Do the states try to trade off environmental quality tomorrow for jobs today?

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Abstract

The paper models and tests the hypothesis that a self-interested policymaker will pursue projects that create jobs now at the environmental expense of future generations. An optimal-control model shows that jurisdictions are most likely to pursue such a project when they are characterized by low income, high unemployment, politically powerful industry, pollution-intensive industry, poorly functioning land markets, or residents who are near the end of their lives. The paper tests the model with OLS specifications of subnational expenditures per capita in the U.S. for hazardous waste in the 1980s and for air pollution in the 1960s. The results reject the hypothesis that jurisdictions try to trade off future environmental quality for current manufacturing jobs. The results instead suggest a powerful relationship between housing values and environmental expenditures.

1 Introduction

In 1987, a United Nations commission headed by Gro Harlem Brundtland, prime minister of Norway, asserted that

> we borrow environmental capital from future generations with no intention or prospect of repaying....We act as we do because we can get away with it: Future generations do not vote; they have no political or financial power; they cannot challenge our decisions ([39], p. 8).

Here are the seeds of an influential idea that I call the “Brundtland hypothesis”: Societies overuse environmental assets, because they do not have to fear the retaliation of future generations. The hypothesis has become a rallying point of those who seek “sustainable” limits on resource use. Yet it is not obviously true. Land markets might discipline polluters by cutting property values by the present value of future pollution damages.[1] Through an overlap in generations, the young might discipline the old. Finally, an individual might care about his progeny though not about an entire future generation. Recognizing that other individuals are like him, he might contract with them to provide a public good to the future generation in order to protect the interests of his progeny.[2]

The Brundtland hypothesis needs empirical testing. Toward that end, this paper will develop a model that assumes that the Brundtland hypothesis is true. From that model, it will develop and test six implications.

The paper departs somewhat from the literature on environmental public choice. This literature has focused on short-lived pollutants, which generate economic benefits and environmental costs at the same time.[3]

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[1] Oates and Schwab discuss this argument in [18].

[2] This rationale might justify national policies to protect the interests of future generations. Such policies would differ from the “sustainability” paradigm because they would not try to coerce individuals alive today to act against their interests.

[3] I know of no published survey of economic papers that focuses on environmental decision-making by self-interested public officials. Yandle provides lively discussion of several themes in the literature [41].

As a utility burns coal to generate electricity, it generates jobs. It also generates an eyesore, a smoke plume, which normally dissipates quickly. Because short-lived pollution imposes benefits and costs at the same time, the policymaker has some incentive to try to manage it in a way that enhances efficiency, if spatial spillovers do not occur.

The paper will instead consider long-lived pollutants, which generate benefits now and costs later. For instance, production of nuclear weapons during the Cold War created thousands of jobs in rural regions, like eastern Washington. But production also created nuclear wastes that will remain radioactive for thousands of years. Did the lack of safeguards result partly from a perceived delay in environmental costs?[4]

The paper offers a stylized model of a policymaker's tradeoff between jobs and environmental quality. The policymaker is a careerist whose main goal is to stay in office.[5] She must balance the interests of two groups. One favors development; the other, the environment. By attracting industry to her jurisdiction, the policymaker creates jobs for now, but at the expense of creating future pollution.

The model particularly concerns jurisdictions with chronic unemployment and with many low-skill workers, since these are the jurisdictions that compete most keenly for polluting industry. Because the analysis focuses on the case in which unemployment is structural, it usually assumes that neither the wage nor migration clears the labor market.[6]

My aim in modeling is not to argue that myopic behavior occurs but to create tests of whether it occurs. Here are the intuitions behind the main implication that I will test: Suppose that a pollutant would linger in the environment for 30 years. Suppose that residents worry about their lives, not future lives; suppose that they do not concern themselves with any overlap in generations. Suppose that they expect to live only 10 more years. Suppose that they select, for time t, the rate of pollution emissions that is optimal for them. Then increasing their life expectancy by 20 more years – say, beyond time T – will lead them to decrease future levels of pollution (measured, for instance, as atmospheric concentrations) by decreasing the rate of emission at time t. For, when they expect to live longer, then they will worry more about the lingering effects of pollution emitted today, and they will wish to cut emissions.

Now suppose that residents worry as much about future lives as about their own. Then changing the expected length of the rest of their own lives will not affect the pollution level allowed. Since they act as if generations did not overlap, they mentally delay the start of the next generation by the addition to their own years; in effect, over the period from T to $T+20$, they substitute 20 years of their own lives for those of the next generation. Since they care no more about their own lives than about future lives, the substitution does not affect the way that they value emissions.

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[4] Another example: Lead has accumulated in soil near heavy metal smelters and near roads in countries (particularly Mexico) that have used lead-based gasoline [1]. Lead has also accumulated in the bones and tissue of small children, largely from vehicle exhaust and lead-based paint. Over time, the build-up of lead might cause mental retardation, blindness and chronic kidney disease [21]. The health costs of lead occur years after its economic benefits – the creation of jobs for painters, drivers and smelter workers, for instance.

[5] Wilson's survey suggests that ideology *may* influence policymakers – but career incentives almost certainly do [38].

[6] The model holds labor immobile with respect to variations in environmental standards. In reality, catastrophes spur migration. But over the time horizon T that will concern us, day-to-day decisions about environmental standards are more likely to influence the flow of capital than of labor.

