\sigma+(1-\Gamma)\right]Y(i)^{1-\sigma}di\right]+x-\lambda\overline{Y}, \tag{1}$$

where $\sigma < 1$ governs the substitution elasticity across varieties, and parameter $g > 0$ indexes a preference shift among green consumers from brown goods Y to green goods y.[5] Consumption of the numeraire is denoted by x. Pollution damages are proportional to $\overline{Y}$, the total consumption (production) of all brown goods, and falls equally on both groups, as captured by parameter $\lambda > 0$.

The common budget constraint is

$$R \geqslant x+\int_0^\gamma p(i)\,y(i)\,di+\int_\gamma^1 P(i)\,Y(i)\,di, \tag{2}$$

where R is combined income (equal for all consumers) from the numeraire endowment and profits.

Individual demands, by type $\Gamma \in \{0, 1\}$, for each variety i follow from expressions (1) and (2). Aggregating these across

4. Taken literally, our model assumes that both types of transitions happen at the same pace. Plausibly, value transitions—which take place on a generational scale in the model below—is a (much) slower process. However, we conjecture that allowing for this would not qualitatively effect the main results. A more realistic model would have a large analytical cost, though: it would assume that technological decisions are taken in every period, while value decisions are taken less frequently. Alternatively (in a model of multiple generations) a larger share of firms than households would take a decision in every period.

5. We treat g as fixed throughout the analysis, modeling value transitions as changes in μ. Doing the opposite—or, more generally, modeling the roots of g—would be another possible strategy.

consumers, we get market demands

$$(3) \qquad y(i) = \left[1 + \mu g\right] p(i)^{-\frac{1}{\sigma}}, \qquad Y(i) = \left[1 - \mu g\right] P(i)^{-\frac{1}{\sigma}}.$$

As green consumers have stronger (weaker) demands for green (brown) goods, the market demand for each green (brown) variety goes up (down) in green-consumer share μ—more so, the larger the value-induced taste shift g.

2. *Technologies and Production*. We study a symmetric equilibrium, where prices and outputs are equal across all green and brown varieties, respectively. Thus, we remove index i within each group of goods. Firms produce their varieties using clean/green or dirty/brown inputs, where the former are more costly. The marginal cost of brown goods χ is thus lower (in numeraire units) than that of green goods $\chi + \zeta$, $\zeta > 0$.

Each variety is monopolized. Firms produce their own variety with the technology chosen last period and set prices to maximize profits. Standard arguments imply a fixed mark-up over marginal cost

$$(4) \qquad P = \frac{\chi}{1-\sigma} < p = \frac{\chi + \zeta}{1-\sigma}.$$

Thus, higher private production costs of green goods show up in higher prices to consumers.

3. *Profits.* Profits are

$$(5) \qquad \pi_s(i, \mu) = \sigma\kappa(\zeta)\left[1 + \mu g\right] - mi, \qquad \Pi_s(\mu) = \sigma\kappa(0)\left[1 - \mu g\right].$$

A higher green-consumer share μ means a higher (lower) market share and profitability for green (brown) goods. Note that $\kappa(x) = \left(\frac{\chi + x}{1-\sigma}\right)^{1-\frac{1}{\sigma}}$ is a decreasing function because $\sigma < 1$.

For firm i, the cost of using the green technology is mi, where $i \in \left[0, \overline{\gamma}\right]$. This (resource) cost is paid in each period of use.[6] One interpretation of this is a "license fee" for using the green

6. An alternative approach would be to assume a one-off adoption cost. This would add some complexity since each firm would have to consider the entire future paths of green and brown profits—and hence the entire path of green consumer shares—rather than just one-period-ahead profits. But the dynamics would be similar due to the monotonic dynamics for the green-consumer share that we derive below.

technology.[7] This fee is ultimately borne by citizens in the period (via lower profits). As discussed further in the next subsection and stated in the timing above, the technology choice is forward-looking—producing in a green way in $s + 1$ is decided at stage (iii) in s. This decision is based on (rationally) expected future profits: the expectation of equation (5) one period ahead.

III.B. Dynamics

We now study the forward-looking decisions on value transitions (socialization) by households and on technology transitions (adoption) by firms. Connecting these decisions, we can pin down the equilibrium dynamics.

1. *Value Transitions: Consumers Going Green*. The key driver of values is the expected payoff from holding green or brown values, which depends on future consumption opportunities for each group. Online Appendix A gives an example of a microfoundation for our dynamic model of consumer values.[8] Because each household is atomistic, it takes these opportunities as given. Denote the (rationally) expected gain from holding green, rather than brown, values at $s + 1$ by $\Delta' \gtreqless 0$. When green consumers have (do not have) a "fitness advantage," they thrive (flounder) relative to brown consumers. This formulation makes value transitions fully forward-looking and makes for a relatively simple model, where value transitions are parallel with technology transitions (which we consider next).

7. This approach can be microfounded. Section VI in Besley and Persson (2022b) studies a setting where the prospective rents from licensing spurs innovation in new green technologies by a set of innovation firms. In that setting, successful innovation drives down m over time.

8. It is similar to the forward-looking socialization models with overlapping (or sequential) generations in Bisin and Verdier (2001), Tabellini (2008), and Besley and Persson (2019a, forthcoming a). A richer model could also add a backward-looking component. For example, parental values and consumption patterns at s could directly influence children's values and consumption patterns at $s + 1$. Such a model would be much more complex to study, as consumption decisions would have a forward-looking element. Moreover, choices of current tax policy would become dynamic unlike the outcome in this model (see Section IV). Another possibility would be that children would choose values as better-off individuals. This would make value transitions entirely backward-looking, such that tax policy decisions would again become dynamic rather than static.

Online Appendix A shows that we can approximate—to the first order—the growth rate of green consumers by:

$$\frac{\mu' - \mu}{\mu} = \varkappa \Delta', \tag{6}$$

where $\varkappa > 0$ reflects conditions such as social mixing. Green values, and thus green consumption, will grow (shrink) *iff* $\Delta' > 0$ (< 0).

Using expressions (1), (3), and (4), we obtain

$$\Delta' = \widehat{\delta}\left(\gamma'\right) = \frac{\sigma g}{1-\sigma}\left[\gamma' \kappa(\zeta) - (1-\gamma')\kappa(0)\right]. \tag{7}$$

Equilibrium fitness of green values thus goes up linearly in the expected share of green goods. Let us assume that $\overline{\gamma} > \frac{\kappa(0)}{\kappa(\zeta)+\kappa(0)}$, so that $\Delta' > 0$ when maximal green production is anticipated.

2. *Technology Transitions: Producers Going Green.* Unable to influence aggregate outcomes, individual firms take future market shares and their dependence on μ' as given. Using equation (5) one period ahead—and ignoring discounting to keep things simple—we find that firm i uses a green technology next period if

$$\sigma\left(\mu' g\left[\kappa(\zeta) + \kappa(0)\right] + \left[\kappa(\zeta) - \kappa(0)\right]\right) \geqslant mi. \tag{8}$$

We assume that $\left[(1+g)\kappa(\zeta) - (1-g)\kappa(0)\right]\frac{\sigma}{m} < \bar{\gamma}$, so some brown production below the technology limit persists even if $\mu' = 1$. A firm will go green if its individual cost (proportional to i) is low enough, or the green consumer share μ' is high enough. The equilibrium green-firm share γ' is given by the firm whose profits as green and brown are equal:

$$\widehat{\gamma}\left(\mu'\right) = \max\left\{0, \sigma\frac{(1+\mu' g)\kappa(\zeta) - (1-\mu' g)\kappa(0)}{m}\right\}. \tag{9}$$

If interior, the green-firm share rises linearly in μ', a relation akin to the market-share effect in the work on directed technical change (Acemoglu and Linn 2004). From equation (9), lower values of m or ζ, and higher values of g, give a higher interior $\widehat{\gamma}(\mu')$. For

$$\mu' < \frac{\left[\kappa(0) - \kappa(\zeta)\right]}{g\left[\kappa(\zeta) + \kappa(0)\right]}, \tag{10}$$

the prospective market is too small and unprofitable for any firm to go green at $s+1$. Since there is a green-goods cost disadvantage ζ, this is always true for $\mu' = 0$.

3. *A Dynamic Complementarity*. Putting the pieces together, we get the equilibrium fitness of green values

$$\Delta'(\mu') = \delta(\mu) = \widehat{\delta}\left(\widehat{\gamma}\left(\mu'\right)\right). \tag{11}$$

As $\widehat{\delta}$ and $\widehat{\gamma}$ are continuous, (weakly) increasing functions, so is $\delta(\mu)$. This is the dynamic complementarity mentioned above: a green technology makes more expected profit at $s+1$ with more green consumers (the market-share effect). And if more firms go green, the expected-utility difference between holding green and brown values at $s+1$ goes up. Therefore, more consumers decide to go green, as shown in equation (6).