Finally, suppose that residents do concern themselves with the overlap in generations. Then an increase in their life expectancy will lead them to decrease emissions at time t whether or not they value future lives as much as their own.

The paper follows this plan. Section II develops the model and extracts from it tests of the Brundtland hypothesis. Section III presents my tests on cross-sectional data in the United States. I cannot support the Brundtland hypothesis, but it embodies a large idea. I also cannot support the corollary hypothesis that jurisdictions try to trade off future environmental quality for current jobs. Section IV discusses the results and suggests a new orientation for research into environmental federalism.

Before detailing the model, I note three assumptions. The model concerns the decision of one jurisdiction; it holds fixed the decisions of all others. Agents know the future consequences of environmental decisions. All agents die at time T, succeeded by a new generation. These assumptions are in the spirit of the Brundtland hypothesis, and they sharpen results.

2 The model

All agents, including the policymaker, are born at time 0, when they begin working. They keep working until time T. They know that they will die at T, and they don't care what happens after they die.

Pollution creates "blue-collar" jobs only. Other jobs are "white-collar." Pollution afflicts all workers. A policymaker must reconcile the conflict between blue-collar jobs and environmental quality. He must court both groups of workers.

Each group is homogeneous. The subscript w denotes the white-collar group, with $N_w(t)$ workers at time t; the subscript b denotes the blue-collar group, with $N_b(t)$ workers. The employer pays each worker salary ${Y^0}_i(t)$, $i = b, w$. Not all blue-collar workers have jobs. Those not employed receive exogenous income, ${Y^1}_b(t)$.

There are $L_i(t)$ jobs in group i, where $L_i(t) \leq N_i(t)$ for all $t \in [0, T]$. In each group, the jobs are identical. All white-collar workers have jobs: $L_w(t) = N_w(t)$ for all $t \in [0, T]$.[7] Each blue-collar worker faces two states at time t, employment and unemployment. The respective probabilities of the states are

$$\frac{L_b(t)}{N_b(t)}, \ \frac{N_b(t) - L_b(t)}{N_b(t)}. \tag{1}$$

At time t, manufacturing generates a residual called pollution, $S(t)$. Pollution and labor are complementary inputs. If the policymaker wants firms to create more blue-collar jobs, he must let them produce – and pollute – more. The number of blue-collar jobs created at time t in his jurisdiction is given by

$$L_b(t) = f\left[S(t), Y_b(t)\right], \ 0 \leq L_b(t) \leq N_b(t), \tag{2}$$

and characterized by

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[7] To permit white-collar unemployment is to complicate the model, not enrich it.

$$\begin{aligned}\frac{\partial f}{\partial S} &> 0 \; S < S_0,\\ \frac{\partial f}{\partial S} &= 0 \; S = S_0,\\ \frac{\partial f}{\partial S} &< 0 \; S > S_0,\\ \frac{\partial^2 f}{\partial S^2} &< 0 \; \frac{\partial f}{\partial Y} < 0,\\ & S_0 > 0. \qquad (3)\end{aligned}$$

Emissions exceeding S_0 hinder workers so much that firms will eliminate jobs.

$S(t)$ is a flow, a change in the pollution stock, $P(t)$. $S > 0$ denotes emissions; $S < 0$ denotes cleanup. The pollution stock decays at rate $d(t)$, $0 \leq d \leq 1$:

$$\begin{aligned}\frac{\partial P}{\partial t} &= S(t) - d(t)P(t),\\ P(0) &= P_0 \geq 0. \qquad (4)\end{aligned}$$

Equating d to 1 gives the classical case of a pollutant that dissipates immediately. Equating d to 0 gives a pollutant that never dissipates. Iodine-129, a fission product of uranium 235, almost fills that bill; its half-life stretches into millions of years.[8]

All residents suffer from $P(t)$. Blue- and white-collar workers have utility functions V_i of the von Neumann-Morgenstern form, $i = b, w$:

$$V_i(t) = \frac{L_i(t)}{N_i(t)} U\left[{Y^0}_i(t), P(t)\right] + \frac{N_i(t) - L_i(t)}{N_i(t)} U\left[{Y^1}_i(t), P(t)\right], \qquad (5)$$

$$\frac{\partial U}{\partial Y} > 0 \; \frac{\partial^2 U}{\partial Y^2} < 0, \qquad (6)$$

$$\frac{\partial U}{\partial P} < 0 \; \frac{\partial^2 U}{\partial P^2} < 0, \qquad (7)$$

$$\frac{\partial^2 U}{\partial P \partial Y} < 0. \qquad (8)$$

Equation (8) reflects the observation that the rich value environmental quality more than the poor.[9]

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[8] See [8].

[9] See [5].

2.1 The policymaker's problem

The policymaker maximizes a weighted average of the welfare of constituents over his career. He might be a politician, who considers voter welfare to win elections. He might be a regulator, who considers constituent welfare to win promotions. I assume that a committee, containing conflicting interests, would make the same decision as a single leader who reconciles these interests. I posit that in a democracy with complete information, the number of decision-makers affects the time and resource costs of the decision; it does not affect the decision itself.[10]

This is a dialectic model of interest groups.[11] The policymaker weights the welfare of the blue- and white-collar groups in terms of their political power. The blue-collar group weight is αN_b; the white-collar group weight is $(1-\alpha)N_w$. Each group weight has two parts. One part reflects group size – N_b for the blue-collar group; N_w for the white-collar group. Were all other things equal, then the larger the group, the greater its political influence.