4. *Which Steady State?* We now show that the complementarity leads to divergent value dynamics, where the economy converges to a green steady state at $\mu = 1$, or a brown steady state at $\mu = 0$. To see this, use equations (7) and (9) to derive a closed form for continuous function δ, namely,

$$\Delta' = \delta(\mu) = \max\left\{-\frac{\sigma g \kappa(0)}{1-\sigma}, \delta_0 + \delta_1 \mu'\right\}, \tag{12}$$

where

$$\delta_0 = \frac{\sigma g}{1-\sigma}\left[\frac{\sigma\left[\kappa(\zeta)^2 - \kappa(0)^2\right]}{m} - \kappa(0)\right] < 0, \tag{13}$$

and

$$\delta_1 = \frac{\sigma^2 g^2}{1-\sigma}\frac{\left[\kappa(\zeta) + \kappa(0)\right]^2}{m} > 0. \tag{14}$$

That $\delta_0 < 0$ follows from $\zeta > 0$, the higher marginal cost of producing green goods.[9]

We assume that technology and taste parameters (ζ, m, and g) are such that $\delta(1) = \delta_0 + \delta_1 > 0$, so that a green transition is feasible. This requires a positive fitness of being green when everyone else is. From equation (12), we know that $\delta(0) < 0 < \delta(1)$.

9. We assume that $\varkappa$ is small enough such that $\delta_1 \varkappa < 1$.

Given $\delta_\mu(\mu) \geqslant 0$ and continuity of $\delta(\mu)$, the opposite-signed extreme values (by the intermediate-value theorem) imply a critical value of μ where the relative fitness of green values is zero, $\delta(\hat{\mu}) = 0$. This and the positive feedback dynamics gives us (the proof of this proposition and all others are found in Online Appendix B):

PROPOSITION 1. *If* $\delta_0 + \delta_1 > 0$, *a laissez-faire economy converges to a green* (*brown*) *steady state with* $\mu = 1$ ($\mu = 0$) *iff initial green values are large* (*small*) *enough that* $\mu \geqslant -\frac{\delta_0}{\delta_1}$ ($\mu < -\frac{\delta_0}{\delta_1}$).

We get two steady states, but a unique dynamic path. For example, if the initial green-values share is small enough, few producers want to produce green goods. The inability to consume green goods makes it unattractive to be a green consumer, so the green-values share is shrinking and the economy converges to a brown steady state.

5. *Slope and Level Effects*. Equation (12) pinpoints the dynamic forces of the model. The parameter δ_0 represents a level effect, the vertical position of $\delta_0 + \delta_1\mu$ in (μ, Δ) space, while the parameter δ_1 represents a slope effect, influencing the convergence speed. We already know from equation (6) that the green-consumer share grows according to $\frac{\mu' - \mu}{\mu} = \varkappa\Delta'$. From equation (9), the green-firm share grows at the same rate.

Figure I illustrates the dynamic paths in Proposition 1. Although a green transition is feasible, it only materializes if green values exceed critical value $\hat{\mu} = -\frac{\delta_0}{\delta_1}$. By the market-size effect, producers must anticipate a large enough market for green goods to go green. If they do, more consumers go green, which reinforces the dominance of green consumers and producers over time. The flat portion of the δ-curve corresponds to low levels of μ that make green production unprofitable.

6. *Comparative Dynamics*. How do level and growth effects depend on key parameters: $\{m, \zeta, g\}$? From the definition of δ_1 in equation (14), we have:

COROLLARY 1. *Given initial green values* μ, *a green transition is more likely when* m *is lower. Slope parameter* δ_1 *decreases in* m, ζ *and increases in* g, *and level parameter* δ_0 *increases in* m *and decreases in* ζ.

For example, in Figure I, a lower green-technology cost m shifts the $\delta(\mu)$ curve up and left, implying a lower critical value $\hat{\mu}$.

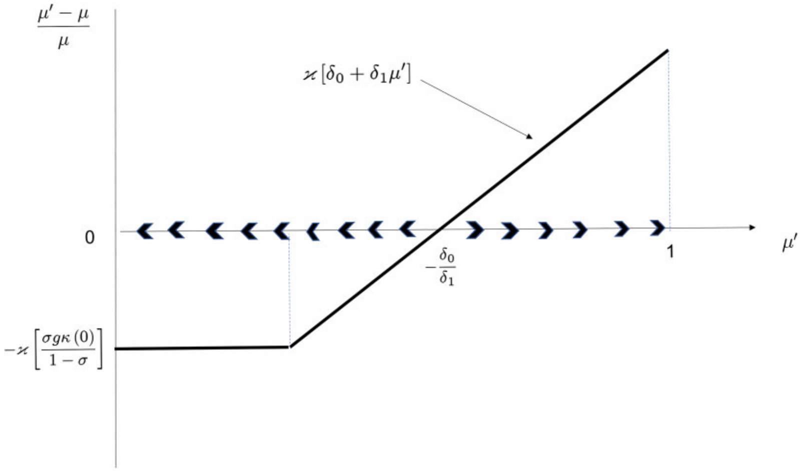

FIGURE I

Divergent Dynamics under Laissez-Faire

So does a lower marginal cost of green production ζ, as well as a greater preference tilt among green consumers g.

7. *Pollution Growth*. We can think about a green transition in terms of economy-wide pollution $\lambda\overline{Y}$. Integrating over (symmetric) brown firms, the closed-form solution for total (per capita) brown production is:

$$\overline{Y} = (1-\gamma)(1-\mu g)\kappa(0)^{\frac{1}{1-\sigma}}. \tag{15}$$

The growth rate of pollution is $\frac{(1-\gamma')}{(1-\gamma)}\frac{(1-\mu' g)}{(1-\mu g)} - 1$, a nonlinear decreasing function of γ' and μ', the future shares of green production and consumption. Evidently, pollution falls whenever these shares rise, so that $\mu' > \mu$ and $\gamma' > \gamma$.

III.C. Welfare

Because technology transitions do not reflect the pollution externality $\lambda\overline{Y}$, we do not expect a laissez-faire equilibrium to be socially optimal. But our dynamic model adds an extra twist, as evolving values μ shape the externality via $\overline{Y}$. A green transition reduces the externality, even absent government intervention. Favorable laissez-faire dynamics can thus potentially "solve" the pollution problem over time.

1. *Individual Utilities and Social Surpluses*. Our welfare criterion is utilitarian welfare, whose flow at s is

$$\Omega(\mu) = \hat{\gamma}(\mu)(1+\mu g)\, w(\zeta) + (1-\hat{\gamma}(\mu))(1-\mu g)\, W(\lambda) + I - \frac{\hat{\gamma}(\mu)^2 m}{2}. \tag{16}$$

In this expression,

$$w(\zeta) = \left[\frac{\kappa(\zeta)}{1-\sigma} - (\chi+\zeta)\kappa(\zeta)^{\frac{1}{1-\sigma}}\right] \text{ and}$$
$$W(\lambda) = \left[\frac{\kappa(0)}{1-\sigma} - (\chi+\lambda)\kappa(0)^{\frac{1}{1-\sigma}}\right], \tag{17}$$

are the gross "social surpluses"—that is, utility plus profits—for a typical green and brown good. The negative externality from brown production is reflected in the decreasing function $W(\lambda)$. We obtain utilitarian welfare by summing these surpluses across all goods, adding lump-sum income I, and deducting technology adoption costs $\frac{\hat{\gamma}(\mu)^2 m}{2}$.[10]

2. *Welfare Rankings*. Aggregate welfare computed from period s (again ignoring discounting) is

$$\Omega(\mu_s) + \sum_{j=s+1}^{\infty} \Omega(\mu_j). \tag{18}$$

Let us compare the utilitarian welfare sums on two different dynamic paths for green shares $\boldsymbol{\mu} = \{\mu_s, ..., \mu_\infty\}$ and $\tilde{\boldsymbol{\mu}} = \{\tilde{\mu}_s, ..., \tilde{\mu}_\infty\}$. We say that $\tilde{\boldsymbol{\mu}} > \boldsymbol{\mu}$ when the green shares in $\tilde{\boldsymbol{\mu}}$ are no smaller than those in $\boldsymbol{\mu}$ in each and every period. Moreover, let us formulate the condition

CONDITION 1. $w(\zeta) > 0 > W(\lambda)$.

Then we have:

PROPOSITION 2. If Condition 1 *holds, then welfare is higher along any dynamic path for which* $\tilde{\boldsymbol{\mu}} > \boldsymbol{\mu}$. *Moreover, the green steady state is welfare superior.*

10. To see this, note that all firms $i \in [0, \hat{\gamma}(\mu)]$ pay costs mi. The total cost for technology adoption is thus given by triangular area $\frac{1}{2}\hat{\gamma}(\mu) \cdot m\hat{\gamma}(\mu)$.