Not all other things are equal, however: The political influence of a group also depends upon the contribution of an average member to its efforts. By normalizing, I denote the level of a member's contribution as α in the blue-collar group and as $(1-\alpha)$ in the white-collar group. The level of a member's contribution depends inversely on group size. In large groups, the temptation to free ride is great.[12] Adding a member to either group will increase its political influence at a diminishing rate.

The policymaker projects the effects of policy only for the rest of the voter's (and policymaker's) life.[13]

The discount rate of the policymaker, $r(t)$, expresses the immediacy with which he makes his reputation. The policymaker's first decisions go far toward establishing him, in the minds of voters, as competent or not, an environmentalist or not. I assume that $r > 0$ for all $t \in [0,T]$. Where journalists are aggressive, voters' memories are likely to be long – and r large. "Current value" is the value that a variable would take if the policymaker made his reputation at that instant. "Present value" reflects the policymaker's history.

The policymaker seeks to maximize

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[10] Here's an example. Historically, the governor of Minnesota has been weak. The state has made key decisions through small advocacy agencies run by committee. Environmental decisions were made by a Pollution Control Board. Each of its nine members represented an interest group, such as farmers, industrialists and environmentalists [13]. I assume that one can model such committee decisions as if they were made by one person.

[11] See [6].

[12] See [19] and [22].

[13] A career might span several terms in office.

The supposition that the policymaker projects policy only up to time T is part of the Brundtland hypothesis. A skeptical reader might ask why voters would condone such decisions. Here are two reasons. The expected value of an election to a voter is small; his incentive to think carefully about electoral issues is meager. Even with complete and perfect information, thinking about the distant future is hard, because it requires one to synthesize much information. The voter will content himself with analysis of the rest of his life.

Second, some environmental costs will fall upon future generations, which do not engage the voter's sympathy as deeply as his own does. Empirical evidence for this view exists. Cropper et al. surveyed, by telephone, several thousand households in the United States. They found that Program A, undertaken 25 years from now, would have to save four times as many lives as Program B, undertaken today, before respondents would prefer A [10].

$$\int_0^T e^{-rt}\left[\alpha(t)N_b(t)V_b(t) + (1-\alpha(t))N_w(t)V_w(t)\right] dt \tag{9}$$

subject to (4) through (8). $P(t)$ is the state variable; $S(t)$ is the control. The current-value Hamiltonian is[14]

$$\begin{aligned} H(t) = \alpha(t)N_b(t)V_b(t) + (1-\alpha(t))N_w(t)V_w(t) \\ -m(t)\left[S(t) - d(t)P(t)\right]. \end{aligned} \tag{10}$$

The first line of (10) expresses the political benefits to the policymaker when he allows emissions at time t. Emissions create blue-collar jobs and – for the policymaker – blue-collar support. The second line subtracts the political cost of the increase in the pollution stock, which is incurred over the rest of the time horizon T. This cost is the shadow political price paid by the policymaker for each unit of the pollution stock (m) times the change in the stock ($\partial P/\partial t = S(t) - d(t)P(t)$).

The benefits are all of the moment; the costs are spread out over time, unless the pollutant decays instantly. In that case, $d(t) = 1$ and $P(t) = S(t)$ for all $t \in [0,T]$. The second line of (10) becomes zero. The problem becomes static. The problem is dynamic only if the pollutant is durable.

2.2 Conditions for optimality

To maximize (10), the policymaker's choice of $S(t)$ must satisfy, for every $t \in [0,T]$,

$$\alpha\frac{\partial L_b}{\partial S}\left[{U^0}_b - {U^1}_b\right] = m. \tag{11}$$

Here, ${U^0}_b$ is the utility of the blue-collar worker when he works; ${U^1}_b$ is his utility when he doesn't work. I will suppose the worker receives at least as much money when he works as when he does not. Thus ${Y^0}_b \geq {Y^1}_b$ and ${U^0}_b \geq {U^1}_b$.

From (3), the policymaker would gain nothing by choosing $S(t) > S_0$; that choice would decrease jobs and increase disutility from pollution. He must choose $S(t)$ to satisfy the condition $\partial L_b/\partial S \geq 0$. From (11), it follows that $m(t) \geq 0$.

The left-hand side of (11) gives the marginal benefit, to the policymaker, of allowing emissions. It's the net welfare gain to blue-collar workers of the added jobs, weighted by the political power of an average blue-collar worker. The right-hand side gives the marginal cost to the policymaker of adding to the pollution stock.

Suppose that the cost of one more unit of pollution stock exceeds the value to the policymaker of the jobs that it creates. Formally, suppose that

$$\alpha\frac{\partial L_b}{\partial S}\left[{U^0}_b - {U^1}_b\right] < m. \tag{12}$$

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[14] I assume that the objective functional is continuous in the control trajectory and that the subset containing the trajectory is compact. Thus I rule out the possibility of an infinite jump in pollution. These assumptions ensure that a solution exists [14].

Then he will set $S(t) \leq 0$, instigating a moratorium or a cleanup. This will boost $\partial L_b/\partial S$ until the equality in (11) again holds.

Optimality condition (11) suggests several factors that make this more likely. First, the average environmentalist is quite active (α is small); perhaps Vermont is an example.[15] Second, pollution generates few jobs ($\partial L_b/\partial S$ is small), so crackdowns are cheap. The shift of an economy from manufacturing to informational services helps environmentalists. Third, the net welfare gain of blue-collar employment to an individual is small. That scenario is the policymaker's dream: Blue- and white-collar interests alike support moratoria. Finally, (11) implies that the policymaker will allow higher levels of short-lived pollutants than of long-lived ones ($\partial S(t)/\partial d > 0$, $t < T$).[16] One cannot dismiss the Brundtland hypothesis solely by observing that governments control long-lived pollutants more strictly than short-lived ones.

The multiplier equation yields, for each $t \in [0,T]$,

$$\frac{\partial m}{\partial t} = (r-d)m + \left[\alpha\left(L_b \frac{\partial U^0{}_b}{\partial P} + [N_b - L_b]\frac{\partial U^1{}_b}{\partial P}\right) + (1-\alpha)N_w \frac{\partial U_w}{\partial P}\right]. \qquad (13)$$

I will show later that, under simplifying assumptions, $\partial m/\partial t < 0$ for all $t \in [0,T]$. The policymaker chooses an emissions path that reduces the political cost of pollution (in current value terms) over time. Here is the intuition: As the hourglass runs out for residents, the future effects of pollutants become increasingly irrelevant, so the marginal cost of pollution to the policymaker falls.

2.3 Carving out hypotheses to test

To derive implications for testing, I will characterize the path of $m(t)$ in a simple environment.

Definition 1 *A* **simple myopic state** *exists when*

(a) $\alpha, r, d, N_i, Y^j{}_b, Y^0{}_w$ *and* L_w *each is constant over* $[0,T]$, *where* $i \in \{b,w\}$ *and* $j \in \{0,1\}$*;*

(b) the parameter d *is small enough to ensure that, for all* $t \in [0,T]$, *no unit of the pollutant* $S(t)$ *fully decays by time* T*;*

(c) $Y^0{}_b > Y^1{}_b$*;*

(d) $\partial m/\partial t$ *is a continuous function over* $[0,T]$*;*

(e) the policymaker chooses $S(t), t \in [0,T]$, *to maximize (9).*

The restrictions will help me obtain the following theorems, which yield empirical tests. Restriction (b) is strong; Brundtland myopia might arise even if only one unit of $S(t)$, for some t, failed to decay by T. Control problems are complex, however, and their solutions often require parameter restrictions. Restriction (d) is stronger than the Maximum Principle requires but entails little loss in economic insight for the problem that I have in mind.

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[15] See [3].

[16] The appendix derives this result.

Theorem 1 *Consider any $t \in [0,T]$. In the simple myopic state, $\partial m/\partial t < 0$.*

The appendix shows that $\partial m/\partial t \neq 0$.

Lemma 1 *In the simple myopic state, either $\partial m/\partial t < 0$ for all $t \in [0,T]$, or $\partial m/\partial t > 0$ for all $t \in [0,T]$.*

Proof of Lemma 1. To conserve notation, denote $\partial m/\partial t$ as n. By Definition 1(d), n is a continuous function, so the Intermediate-Value Theorem applies. Suppose $n(0) < 0$ and $n(T) > 0$. Then there is a $t \in (0,T)$ such that $n(t) = 0$. But that contradicts Proposition 1 in the appendix. A similar argument applies when $n(0) > 0$ and $n(T) < 0$. It follows that $n(0)$ and $n(T)$ have the same sign.

Consider any subset $[t_1,t_2]$ of $[0,T]$. We have that $n : [0,T] \to \Re^1$ is a continuous function. So $n : [t_1,t_2] \to \Re^1$ is also a continuous function. From the argument in the preceding paragraph, it follows that $n(t_1)$ and $n(t_2)$ have the same sign.

Proof of Theorem 1. Suppose that $n > 0$ in the neighborhood of T. By the transversality condition, $m(T) = 0$. So $m(T-\varepsilon) < 0$, where ε is positive but arbitrarily small. But by (11), no $m(t) < 0$ in the simple myopic state. So it is not true that $n > 0$. Then, by Lemma 1, $n < 0$ in the neighborhood of T. By induction, $n < 0$ for all $t \in [0,T]$.

Theorem 2 *In the simple myopic state, either $\partial S(t)/\partial t > 0$ or $S(t) > dP(t)$ for any given $t \in [0,T]$.*

Proof. Theorem 1 and (11) together imply that either ${U^0}_b - {U^1}_b$ or $\partial L_b/\partial S$ diminishes over time. Suppose that $\partial L_b/\partial S$ diminishes over time. Then, by (3), $S(t)$ must rise over time. Suppose that ${U^0}_b - {U^1}_b$ diminishes over time. Then $P(t)$ must rise over time.[17] So $S(t) > dP(t)$.

Theorem 2 says either emissions or the pollution stock increases over time.