The first part of Condition 1 says that green goods have social value even though their costs are relatively high $\zeta > 0$. The second part says that λ is large enough so that brown goods are not socially valuable. So the externality has to be large enough that it is always worthwhile to move fully toward green production, even if no green firms exist as $\hat{\gamma}\,(\mu) = 0$ by equation (9). This rules out a region where $\Omega(\mu)$ is decreasing because it reduces the welfare of brown consumers when they are many—that is, when μ is low. To summarize, Condition 1 spells out a sufficient condition under which a full green transition to the technological limit for green goods is socially desirable.

The following result is immediate.

COROLLARY 2. *Under Condition 1, an economy with $\mu < -\frac{\delta_0}{\delta_1}$ that approaches the brown steady state could raise its (utilitarian) welfare by a green transition. A higher value of λ relative to ζ widens the range of μ for which the economy is caught in such a trap.*

The possible trap is perhaps not surprising, as firms maximize profits rather than social surplus. What may be more surprising is that the economy can escape the trap through a transition of individual values, absent collective action.

3. *Discussion*. Our welfare analysis imposes two conditions. First, it is socially desirable that all goods are green, given the current state of technology as represented by ζ, m, and $\overline{\gamma}$—for example, if $\zeta \to 0$ and $m \to 0$, $w\,(0) - W\,(\lambda) = \lambda\kappa\,(0)^{\frac{1}{1-\sigma}} > 0$. Second, the externality has to be large enough, given the costs of going green—in particular, if $\lambda > \chi\left[\frac{1-(1-\sigma)^2}{(1-\sigma)^2}\right]$, $W(\lambda) \leqslant 0$.

To see what can go wrong, note that for low μ no green goods are produced and $\Delta' = -\frac{\sigma g\kappa(0)}{1-\sigma} < 0$ is independent of λ. So μ falls over time, even though λ is large and the social surplus from brown production is negative. On top of the static distortion, there is thus a dynamic distortion: the green share μ' falls, although it is socially optimal for it to rise.

An obvious response to this—as in any situation with externalities—is to introduce Pigouvian taxes. But as we shall see, such policies may deal with static distortions without necessarily resolving dynamic distortions.

IV. Policy and Politics

This section studies policy outcomes in a model of electoral competition. We develop a benchmark where voting delivers a short-term utilitarian outcome. Richer political settings, which permit lobbying by firms, or political activism by individuals, are considered in Section V.B.

1. *Policy Instruments and Timing.* We suppose that the government can set current production taxes (or subsidies) on green and brown goods $\{t, T\}$. As Pigouvian taxes, these can address market distortions from externalities and monopoly pricing. Each period s now has five stages.

(i) Shares of green consumers μ and green firms γ are inherited from the previous period.
(ii) (a) Parties announce electoral platforms $\{t, T\}$; (b) idiosyncratic and aggregate shocks are realized and determine the election outcome.
(iii) Price-setting, production, and consumption decisions are made.
(iv) Technology transitions among producers determine γ'.
(v) Value transitions among consumers determine μ'.

IV.A. Static Politics

We now explore the policies chosen in a political equilibrium, absent commitment.

1. *Effects of Taxes*. Taxes fall on producers and hence affect the prices they charge. These become $P = \frac{\chi+T}{1-\sigma}$ and $p = \frac{\chi+\zeta+t}{1-\sigma}$. Substituting the new prices in our prior expressions, we obtain equilibrium consumer demands for green and brown goods. Tax revenues, given by

$$t\gamma\left[1+\mu g\right]\kappa\left(\zeta+t\right)^{\frac{1}{1-\sigma}}+T(1-\gamma)\left[1-\mu g\right]\kappa\left(T\right)^{\frac{1}{1-\sigma}},$$

are distributed back to all consumers in equal amounts. But different consumption baskets still mean that different taxes on green and brown goods alter the relative welfare of green and brown consumers.

2. *Electoral Competition*. Following Besley and Persson (2019a), we study two-party competition around green and brown taxes with probabilistic voting (Lindbeck and Weibull 1987,

Persson and Tabellini 2000).[11] We label the two (given) parties $D = A, B$ and assume they are solely motivated by winning elections. Each party D proposes a tax platform for the current period: $\{t^D, T^D\}$. Voters are of two kinds. Swing voters cast their ballots based on proposed policy platforms and loyal voters cast their ballots for one party independent of policy. Our model has the same proportion of swing voters among green and brown consumers. Swing voters are subject to idiosyncratic and aggregate popularity shocks. Parties maximize their expected payoffs knowing the distributions (but not realizations) of these shocks.

3. *Objectives and Equilibrium Taxes*. Equilibrium policy is determined by a Nash equilibrium in platforms $\{t, T\}$ when each of the parties seeks to win the election. Proposition 3 states the equilibrium policy choices (see Online Appendix B for details and proof). Although the model is dynamic and all actors are forward-looking, equilibrium taxes only reflect static political incentives. This reflects the fact that even though parties at s do internalize the preferences of forward-looking voters, they cannot affect the expected payoffs (to the voters' offspring) at $s + 1$. Due to the forward-looking choices of values and technologies emphasized in Section III, these expected payoffs depend only on future variables $\{t', T', \gamma', \mu'\}$. Without commitment, parties cannot choose t', T' directly. Neither can they affect $\{t', T', \gamma', \mu'\}$ indirectly, because the current policies t and T which they do control do not influence these future variables.

In the absence of commitment, each party will therefore make a static decision, acting "as if" it is maximizing a utilitarian objective function defined over current payoffs only:

$$\begin{aligned} \Omega(\mu, t, T) = {} & \hat{\gamma}(\mu)(1 + \mu g)\, w(\zeta + t) \\ & + (1 - \hat{\gamma}(\mu))(1 - \mu g)\, W(T, \lambda) + I - \frac{\hat{\gamma}(\mu)^2 m}{2}, \end{aligned} \tag{19}$$

where $w(\zeta + t) = [\frac{\kappa(\zeta+t)}{1-\sigma} - (\chi + \zeta)\kappa(\zeta + t)^{\frac{1}{1-\sigma}}]$ and $W(T, \lambda) = [\frac{\kappa(T)}{1-\sigma} - (\chi + \lambda)\kappa(T)^{\frac{1}{1-\sigma}}]$. Combining forward-looking private

11. We pick this formulation for convenience. As discussed in Besley and Persson (2019a), other political models would yield similar conclusions. One possibility would be to have parties whose ideologies were correlated with green preferences, as found in the data (Anderson, Marinescu, and Shor 2019).

choices of values and technology and lack of policy commitment permits a simple analytical solution for politically optimal taxes:

PROPOSITION 3. *In an equilibrium with electoral competition, parties converge on taxes which maximize the payoff in equation (19), that is,*

$$T = (1 - \sigma)\lambda - \sigma\chi \quad \textit{and} \quad t = -\sigma(\chi + \zeta).$$

Equilibrium taxes correct the damages from brown-sector pollution (the term in $(1 - \sigma)$) and offset the distortion from monopoly pricing (the terms in $-\sigma$). As a result, the green tax is negative—that is, a subsidy. Note that by equation (19), $\chi + \lambda$ is the social marginal cost of a brown good, while $\chi + \zeta$ is the social marginal cost of a green good. Taxes induce firms to internalize social surplus rather than profit—green goods are priced at marginal cost, $\chi + \zeta$. The taxes are constant over time and independent of μ, something we relax in Section V.

Throughout the remaining analysis, we assume that $\lambda > \zeta$—that is, the externality exceeds the additional cost of producing green goods, meaning that the social cost is higher for brown goods than green goods. To simplify notation, let $k = \kappa(\zeta + t)$ and $K = \kappa(T)$ when taxes are set at the equilibrium level given in Proposition 3.

As noted already, $\kappa(\cdot)$ determines profits and utility levels. If $\lambda > \zeta$, then $k' = k > K = K'$ when taxes are given by Proposition 3. In words, brown taxes are high enough to make anticipated future profits higher for green goods than brown goods, even though green firms produce at higher (physical) marginal cost.

A key feature of the solution in Proposition 3 is that politics is essentially static. This serves as a useful, albeit limiting, benchmark which we relax in some extensions developed in Section V.

IV.B. Dynamics and Equilibrium Policy

Even though the taxes in Proposition 3 are time invariant, they affect the incentive to choose green values and technologies. We explore these dynamics.

1. *Value Transitions*. Our analysis of forward-looking value transitions in the laissez-faire economy continues to apply, so the dynamics for the green share in equation (6) still hold. However, the expression for relative fitness Δ' in equation (7) is modified to

$$(20) \qquad \Delta' = \widehat{\delta}\left(\gamma'\right) = \frac{\sigma g}{1-\sigma}\left[\gamma' k' - (1-\gamma')K'\right],$$

where future equilibrium taxes $\{t', T'\}$ which define k' and K' are given by Proposition 3. As lower t' and higher T' raise green fitness Δ', taxes affect incentives to adopt green values in the expected direction. If we assume that $\overline{\gamma} > \frac{K'}{k'+K'}$, the green-consumer share is rising when the green-firm share is at its technical maximum.