Theorem 3 *Let $\alpha > 0$ and $S(T) > 0$ in the simple myopic state. Then $S(T)$ is the unique maximum of $S(t), t \in [0,T]$.*

Proof. I will show that $S(T)$ is a maximum of $S(t)$. Then I will show that $S(T)$ is the only maximum of $S(t)$.

The transversality condition is $m(T) = 0$. Using the optimality condition in (11), this implies that if $S(T) > 0$, then at T,

$$\alpha \left[{U^0}_b - {U^1}_b\right] \frac{\partial L_b}{\partial S} = 0. \tag{14}$$

This implies that

$$\frac{\partial L_b}{\partial S} = 0 \text{ or } \alpha = 0. \tag{15}$$

By (2) and (3), $\partial L_b/\partial S = 0$ at T implies that $S(T)$ is a maximum of $S(t)$.

Now I will show that $S(T)$ is the only maximum of $S(t)$. The proof proceeds by contradiction. Suppose that $t^* < T$ exists such that $S(t^*) = S(T)$. Then, by (3),

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[17] Recall that ${Y^0}_1$ and ${Y^1}_b$ are fixed over time. Also recall that $\partial^2 U/\partial P \partial Y < 0$.

$\partial L_b/\partial S = 0$ at t^*. From (11), $m(t^*) = 0$. From (13), $\partial m/\partial t < 0$ at t^*. Then $t^{**} \in (t^*, T]$ exists such that $m(t^{**}) < 0$. But if $t^{**} = T$, the transversality condition cannot hold. So t^{**} is in (t^*, T). But by (11), $m(t)$ is not negative for any $t \in (t^*, T)$. Thus $\partial L_b/\partial S$ cannot equal zero for any $t < T$.

Theorem 3 means this: Unless the policymaker ignores blue-collar workers ($\alpha = 0$), he will find it optimal, at the end of his career, to invite all factories that create jobs, regardless of future environmental consequences. The result holds even if he cares a lot more about the environmentalists than about the workers ($0 < \ \ll .5$). Moreover, the policymaker will find it optimal only at the end of his career to invite all factories that create jobs. These results obtain because, at time T, selfish residents are ending their lives and have no reason to fear pollution that outlives them.

Theorem 4 *In the simple myopic state,* $\partial S(t;T)/\partial T < 0$ *at* $t = T$.

Proof. By (3) and Theorem 3, $S(T) = S_0$. Push T further into the future, from t to $t + \Delta t$. Now t is no longer the endpoint; so by Theorem 3, $S(t) < S_0 = S(t + \Delta t)$. More generally,

$$\frac{\Delta S(T)}{\Delta T} \equiv \frac{S(t; T = t + \Delta t) - S(t; T = t)}{\Delta t} < 0. \tag{16}$$

I will summarize the theorems. In the simple myopic state, the policymaker lets either emissions or the pollution stock rise over time, because the marginal cost to him of doing so falls. This cost falls because a growing share of the environmental damages shift beyond time T, onto future generations. Emissions peak at time T, when residents bear the consequences only for an instant. Postponing T will cause emissions at the old terminal date to fall.

If the model holds, then time-series analysis of a long-lived pollutant, which controlled for the exogenous variables listed in Definition 1(a), would find that the level of emissions correlated positively with time. Indeed, in the simple myopic state, a succession of generations will generate a path of increasing pollution much like the one predicted by the Club of Rome model.[18] For testing the Brundtland hypothesis, data is more abundant in cross-section than in time series. Theorem 4 suggests a cross-section test: At a given moment, jurisdictions with a long time horizon remaining will control long-lived emissions more strictly than jurisdictions with a short time horizon remaining. Section 3 discusses this test.[19]

2.3.1 Salvage value

Additional tests emerge from analysis of how the policymaker would behave if his constituents compelled him to weigh the future consequences of his actions. Denote the value of these consequences as

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[18] See [16]. The paths of the two models differ in one way: The Club of Rome model assumes that high rates of emission will eventually affect life expectancy. In my model, T is exogenous.

[19] Here's a related inference that one can test: Suppose that older policymakers come from older populations and that younger policymakers come from younger populations. Then older policymakers will support economic growth; younger policymakers will support pollution control.

$$V[P(T)], \frac{\partial V}{\partial P} < 0. \tag{17}$$

V might represent the value of land that owners would sell at time T to a new generation; they would instantly convert V to consumption before dying.

Attach the salvage value V to the original optimization problem in (9). Now the transversality condition implies that, at time T,

$$\frac{\partial L_b}{\partial S} = \frac{-\frac{\partial V}{\partial P}}{\alpha(T)[U^0{}_b - U^1{}_b]}. \tag{18}$$

The policymaker limits industrial recruitment severely if it would affect future generations severely ($-\partial V/\partial P$ is large); if he cares little about blue-collar workers (α is small); or if employment means little to blue-collar workers ($U^0{}_b - U^1{}_b$ is small).

Suppose that an intergenerational transfer mechanism – such as a land market – does not discipline Brundtland behavior. Then, from (14), the severity of the pollutant will not affect the jurisdiction's pollution control policy at time T as long as the value of S_0 itself does not change. An empirical implication is that, for jurisdictions near the end of their time horizon, undisciplined Brundtland behavior implies zero correlation between the marginal severity of the pollutant and the level of pollution control. One will observe a positive correlation if Brundtland behavior is disciplined or absent.

3 Empirical tests

3.1 Specifying the equation to estimate

The optimality condition (11) is satisfied by a control function of the form

$$S^*(t) = f\left[Y^0{}_b, Y^1{}_b, r, d, N_b, N_w, Y_w, T, P_0; E\right], t \in [0, T]. \tag{19}$$

E is a vector of exogenous variables. I seek a reduced form of (19) for estimation, using cross-state samples.

Compared to the pollution level, a more direct measure of the intensity of a state's effort toward pollution control is its level of expenditures on pollution control. I will model this variable, $SPEND(t)$, as a decreasing monotonic transformation of $S^*(t)$:

$$SPEND(t) = g[d, r, N_b, N_w, Y_w, Y^0{}_b, Y^1{}_b, T, P_0; E], \tag{20}$$

$$sgn\left[\frac{\partial g}{\partial x_i}\right] = -sgn\left[\frac{\partial f}{\partial x_i}\right]. \tag{21}$$

The cross-section tests use the same pollutant for all observations, so d becomes a constant. One can manipulate the first-order approximation of (20) into OLS form. I also express variables in per-capita terms where appropriate – for instance, $Spend = SPEND/(N_b + N_w)$. I obtain

$$\begin{aligned} Spend = constant + f_1\frac{N_b}{N_b+N_w} + f_2{Y^0}_b \\ + f_3{Y^1}_b + f_4\frac{L_b}{N_b+N_w} + f_5 r \\ + f_6\frac{N_w}{N_b+N_w} + f_7 Y_w + f_8 T + f_9 P_0 + \sum f_i E_i + \varepsilon. \end{aligned} \tag{22}$$

The disturbance term captures errors due to excluding higher-order terms or variables affecting $Spend$ from (22).

To reduce multicollinearity, I drop $N_w/(N_b+N_w)$ as an independent variable; and I substitute per-capita income, Y, for ${Y^0}_b, {Y^1}_b$ and Y_w. Lacking a satisfactory proxy, I omit r. Finally, for ease of interpretation, I substitute the blue-collar unemployment rate, $N_b - L_b)/N_b$, for L_b/N_b. I obtain

$$Spend = \overline{Spend} + g_1\frac{N_b}{N_b+N_w} + g_2 Y + g_3 T + g_4 P_0 + g_5\frac{N_b - L_b}{N_b} + \sum_6^n g_i E_{7-i} + \varepsilon. \tag{23}$$

3.2 Six hypotheses to test

Of the model's empirical implications, I picked six for testing – in part because they presented the least formidable data problems; and in part because they illustrated most clearly the larger hypotheses of political tradeoff and generational selfishness.

The first four implications come out of the optimality condition (11). Of these four, the first two arise from the assumption that public officials make a political tradeoff between jobs and environmental quality; the other two arise from traditional assumptions about household demand for environmental quality. The fifth hypothesis comes out of Theorem 4; it arises from the assumption that residents don't care what happens after they die. The sixth hypothesis comes out of the transversality condition; it arises from the assumption that land markets can discipline environmental decisions.

Hypothesis 1: States where blue-collar interests are politically powerful will allow higher emissions (spend less to control emissions) than states where these interests are less powerful. Null hypothesis: $\partial Spend/\partial N_b \geq 0$. Alternative hypothesis: $\partial Spend/\partial N_b < 0$. Level of significance: .05.[20]

Hypothesis 2: States where the unemployment rate in blue-collar industries is high will allow higher emissions (spend less to control emissions) than states where this unemployment rate is low. Null hypothesis: $\partial Spend/\partial(1 - L_b/N_b) \geq 0$. Alternative hypothesis: $\partial Spend/\partial(1 - L_b/N_b) < 0$. Level of significance: .05.

Hypothesis 3: States where income is low will allow higher emissions (spend less to control emissions) than states where income is high. Null hypothesis: $\partial Spend/\partial Y \leq 0$. Alternative hypothesis: $\partial Spend/\partial Y > 0$. Level of significance: .05.

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[20] The choice of the level of significance is subjective. Here is my criterion: The alternative hypothesis must satisfy the level of significance that I specify before I will recommend that policymakers act upon the assumption that the hypothesis is true. (I regard the condition as necessary, not sufficient, for policy changes.) The alternative hypothesis need not satisfy the level of significance to justify more research of it.

Hypothesis 4: States that have low initial levels of pollution will allow higher emissions (spend less to control emissions) than states that have high initial levels of pollution. Null hypothesis: $\partial Spend/\partial P_0 \leq 0$. Alternative hypothesis: $\partial Spend/\partial P_0 > 0$. Level of significance: .05.

Hypothesis 5: Consider states that have a short time horizon remaining. They will allow a higher level of long-lived emissions (spend less to control long-lived emissions) than states that have a long time horizon remaining. The time horizon is the remaining number of years in the life of a resident. Null hypothesis: $\partial Spend/\partial T \leq 0$. Alternative hypothesis: $\partial Spend/\partial T > 0$. In both hypotheses, d satisfies $0 \leq d < 1$.[21]

For Hypothesis 5, I set the level of significance higher than usual, at .10, to reduce the chance of a Type II error. Acceptance of the null hypothesis when it is false favors me at the expense of future generations. To maintain my impartiality as an observer, I should instead permit a large probability of type I error. Hypothesis 5 is the main test of the Brundtland hypothesis.