2. *Technology Transitions*. Profits also depend on taxes. With policy in Proposition 3, we get $\Pi(T', \mu') = \sigma K'[1 - \mu' g]$ and $\pi(i, t', \mu') = \sigma k'[1 + \mu' g] - mi$. Thus, equation (9), our prior expression for the fraction of green firms in $s + 1$, is replaced by:

$$(21) \qquad \gamma' = \hat{\gamma}\left(\mu'\right) = \sigma \frac{k'\left[1+\mu' g\right] - K'\left[1-\mu' g\right]}{m} > 0,$$

where the sign follows from $k' > K'$. Unlike the laissez-faire economy, there is always some green-goods production when policy is set as in Proposition 3. We also assume

$$(22) \qquad \overline{\gamma} > \frac{\sigma\left[(1+g)\,k' - (1-g)\,K'\right]}{m}.$$

This says that, at equilibrium taxes, there is still some brown production if $\mu = 1$.

3. *Interacting Value and Technology Transitions*. Substituting equation (21) into equation (20), we can rewrite equation (12) as:

$$(23) \qquad \Delta'\left(\mu'\right) = \delta\left(\mu'\right) = \widehat{\delta}_0 + \widehat{\delta}_1 \mu',$$

where

$$(24) \qquad \widehat{\delta}_0 = \frac{\sigma g}{1-\sigma}\left[\frac{\sigma\left[(k')^2 - (K')^2\right]}{m} - K'\right].$$

Unlike δ_0 in equation (13), $\widehat{\delta}_0$ need not be negative; indeed, it is positive if $\lambda - \zeta$ is large enough. The counterpart to the slope coefficient equation (14) is:

$$\widehat{\delta}_1 = \frac{\sigma^2 g^2}{1-\sigma}\frac{[k' + K']^2}{m} > 0, \tag{25}$$

which is positive like δ_1.[12]

The key difference with laissez-faire is that $\widehat{\delta}_0$ and $\widehat{\delta}_1$ now depend on policy. However, as t' and T' are independent of μ, they are constant over time. In fact, the laissez-faire coefficients in equations (13) and (14) are special cases of $\widehat{\delta}_0$ and $\widehat{\delta}_1$ when $t' = T' = 0$. Changes in $\widehat{\delta}_0$ and $\widehat{\delta}_1$ thus become sufficient statistics for the dynamics of values characterized by the function $\delta(\mu')$.

4. *Taxes and Dynamics*. We get the following counterpart to Proposition 1:

PROPOSITION 4. *If* $\widehat{\delta}_0 + \widehat{\delta}_1 > 0$, *a society with endogenous policy always converges to a green steady state if* $\widehat{\delta}_0 > 0$, *a sufficient condition being that* $\lambda - \zeta$ *is positive and large enough. If* $\widehat{\delta}_0 < 0$, *we get convergence to a green steady state iff green values are large enough that* $\mu \geqslant \widehat{\mu} = -\frac{\widehat{\delta}_0}{\widehat{\delta}_1} > 0$.

Society can now converge to a green steady state from any initial green share. This happens when $\widehat{\delta}_0 > 0$, such that $\delta(\mu') > 0$ for all values of μ'. The sufficient condition in the proposition follows from equation (24). In words, a high enough equilibrium brown tax can ensure a green transition, even if the green-consumer share is small (or zero). If this condition does not hold, a green transition requires a large enough green share, but the critical share is generally lower than under laissez-faire.[13]

Proposition 4 says that we can have the same kind of dynamics as in Proposition 1 and illustrated in Figure I: convergence to a brown or a green steady state depending on initial values. However, as Figure II illustrates, we can also get a green transition for any initial green share.

5. *Electoral Competition and Dynamics*. How do the basic model parameters influence the dynamics? We have already seen

12. As before, we assume that $\varkappa$ is small enough such that $\widehat{\delta}_1\varkappa < 1$.

13. There are three possible cases for $\widehat{\delta}_0$. (i) $\widehat{\delta}_0 > 0$, the case illustrated in Figure II. (ii) $-\frac{\sigma g K'}{1-\sigma} < \widehat{\delta}_0 < 0$, which gives $\gamma' > 0$ even if $\mu' = 0$ and $\delta(\mu)$ everywhere increasing. (iii) $\widehat{\delta}_0 < -\frac{\sigma g K'}{1-\sigma}$ and $\gamma' = 0$ if $\mu' = 0$, which gives $\delta(\mu)$ a linear segment as in Figure I.

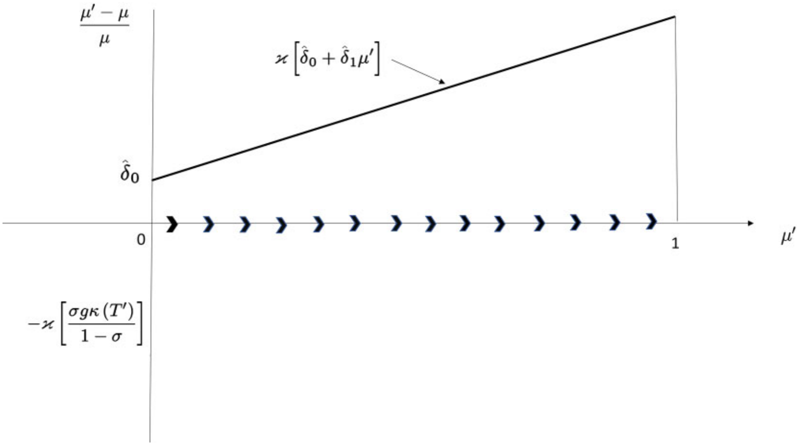

FIGURE II

Policy Leading to Convergent Dynamics toward a Green Steady State

that a high $\lambda - \zeta$ gap can bring about an unambiguous green transition. Combining Propositions 3 and 4, we get:

COROLLARY 3. *With multiple steady states, a higher difference $\lambda - \zeta$ shifts down critical value $\hat{\mu}$ and widens the range of parameters that ensure a green transition.*

The role of $\lambda - \zeta$ is intuitive, as $\lambda + \chi$ is the social marginal cost of brown goods, while $\zeta + \chi$ is the social (and private) marginal cost of green goods. Though politicians only internalize this period's externality, people still expect next period's politicians to set higher taxes on brown firms. A higher externality thus induces more firms and consumers to go green, even though today's politics cannot affect future outcomes or commit to a future policy.

But Proposition 4 and Corollary 3 are only limited causes for optimism. As we shall see, the economy can still be caught in the same kind of trap as in Section III.

IV.C. Welfare and Politics

Policy choices in a political equilibrium maximize short-term utilitarian welfare. But without commitment, policy makers cannot directly influence the dynamic path of values. In general, we would not expect this to maximize long-run welfare.

To explore whether politically chosen policies inhibit or slow down a green transition, we state a new sufficient condition for a full green transition to be socially desirable even though taxes are set as in Proposition 3:

CONDITION 2. $\frac{(1+\sigma)\sigma}{m}\left[(k')^2 - (K')^2\right] - K' > 0.$

Condition 2 says that even with a large group of brown consumers, the negative effect on their welfare due to a greener economy is offset by the smaller pollution externality (and the positive effect on green consumers' welfare). Since K' is decreasing in λ (via higher T'), Condition 2 is more likely to hold when λ is large. But there is an important difference from Condition 1. With policy set as in Proposition 3, the social surplus from brown goods may not be negative with high λ, as equilibrium taxes induce producers and consumers to internalize the pollution externality from such goods. But when λ becomes large, brown-goods social surplus shrinks to a point where Condition 2 holds. Using this condition, we have:

PROPOSITION 5. *If Condition 2 holds, then welfare is higher along any dynamic path for which $\tilde{\boldsymbol{\mu}} > \boldsymbol{\mu}$. Moreover, the green steady state is welfare superior.*

An immediate corollary of Proposition 5 is that long-run welfare is lower in a trap where a green transition does not take place. But the proposition is also relevant for an economy with $\Delta' > 0$, which is already in a green transition. It says that a small one-off policy deviation—with higher brown taxes T' and/or lower green taxes t' than the values in Proposition 3—would raise welfare. When t' and T' are at their static optimum, the direct effect on $\Omega(\mu', t', T')$ of changing $\{t', T'\}$ is negligible. But from equation (23) the deviation would raise Δ' and hence μ', which would speed up the green transition. Condition 2 guarantees that this indirect effect will raise $\Omega(\mu', t', T')$. Moreover, μ will be higher also in all future periods. Thus, the first part of Proposition 5 implies:

COROLLARY 4. *If Condition 2 holds, welfare would be higher during a green transition if parties could commit, hypothetically, to one-period-ahead tax rates $t' \leqslant -\sigma(\chi + \zeta)$ and $T' > (1 - \sigma)\lambda - \sigma\chi$.*

This result makes precise when the commitment problem in politics generates a government failure. Moreover, the cost of lacking commitment remains even if the economy is on a path to a green transition and policy has eliminated a trap that existed under laissez-faire.