In a cross-section test of Hypothesis 5, one must somehow control for the starting points of all jurisdictions. Otherwise, the relative lengths of life that remain at a given time of observation might not correspond to the relative time horizons that remain. My resolution of this problem is to suppose that all jurisdictions respond at the same time to an exogenous event – the 1986 passage of the Superfund Amendments and Reauthorization Act, which called for more state involvement in hazardous waste control.[22] By fiscal 1990, all states but Nebraska had set up cleanup programs. I choose fiscal 1988 as the year of observation in order to allow the states two years of "planning time." In effect, this is the period before time 0, in which agents solve the optimal control problem.

Hypothesis 6: Near terminal time T, states with low property values will allow higher emissions (spend less to control emissions) than states with high property values. Null hypothesis: $\partial Spend/\partial V \leq 0$. Alternative hypothesis: $\partial Spend/\partial V > 0$. Level of significance: .05.

I infer this hypothesis from (18), in which the level of pollution relates negatively to the marginal severity of the pollution for all future generations. This marginal severity cannot be observed directly; I assume that it would be reflected in the property values of jurisdictions, particularly those with residents who are close to the ends of their lives.

Here is my strategy. I hold constant the pollution level $P(T)$ and consider the family of functions V_i, where i indexes the jurisdiction. I assume that where $V_i(T)$ is large, so is $-\partial V_i(T)/\partial P$. The intuition is that if another unit of pollution will wreak the same physical damage in two jurisdictions, then the value of the damages will be greater in the jurisdiction where the value of property is greater.

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[21] From Theorem 4, the hypothesis is based on a difference quotient, $\Delta S(t;T)/\Delta T$, which is negative for an arbitrary change in T. In the cross-section sample, I will fix t and let T vary over jurisdictions.

[22] See [34].

3.3 Data

3.3.1 Endogenous variables

The proxy for $Spend$ is state expenditure per capita to control hazardous waste in fiscal 1988.[23] Hazardous waste seems a pollutant that might affect future generations.[24]

The state data available did not distinguish between expenditures to control existing sites and those to control abandoned sites. But even expenditures to control abandoned sites might entail, in principle, some reduction in jobs. Most "voluntary" cleanups and consent agreements hinge on the state's willingness to draw down its superfund for remediation now and to recover costs from the polluter later.[25] By spending little out of its superfund, the state signaled manufacturers that it would not impose high monitoring and enforcement costs upon them. In addition, low spending on permitting slowed processing and approval. That could have helped polluters: Enforcers preferred going into court with a violation of a permit than with a violation of general regulations.[26] Finally, the abandoned sites entailed pollutants that might have affected future generations. In 1991, more than half of the sites on the National Priorities List (NPL) contained metals, solvents or organic chemicals.[27]

Estimating the initial pollutant stock, P_0, might pose a simultaneity problem. A reasonable proxy for P_0 is the number of hazardous waste sites in each state. The states estimated, however, that for every site known, three were suspected.[28] Evidently, state programs with a lot of money might have uncovered more hazardous waste sites than state programs with less money. To reduce simultaneity, I use the number of hazardous waste sites in a state that are federal facilities on the 1989 National Priorities List (*FedSites*).[29] Since these sites were better known *a priori* than small, private sites, the number of them that were identified in a state was less likely to vary with program expenditures.[30]

Representing blue-collar political power is manufacturing's percentage of all jobs in 1989 (*ManSh*). Representing blue-collar unemployment is the average unemployment rate in manufacturing from 1986 through 1988 ($Unem8688$). I focus on manufacturing, because it generated most hazardous waste that governments regulated. Where unemployment in manufacturing was high, a policymaker might have tried to conserve jobs by reducing monitoring and enforcement at manufacturing sites that generate haz-

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[23] Readers may obtain datasets by sending me a 3.5" microfloppy and stating their preference among the formats of major DOS or Windows spreadsheets; or readers may obtain the datasets in ascii format from me by electronic mail.

[24] While sketchy, research on the health effects of hazardous wastes sites indicates that most sites pose very small risks to life [11]. So I have not estimated simultaneous equations for hazardous waste expenditures and for average life expectancy.

[25] See [34].

[26] See [36], p. 32.

[27] See [9].

[28] See [34].

[29] A site had to place on the List to qualify for Superfund cleanup. For a site to place, EPA had to determine that the site significantly threatened public health; and the U.S. Agency for Toxic Substances and Disease Registry had to recommend site evacuation [28]. State and federal agencies nominated sites for the List.

[30] This variable might also capture the fiscal effects of interjurisdictional agreements between the state and federal agencies, such as the defense and energy departments, that operated hazardous waste sites.

ardous waste.[31]

Representing V is the top value of the lowest quartile of owner-occupied houses in each state in 1990 (*House*). I use this value, rather than the median value of all owner-occupied housing, since low-income housing was the type most likely to skirt hazardous waste sites.[32]

3.3.2 Exogenous variables

I turn to exogenous influences. The model assumes that all residents are in the labor force. To control for the number of residents outside of the labor force and for overlap in generations, I introduce as an independent variable the share of the population that received Social Security benefits in 1988 (*Retired*). I expect a positive coefficient.