V. Developing the Framework

This section develops our framework in different directions, some of which yield new results while other extensions are more to check the robustness of our results. Section V.A, where we incorporate moral concerns among green consumers, is looking for additional results. Moral concerns affect value transmission and policy making, with policy now responding to the share of green consumers. In Section V.B, we permit a wider range of political activities, adding lobbying via campaign contributions and "private politics." Section V.C enriches the economic model. We check the robustness of our main results when the costs of going green are decreasing due to learning by doing or increasing due to crowding. We also extend the policy menu with a subsidy to technology conversion. Finally, we make our model more applicable to the climate problem, by letting the externality be generated by pollution stocks rather than flows. This stock externality makes the motives in tax policy strategic.

V.A. Richer Values

We now incorporate moral concerns in green values and explore their consequences for policy making and value transmission.

1. *Green Moral Values*. Following Enke (2020) and Enke, Polborn, and Wu (2022), we add an additional component to the preferences of green consumers modifying expression (1) to

$$\frac{1}{1-\sigma}\left[\int_0^{\gamma}(1+g)^{\sigma}\,y(i)^{1-\sigma}di+\int_{\gamma}^{1}(1-g)^{\sigma}\,Y(i)^{1-\sigma}di\right]$$

$$+x-\lambda\overline{Y}+\theta P\left(\overline{Y},\underline{Y}\right), \tag{26}$$

where P represents the moral component of preferences. Parameter θ, which we take as given throughout, indexes the strength of moral concerns. As in Besley and Persson (2019b), we model such concerns by comparing the outcome with a reference point, here labeled $\underline{Y}$. In particular, moral preferences have the form:

$$P\left(\overline{Y}, \underline{Y}\right) = \begin{cases} 0 & \text{if } \overline{Y} < \underline{Y} \\ -(\overline{Y} - \underline{Y}) & \text{otherwise.} \end{cases}$$

Pollution below the current reference point $\underline{Y}$ thus leaves a green consumer morally content. However, above this reference point (the morally acceptable level of pollution), she experiences a utility loss that grows in the distance between her moral standard and actual pollution. To begin with, we treat the reference point $\underline{Y}$ as exogenous.

Moral preferences $\theta P\left(\overline{Y}, \underline{Y}\right)$ represent a public-good concern. As such, they do not affect private consumption decisions and therefore all the key results from Sections III and IV on consumer demands and—a fortiori—on producer pricing, production, and profits are unchanged. However, moral preferences will have an effect on voting and hence on policy.

2. *Equilibrium Policy*. For moral preferences to have bite in generating a higher tax rate on brown goods, moral reference point $\underline{Y}$ has to prescribe a lower pollution level than the one implied by the tax in Proposition 3. Moral preferences have maximum impact when the reference point is at least as demanding as the equilibrium tax rate, which requires that[14]

$$\underline{Y} \leqslant (1-\gamma)(1-\mu g)\kappa((1-\sigma)(\lambda+\mu\theta)-\sigma\chi)^{\frac{1}{1-\sigma}}. \tag{27}$$

This is shown in:

PROPOSITION 6. *For all moral reference points that satisfy condition (27), both parties choose the same taxes:*

$$T = (1-\sigma)(\lambda+\mu\theta)-\sigma\chi \quad \text{and} \quad t = -\sigma(\chi+\zeta).$$

The subsidy on green goods is the same as in Proposition 3, while—for any $\mu > 0$—the tax on brown goods is higher. As green consumers/voters demand a higher pollution tax than brown ones,

14. To write this expression, we use the fact that

$$Y(T) = (1-\gamma)(1-\mu g)\kappa(T)^{\frac{1}{1-\sigma}}.$$

they are courted more by parties. The higher demand directly reflects their dual, materialistic and moral, role. It is "as if" each green voter perceives a loss of $-(\lambda+\theta)\bar{Y}$ from pollution—thus her brown-tax preferences are more salient to the political parties that compete for her ballot.

Unlike in Proposition 3, the brown tax in Proposition 6 responds to the share of green consumers. That may also affect the value dynamics, depending on how $\underline{Y}$ is set (as this determines whether $P\left(\overline{Y},\underline{Y}\right)\gtreqless 0$).

3. *Choice of Reference Point*. As Kőszegi and Rabin (2006) discuss, reference points can be endogenized in different ways. We follow one of their core ideas. Thus, we let the reference point be forward-looking, based on the expected next-period political equilibrium (and thus next generation's well-being). This assumes that green consumers/voters have realistic expectations about politically feasible policies. Moreover, as policy varies with the green-consumer share over time, so does the moral reference point.

This rules out a form of unrealistic idealism, say, with reference point $\underline{Y}=0$. This pollution level is politically infeasible even if $\mu=1$. Such idealism would also hurt the fitness of green consumers via constant disappointment (reducing their utility).

Instead, we work with pragmatically moral green consumers/voters, who use the reference point:

$$\underline{Y}_s=(1-\gamma)(1-\mu_s g)\kappa((1-\sigma)(\lambda+\mu_s\theta)-\sigma\chi)^{\frac{1}{1-\sigma}}, \tag{28}$$

the upper bound in condition (27). As green share μ grows (shrinks) over time, the pragmatic moral reference point becomes more (less) demanding.[15]

Whatever its realism, this is a natural benchmark. Together with Proposition 6, it implies $P\left(\overline{Y}_s,\underline{Y}_s\right)=0$ at all s—that is, there is no direct effect of morality on the fitness of being green. Instead, any morality influence is indirect through policy. A reference point below the one defined by equation (28) would not change policy, but reduce green fitness. In evolutionary terms, a reference point

15. Recall that $\kappa(\cdot)$ is a decreasing function.

given by condition (27) maximizes the fitness of green consumers with moral preferences.

4. *Dynamics*. If moral preferences only affect dynamics via expected policy, all that matters is what happens to Δ' in equation (6). Recall that, at interior solutions, $\Delta' = \widehat{\delta}_0 + \widehat{\delta}_1\mu'$, with $\widehat{\delta}_0$ and $\widehat{\delta}_1$ defined by equations (24) and (25). An important modification of our earlier results is that $T'(\mu')$ in the expressions for $\widehat{\delta}_0$ and $\widehat{\delta}_1$ is no longer constant but growing (shrinking) over time as moral values (by Proposition 6) translate into policies.

Formally, consider the effect via $\widehat{\delta}_0$. From equation (24) $\widehat{\delta}_0$ is increasing in T' and from Propositions 3 and 6, expected brown tax $T'(\mu')$ rises in μ' and exceeds its nonmoral benchmark for all $\mu' > 0$. In Figure II, the intercept of the $\widehat{\delta}_0 + \widehat{\delta}_1\mu'$ curve is higher ceteris paribus, which widens the parameter range permitting a green transition. Green consumers/voters with moral preferences get more attention and push up brown taxes, even as a minority. The intercept of the $\widehat{\delta}_0 + \widehat{\delta}_1\mu'$ curve shifts up (down) in each period μ is growing (shrinking), which speeds up the transition to the green (brown) steady state.

The effect of μ' on $\widehat{\delta}_1$ via $T'(\mu')$ goes in the other direction, diminishing (though not eliminating) the positive slope. But the overall effect of μ' on Δ' is still positive. Moreover, a green transition becomes more likely with moral values, once we take their full effect on policy into account.

We note that adding moral concerns among green consumers diminishes both welfare costs of lacking commitment that we identified in Section IV.C, by making a green transition more likely and more rapid should it occur.

5. *Discussion*. This extension suggests a wider agenda on moral preferences, policy outcomes, and the evolutionary dynamics of environmentalism.

For example, current parameter θ could reflect education or information campaigns. It could also be influenced by green social movements if they inculcate a sense of collective identity among environmentalists. In both cases, θ would become an increasing function of μ and generate an additional policy multiplier.

One could also consider a wider range of moral concerns, including those around social justice and distribution. If the propensity to be green goes up with income—due to the link with education—then brown consumers/voters will on average be poorer than green ones. Policies that impose large green-transition costs on the poor may overlook such moral concerns and, if not addressed, could limit efforts to curtail pollution.[16] Such tensions are also present in international negotiations and were manifest in recent COP27 discussions, reflecting a potential moral dilemma between accelerating the green transition and supporting poorer countries.

V.B. Richer Politics

We now explore extended models of politics, beyond voting and electoral competition.

1. *Lobbying.* To introduce lobbying in a simple way, suppose that the two parties interact not just with voters but with lobbying firms whose (endogenous) contributions can help secure an election victory. How this plays out depends on the organization of green versus brown firms. We assume that a share ϕ of all green firms are organized as a lobby that makes campaign contributions where each participating firm contributes c^D to party D at cost $\frac{1}{2}(c^D)^2$. Similarly, a share Φ of all brown firms make contributions C^D at costs $\frac{1}{2}(C^D)^2$. Aggregate contributions raise party D's probability of winning, indexed by a parameter ξ.[17]

Following Baron (1994), we assume that the (coalitions of) firms decide on contributions after parties have designed their policy platforms, but before the election. In relation to the timing in Section IV, contributions are paid in between stages (ii)(a) and (ii)(b).

i. Statics and Lobbying. Online Appendix B shows that election *cum* lobbying implies the following policy outcome:

16. Dechezleprêtre et al. (2022) study individual attitudes to climate change and policy interventions in 20 countries. They find that attitudes indeed differ systematically by education and also crucially depend on perceived distributional effects.

17. We treat "organized" shares ϕ and Φ as given. It would be interesting to endogenize these shares, especially in the dynamic analysis that follows. A simple static model of endogenous formation of lobby groups appears in Mitra (1999). Allowing lobby formation related to profitability would add a new dynamic element.

PROPOSITION 7. *In an equilibrium with electoral competition and lobbying, parties converge on taxes:*

$$T = \frac{(1-\sigma)\lambda - \sigma(1+\Phi\xi)\chi}{1+\Phi\xi\sigma} \quad \textit{and} \quad t = -\sigma(\chi+\zeta)\left[\frac{1+\xi\phi}{1+\xi\phi\sigma}\right].$$

Proposition 3 is a special case of Proposition 7, when either $\xi = 0$—money is ineffective in politics—or $\Phi = \phi = 0$—no firms are organized to lobby. As ξ becomes positive, the green-goods subsidy rises and the brown-goods tax falls. However, the policy changes strike differently across green and brown sectors to the extent that Φ and ϕ differ—i.e., lobbying organization is asymmetric. If brown firms are better organized ($\Phi > \phi$), this cuts T relative to t.

ii. Dynamics and Lobbying. Lobbying can undermine the power of policy to create a green transition. To illustrate this, consider the special case where the green sector is not organized—that is, $\phi = 0$. Then, the tax-inclusive marginal costs faced by green firms are proportional to $\chi + \zeta$, while those of brown firms are proportional to $\lambda + \frac{\chi}{1+\Phi\xi\sigma}$. If $\Phi\xi$ is sufficiently high—that is, brown firms are well organized or money is influential in politics—then brown firms are disproportionately favored by low taxes.

More generally, Proposition 7 says that the tax on brown (green) goods T' (t') is decreasing in the share of brown (green) firms Φ (ϕ) that belong to the lobbying coalition. Moreover, this dampening effect is larger the higher is ξ, the clout of money in politics. Using these results, the expressions for equations (24) and (25) and Proposition 7 imply:

COROLLARY 5. *A larger (positive) gap between the organization rates of brown and green firms, $\Phi - \phi$, makes a green transition less likely, raising the critical value $\hat{\mu}$. This effect is stronger if ξ is higher—money matters more in politics.*

These results are driven by the effect on equilibrium policy, similar to Corollary 3. However, Corollary 5 carries a more pessimistic message about the policies chosen in political equilibrium. If the lobbying power of brown firms is strong enough relative to green firms—and if money matters enough in politics—then electoral competition *cum* lobbying shrinks the brown-green profitability gap toward its value under laissez-faire.

iii. Policy Failure Redux. To illustrate powerfully the potential costs of brown-firm lobbying, we consider an extreme special case, where all brown firms are organized ($\Phi \to 1$), green firms are not ($\phi \to 0$), and money is very effective in influencing elections ($\xi \to \infty$). Then, Proposition 7 says that $t \to -\sigma(\chi + \zeta)$ and $T \to -\sigma\chi$. In this limit, equilibrium policy addresses the monopoly distortion but pays no attention to the brown-production externality. The price of brown goods is χ, which is even lower than in laissez-faire. Thus, the $\widehat{\delta_0} + \widehat{\delta_1}\mu$ curve lies below the $\delta_0 + \delta_1\mu$ curve in Figure I, such that a green transition is less likely than under laissez-faire. This negative result rhymes well with the policy pessimism of climate activists who point to the harmful policy influence of powerfully organized fossil-fuel industries.

This observation is particularly important when Condition 2 holds. Supposing that brown firms are better organized than green, lobbying increases the prospect of a trap without a green transition and slows down any green transition. Thus it raises both welfare costs associated with the lack of policy commitment.

2. *Political Activism.* We now expand our baseline with private political activism—a form of "private politics" in the sense of Baron (2003). Individual actions against polluting firms are an important real-world example of private politics as discussed in Abito, Besanko, and Diermeier (2019), who also provide a general overview of this research. Individual activists can harass or promote firms directly—and outside of the regular political process—to alter production costs and hence profits. These effects will, in turn, directly affect producer incentives.[18]

i. Private Politics. Activism could be modeled in many ways. To keep things simple, we follow Passarelli and Tabellini (2017), who model protests as a purely emotional activity—that is, group members get a psychological reward by joining others to display aggrievement or frustration. Such emotions make green citizens

18. Another purpose of individual—and particularly group—activism, not present in our model, is to influence policy. But activist protests signal activists' preferences and discontent with government policies. Modeling the policy purpose of activism would be a plausible extension. If green activists were better organized than brown, we conjecture that this would produce results opposite to those of lobbying (with brown firms better organized than green).

take positive action toward green firms and negative action toward brown firms. One example is how protesters in organizations like Extinction Rebellion target fossil-fuel producers and distributors. Resource-intensive companies also fear activists like those in the Rainforest Action Network, who pressure targeted firms to lower their emissions via sit-ins, product boycotts, or campaigns.[19] A good example of positive emotional activism is Greenhouse PR, which promotes green products—for example, via GRIDSERVE, a new UK-based network for electric-vehicle charging.

We take a reduced-form approach to situate private politics alongside public policy.[20] Suppose that disruption for a typical brown firm is proportional to the green-citizen share and pushes up its marginal cost to $\chi + \mu d(\lambda)$, where "disruption" $d(\lambda) > 0$ goes up in λ. Similarly, promotional activities for green firms cut their marginal cost to $\chi + \zeta - \mu a(\lambda)$, where "advertising" $a(\lambda)$ goes down in λ.

ii. Statics and Private Politics. Private activism directly cuts (raises) current profitability and production of brown (green) goods. However, it also affects politically optimal tax rates as follows:

PROPOSITION 8. *With electoral competition and private political activism, both parties choose taxes:*

$$T = (1 - \sigma)\lambda - \sigma(\chi + \mu d(\lambda)) \quad \textit{and} \quad t = -\sigma(\chi + \zeta - \mu a(\lambda)).$$

Private politics influences platforms via the marginal costs of firms. These effects are partially offset by tax policy. For example, negative activism lowers brown-goods taxes although this crowding out is less than one for one. Thus, the net social marginal cost of brown goods is higher with negative activism, namely, $\chi + \lambda + \mu d(\lambda)$. Likewise, the direct cut in green-goods marginal cost from positive activism is thus partially offset by a lower subsidy, but the end result is a lower net marginal cost. In either case, activism affects the relative welfare of green and brown consumers, inducing a higher (lower) overall price of brown (green) goods.

19. Bezin (2015) proposes a model of cultural evolution for environmental preferences based on private contributions to environmental protection.

20. To give our approach microfoundations the key feature would be that protest decisions are strategic substitutes, as in Barbera and Jackson (2020).

iii. Dynamics and Private Politics. Political activism also affects the dynamics (see Online Appendix B for details). As private action and policy depend on the green-citizen share μ, the consequences for marginal costs are similar to those with moral values in Section V.A. However, these consequences now reflect a mixture of private and public action.

We illustrate this in terms of the $\widehat{\delta}_0 + \widehat{\delta}_1\mu'$ curve defined in Section IV. Since $\widehat{\delta}_0$, defined in equation (24), and $\widehat{\delta}_1$, depend on μ'—via equilibrium taxes and the share of green citizens that interact with green and brown firms—the $\widehat{\delta}_0+\widehat{\delta}_1\mu'$ curve shifts over time. Specifically, the relative fitness of green values Δ'—and thus green-values growth—gradually shifts up (down) on a path where the green share is growing (shrinking).

We summarize the overall effect of private political activism:

COROLLARY 6. *Compared with electoral competition only, more forceful activism of either kind—higher values of $d(\lambda)$ and $a(\lambda)$—widens the range of initial green shares that induce a green transition. A higher value $d(\lambda) + a(\lambda)$ also shifts down the critical value $\hat{\mu}$ that ensures a green transition. If a green transition occurs, then the adjustment is more rapid with private politics. Moreover, if Condition 2 holds, then activism is welfare improving.*

One interesting implication of strong private activism is that it pushes green production to the technological limit. So even if equation (22) holds when policy is set as in Proposition 3, we could have a situation where $\gamma = \bar{\gamma}$ with activism. This would give the maximal boost to the green transition.

iv. Discussion. Private political activism introduces an additional feedback effect in the dynamics of the green share. A higher (expected) share of green consumers not only raises the relative (expected) profitability of green production via the market-share effect, but also via more support to green firms and more costly protests toward brown firms. This “private-politics multiplier” further speeds up the share of brown producers that go green and thereby the socialization of consumers. Thus, private activism—like green moral values—may help lower the welfare cost associated with a lack of policy commitment.

Corollary 6 also says that the disincentive to be a brown firm grows with the share of green citizens, μ. This is true even though the pollution externality is actually getting smaller as brown production falls.

V.C. Richer Economic Dynamics

This subsection explores richer intertemporal effects in the economy. We first let the costs for a green technology depend on the fraction of firms who adopt it. The dependence is negative if adoption is subject to crowding due to scarce capacity of key inputs. But it is positive if costs fall over time due to learning-by-doing. In this context, it is natural to consider the role of green-technology subsidies alongside Pigouvian taxes. Finally, we make the model more applicable to the climate problem by considering a stock externality, where the damages from pollution depend on cumulative past pollution rather than the current pollution flow.

1. *Variable Costs of Technology Adoption.* In the benchmark model, an exogenous parameter m governs the (average) costs of adopting green technologies. We now endogenize these costs.

i. General Dynamics of m. Assume that the common cost m follows the dynamic equation

$$m' = mH\left(\gamma', q'\right) - r, \tag{29}$$

where the function $H(\cdot)$ enters multiplicatively with the average investment cost m inherited from the past. It is assumed to have derivatives $H_\gamma(\gamma, q) \geqslant 0$ and $H_q(\gamma, q) \leqslant 0$, which capture—in a simple way—two important economic effects.

The positive partial with respect to γ captures a crowding effect. It could arise, for example, with limited capacity to produce inputs into green technologies. A good example would be scarce semiconductors that makes it increasingly costly to convert to producing battery-driven green products. All else equal, crowding discourages the adoption of green technologies and increases inertia in making a green transition.

The negative partial with respect to q' captures a learning-by-doing effect. Here, $q' = q + \gamma'$ where q is the cumulated share of firms that have adopted (and used) green technologies, up to period s. More experience lowers the cost of producing green inputs for use in production elsewhere. As in standard learning-by-doing models (Arrow 1962; Romer 1986), the lower cost is a spillover from aggregate adoption, which is external to the firm.[21] All else equal, learning-by-doing encourages switching to the green technology.[22] It is natural to assume that $H_{\gamma q}(\gamma, q) < 0$. In words, learning-by-doing reduces the crowding effect—over time, science finds ways of overcoming scarce inputs used in green technologies.

The specification in equation (29) also allows a flat (lump-sum) subsidy of r to those firms that turn from brown to green in the next period. The Green Deal recently announced by the EU is an example of offering grants to firms that switch to new cleaner technologies.

ii. Timing and the Share of Green Firms. The timing is essentially as stated in Section IV except that the technology subsidy r is proposed by the parties at stage (ii)(a), together with current taxes t and T. The subsidy is paid out at stage (iv), when firms choose their future technology, at future (expected) cost m'. Thus, the policy does not run into a credibility problem as it is both decided and paid out in period s. Analogous with the rebate of tax revenue, the costs are borne equally by all consumers.

Taxes remain at the levels in Proposition 3, as current γ is predetermined and current taxes do not affect future costs and benefits driving the future share of green firms γ'. As in Section IV, the best strategy for parties who cannot commit future policies is to take future outcomes as given and offer the living generation current taxes that maximize its average flow utility.

Following the same steps as in Sections III and IV, we can define the equilibrium future green-firm share as the value of γ' that solves

$$\gamma' H\left(\gamma', q'\right) = \sigma \frac{k'\left[1 + \mu' g\right] - K'\left[1 - \mu' g\right] + r}{m}. \tag{30}$$

21. An earlier version of this article (Besley and Persson 2022b) studies a more structural model, along the lines of Romer (1990). There, the technology adoption cost m goes down as a result of realized discoveries along a quality ladder (Grossman and Helpman 1991) by profit-maximizing firms in a separate sector with innovating firms that compete in a market for intermediate inputs in green firms (see also Bezin 2019).

22. The most important learning mechanism may not apply to the technologies for producing green consumption goods, but those for electricity generation from green inputs (like solar and wind). The costs of the latter have been falling exponentially at a high rate (see Samadi 2018 for a survey).

It is interesting to note that the right-hand side of equation (30) with $r = 0$ is the value of γ' in the benchmark model. A sufficient statistic for whether γ' is above or below this benchmark value with Proposition 3 policies is thus whether $H(\gamma', q') \gtrless 1$.

iii. Pure Economic Dynamics. For the moment, we abstract from subsidies and set $r = 0$. To see the pure effect of the dynamics in γ, consider a thought experiment where the green consumer share μ' is fixed.

Clearly, equation (30) implies economic dynamics even in this case. Consider a starting point where $q = \gamma$, such that $H(\gamma, q) = 1$. Now, whether γ' goes up over time or not depends on whether the crowding effect from increasing γ is stronger or weaker than the learning-by-doing effect. If total derivative $\frac{dH(\gamma,q)}{d\gamma} < 0$, then learning by doing puts the economy on a path with a rising green share γ', which is everywhere higher than in the benchmark model. That is, a transition toward green technology occurs even without any change in consumer values.

If instead $\frac{dH(\gamma,q)}{d\gamma} > 0$, then the green technology will be used less in the short run than in the benchmark model. By our assumption that $H_{\gamma q}(\gamma, q) < 0$, this crowding effect may, but need not, be reversed by learning-by-doing dynamics $q' = q + \gamma'$, as long as green technology adoption γ' is positive.

We now explore how these economic dynamics interact with the value dynamics that are the main focus of our article.

iv. Implications for Value Dynamics. The time path of μ' affects the economic dynamics through equation (30). On a path where $H(\gamma', q') < 1$, the value dynamics and the economic dynamics reinforce each other. If $\frac{dH(\gamma,q)}{d\gamma} < 0$, the values of μ' and γ' are thus both higher than in the benchmark model.

A more interesting case is when $\frac{dH(\gamma,q)}{d\gamma} > 0$. There can now be a tension between the economic dynamics and the value dynamics. Starting from a situation with a low anticipated share of green consumers μ', a negative crowding effect and a low market-share effect will feed on each other to lower expected green profits. This means that μ' will definitely be lower than in the benchmark case. With sufficient time, this could be "rescued" by falling costs of technology adoption if learning-by-doing is strong enough. To summarize:

COROLLARY 7. *If learning-by-doing is strong enough, economic dynamics in technology adoption increase the likelihood of a green transition in values and raise the speed of the green transition. But a dominant crowding effect will slow down any green transition.*

If the externality is strong enough that Condition 2 holds, then crowding in technology adoption implies a welfare loss, as the path of μ is below the path which would be seen without crowding.

v. Green Technology Subsidies. Our analysis suggests that it is important to consider the role that the adoption subsidy r can play. As shown in equation (30), it acts directly on the profitability of adopting the green technology and hence the share of firms that do so. The cost of introducing the green subsidy is $r\gamma'$ which is paid by the current generation (via a lower net tax rebate). But the subsidy raises future profits by the same amount, which accrues to the next generation. In the absence of discounting, the cost of the subsidy thus leaves aggregate (intertemporal) welfare unaffected. So the only immediate effect of a green subsidy is to raise γ' and hence μ' relative to the benchmark case (where taxes are set according to Proposition 3).

The following result gives the politically optimal subsidy:

PROPOSITION 9. *If Condition 2 holds, the optimal and equilibrium subsidy to the green technology is*

$$(31)\quad \hat{r}\left(\mu', q\right) = \frac{m\overline{\gamma} H\left(\bar{\gamma}, q+\bar{\gamma}\right)}{\sigma} - k'\left[1+\mu' g\right] + K'\left[1-\mu' g\right],$$

where k' and K' are defined by $\{t', T'\}$ in Proposition 3.

Condition 2 guarantees that welfare is higher with higher μ'. Since the subsidy raises γ' (and hence μ'), political parties find it optimal to use this instrument. This policy is a strategic way of increasing the welfare of future generations. Not only is it paid for by current taxpayers, it also reduces future exposure to pollution with higher production of green goods. It is optimal to set r at its highest possible level, given technology limit $\overline{\gamma}$, to generate not only minimal emissions but maximal green-value growth.

This subsidy is time dependent, but how it changes over time is ambiguous. The effect of changing values is to lower the subsidy, as the profit advantage of green goods increases with μ. Learning-by-doing also reduces the need for a subsidy, as the cost of going green falls. But in the short run, a higher subsidy may be needed to overcome any crowding effects. That is to say, the economic dynamics are important in shaping a green transition, because they influence the political equilibrium policy.

Note that Condition 2 can hold even if $\delta(\mu') < 0$. In such cases, the subsidy shifts the economy from a path where μ is declining to one where it is increasing. Thus, if Condition 2 holds, the equilibrium subsidy guarantees a green transition and eliminates any possible trap. Moreover, it also maximizes the speed of a green transmission by setting $\gamma' = \bar{\gamma}$. To summarize,

COROLLARY 8. *If Condition 2 holds, a subsidy to firms that install a green technology eliminates welfare traps. Moreover, the subsidy raises the future share of green firms and increases the speed of the green transition.*

We should point out that these conclusions are reversed if Condition 2 fails and we start at low μ where $\delta(\mu') < 0$. The reason is distributional. With a low fraction of green consumers at low γ, brown consumers are better off than green consumers. Then, the current generation actually finds a subsidy to the green technology welfare decreasing. Thus, a trap where a green transition does not take place remains a possibility when Condition 2 does not hold.[23]

2. *A Stock Externality.* For polluting greenhouse gases, like carbon dioxide, the benefits of emission cuts take time to materialize. This is because past emissions are (much) more important for damages than current flows. We extend our model to allow for this possibility.

i. Cumulative Emissions. To keep things simple, we use a so-called constant carbon-climate response formulation to write the stock of cumulative emissions up to period s as follows[24]:

$$\begin{aligned}\Lambda_s &= \upsilon \sum_{j=0}^{s} \delta^{s-j} \overline{Y}_{s-j} \\ &= \upsilon \sum_{j=0}^{s} \delta^{s-j} \left[(1-\gamma_{s-j})(1-\mu_{s-j} g) \kappa (T_{s-j})^{\frac{1}{1-\sigma}} \right]. \end{aligned} \tag{32}$$

23. With discounting, those currently alive would see more spending on a technology subsidy as a cost. Hence, policy makers may choose not to push the subsidy to the corner with $\gamma' = \bar{\gamma}$.

24. See Hassler and Krusell (2018) for a discussion of structural economic models of warming and carbon circulation.

In this expression, $\upsilon > 0$ captures the effect of total carbon dioxide emissions on global warming—often called climate sensitivity—and then on to damages. The exponential expression δ^{s-j}, with $\delta < 1$, captures the share of emissions j periods earlier that still remains in the atmosphere at s.[25] When writing the second equality in equation (32), we exploit the expression for aggregate equilibrium emissions $\overline{Y}$ from Section IV (the term in square brackets). Since $\delta < 1$, this specification allows for a gradual decay of greenhouse gas stocks when current emissions $\overline{Y}_s$ are low. But if emissions are high enough, the stock of greenhouse gases keeps growing, and so does the climate externality of pollution.

ii. Strategic Policy Response. In this formulation, λ is a state variable with a law of motion that we can write as

$$\lambda' = \lambda(\delta\Lambda + (1-\gamma)(1-\mu g)\kappa(T)^{\frac{1}{1-\sigma}}). \tag{33}$$

The model has two state variables, μ and λ, which evolve over time. As higher brown taxes reduce the stock of emissions, this opens the door for strategic policy making whereby current policy affects future payoffs. Policy is now represented by a pair of policy functions $t(\mu, \lambda)$ and $T(\mu, \lambda)$, which depend on the two state variables. Although a full analysis is beyond the scope of this article, we can compare the political equilibrium with Proposition 3. Forward-looking political parties can now propose a policy that does influence the future and which benefits current voters. Thus:

PROPOSITION 10. *With a stock externality, the politically optimal policy has $T(\mu, \lambda) > (1-\sigma)\lambda - \sigma\chi$ — that is, taxes on brown goods are higher than in Proposition 3.*

Proposition 10 uses the fact that higher T has a direct positive effect on future generations as lower current pollution reduces future pollution cost λ'. This benefits both green and brown consumers. This argument holds at any point in time.

COROLLARY 9. *Policy accelerates the green transition in values compared to Proposition 3. However, setting stricter policies may not translate into lower externalities over time (compared to the case with flow emissions), due to a race between declining flow emissions and rising stock emissions.*

25. Here, we would set $\delta^0 = 1$ (at least if time were measured in years).

Since the argument in Proposition 10 applies to taxes chosen in the future as well, T' too is higher than in the Proposition 3 benchmark. This raises the fitness of being green and the green-consumer share μ'. But in the near term, the higher taxes need not diminish the stock of pollution which could continue to worsen over time.

iii. Global Implications. Climate change may be a key example of a stock externality. But we have not yet delved into another key aspect of climate change, namely, its global reach. Implicitly, we have thus assumed a worldwide policy. To an important extent, national policy making when global emissions drive climate damages pushes us back toward a case where λ is exogenous for any given country.

In a more realistic setting, policy is set independently by countries $c = 1, 2, \ldots, C$ with world population shares $\alpha_1, \alpha_2, \ldots, \alpha_C$. Then, equation (32) would be replaced by

$$\Lambda_s = \upsilon \sum_{j=0}^{s} \delta^{s-j} \sum_{c=1}^{C} \overline{Y}_{s-j}^{c}, \tag{34}$$

so that lower emissions $\overline{Y}_s^c$ in a single country c have limited effects on global carbon stocks. Moreover, politicians in c would only internalize the externalities for a share α_c of the world population. A global externality would thus considerably weaken national incentives to set higher brown-goods taxes, at least for small countries. This would bring us into the study of international incentive-compatible climate agreements such as in Harstad (2012, 2016).

VI. Final Remarks

Standard analyses of environmental policy omit two important elements that affect the likelihood of a green transition. One is changing values, which shift the indifference map of consumers rather than make them adjust along fixed indifference curves. Such changing values are missing from most dynamic models, and we show how they can respond to economic, political, and moral forces. The second omitted element is incorporating political incentives, which means studying the policies set by governments that are unable to make future policy commitments.

Our results highlight how the standard static Coase theorem (Coase 1960) and the political Coase theorem (Acemoglu 2003) may fail. Under laissez-faire, polluters (or those subject to pollution) do not own the right to a clean environment. Moreover, though a green transition unambiguously raises welfare if λ is large enough, future consumers with green preferences do not have a say over current policy. These complicated economic and philosophical problems deserve further study.

Looking at political and market failures together offers a fresh perspective on how democratic politics may or may not help fix dynamic social problems. Even in our optimistic model of politics—where parties maximize average utility of those currently alive—equilibrium policy may not put society on the right path, and the speed of the green transition may be too slow. Policy activism outside politics may alter the speed and direction of change. In an analog to second-best theory, adding such an apparent political distortion may actually enhance welfare.

We can imagine many extensions of our framework, where evolving values rub off on other forms of behavior. Allowing for motivated scientists (see Besley and Persson forthcoming b) could speed up a green transition, by making green innovation relatively cheaper. In a richer model with meaningful investment decisions, one could compare value-driven "exit" (green investors selling shares of brown firms) with value-driven "voice" (green investors asking brown firms to change) along the lines of Broccardo, Hart, and Zingales (2022).

Our analysis does not allow for endogenous change in political organization (see Besley and Persson 2022a). Social movements, such as the Sierra Club or Greenpeace, have been important in environmental politics. In a setting like ours, such movements could raise the salience of environmental issues, with consequences similar to those in the extension with moral values. Green parties—seen in Europe since the 1970s—are also important. New green parties may tilt policies in a green direction if they build coalitions with traditional parties formed over right-left issues, thus overcoming tendencies to bundle green policies with standard economic issues.

Our extension to a stock externality in Section V takes a step to make our framework more suitable to study the climate challenge. However, as we remark there, a single country may have little sway on a truly global externality. Modeling multiple countries would let us study other (positive) spillovers: making new green technologies globally available. Furthermore, although it would be difficult to analyze, a multicountry model may shed new interesting light on the playout in climate policy of "double-edged diplomacy" (Putnam 1988; Evans et al. 1993), that is, the interplay between domestic politics and international negotiations.

This brings us back to the moral tension, discussed at the end of Section V.A, between helping poor polluting countries and speeding up green transitions. Future work could enrich our understanding of these issues. In particular, the international spread of green values might entail another set of positive international spillovers. A specific way to study this would be to see the reference point in green moral preferences as a candidate for a global moral standard.

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Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online.

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