The model also assumes no federal role. By law, federal policy had to allow the states "substantial" latitude in designing programs for hazardous waste.[33] Almost all states funded and ran their own superfunds. Even so, the federal government provided more than 28 percent of the money spent by states to control hazardous waste. I subtracted the estimated federal Superfund contribution from the expenditures of each state.[34]

Federal aid might also have affected state spending indirectly. When the state acted as the lead agency in a site response, it had several incentives to substitute federal dollars for its own. First, the state had responsibility for non-NPL sites but could share costs with the federal government for NPL sites. That might have influenced the rigor with which the state inspected the site for potential inclusion on the NPL.

The state also paid only 10 percent of cleanup costs until the NPL site remedy became "operational and functional"; then it paid all operating and maintenance costs.[35] The definition of "operational and functional" was elastic. If the remedy called for restoration of ground- or surface water, then it might legally have taken 10 years to become "operational and functional." This might have influenced state design of the remedy.[36]

The control for these indirect effects is the federal Superfund contribution to the state, in dollars per capita, as an independent variable (*FedSh*). Given the ubiquity of the flypaper effect, I expect a positive coefficient.

The model assumes that the jurisdiction might provide for future generations only by improving environmental quality. The proxy for expenditures upon other programs with long-run benefits is the level of state-source revenues per capita on primary and secondary education in 1988. I expect a negative coefficient.[37]

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[31] About 95 percent of the hazardous waste generated remains on site [11].

[32] About 80 percent of all Superfund sites were within one mile of residential areas [9].

[33] See [33].

[34] As for local programs, the state expenditures reflect only that part of the local effort that passed through the state budget.

[35] See [34].

[36] A question for research: Did the incentive for states to pursue permanent remedies, rather than temporary removals, contribute to the ballooning costs of Superfund?

[37] I neither model nor empirically control for an absolute budget constraint, because total environmental expenditures comprise a modest share of the state budget – 1.6 percent for the median state, Maryland, in fiscal 1988 (Brown et al. 1990).

The resident's disutility from hazardous wastes depends partly on his perception of the threat that they pose. This, in turn, might depend upon the spatial frequency of toxins. My proxy for this frequency is the number of pounds of toxins released to surface land in 1987, expressed per square mile of land (*LToxMile*). I choose 1987 to avoid the possibility that state spending on hazardous waste might have affected the level of toxins. I expect a positive coefficient.

Waste sites often occur in out-of-the-way places. They might be harder to find in large rural states than in small urban states. The proxy for this monitoring difficulty is the number of square miles of land per capita (*Miles*). I expect a positive coefficient.

3.4 Tests of reduced equations

The adjusted R^2 for the hazardous waste models is about .50 (Models 1-4 in Table 1; [2]). The F-tests also suggest the merit of the linear specification. The multicollinearity in Model 1 is significant, however. Model 2 nearly halves the multicollinearity, as measured by Theil's effect, by dropping the *Income* variable.[38] Model 3 reduces multicollinearity to modest amounts by dropping three variables from Model 2. Inspection of these three models suggests that multicollinearity does not affect most of the basic results of the tests. The *Years* coefficient changes sign but the estimates are imprecise.[39] At any rate, in any of the models, the *Years* coefficient reflects a relatively small effect on hazardous waste spending, judging from the beta values.

Beta values also suggest that state expenditures on hazardous waste relate most strongly to housing values. There are three reasons for thinking that the relationship does not simply reflect the contribution of the property tax to state revenues. The variable *House* is the top value of the lowest quartile of single-family homes occupied by the owner – a class of housing that often qualifies for exemption from property taxation. State governments do not rely on the property tax as heavily as do local governments. They rely more on personal income taxes; but we will see that income has a relatively modest effect on hazardous waste spending. Finally, the elasticity of state spending on hazardous waste with respect to the house value is not less than 1.[40] Across the specifications, an increase of $10,000 in the respondent's estimate of the value of a low-income house is associated with an increase of about $.20 per capita in state spending on hazardous waste. Evaluated at the means, the point elasticity of state spending with respect to housing value is about 1.07. The housing market might provide a powerful mechanism for intergenerational transfers.

The *Income* coefficient is positive (as expected) but imprecisely estimated; at any rate, its beta value suggests that it has only a small effect upon hazardous waste spending (Model 1). Perhaps affluent households support environmental quality because they seek to protect the value of their property, not because affluence has increased the amount that they would spend on environmental quality.

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[38] See [23].

[39] Standard errors of coefficients are corrected for heteroskedasticity, using White's method.

[40] The specifications treat house value as an independent variable. Many studies suggest that land values reflect the value of such amenities as environmental quality. But as the modest amount of multicollinearity in Model 3 (Table 1) suggests, a two-stage least squares estimation is not appropriate here.

Hypothesis 6 particularly applies to jurisdictions near their terminal times. Models 7 and 8 restrict the sample to jurisdictions with the lowest values of $Years$. The $House$ coefficient is positive in both models; it reflects a relatively large effect on hazardous waste spending, to judge from beta values; and it differs from zero in a sense that is statistically significant in both models at the .10 level of significance or better. Evaluated at the means, the point elasticity of state spending on hazardous waste with respect to housing value is 1.3 when one controls for income (Model 7, Table 2).

When controlling for the transfer mechanism of housing markets, test results suggest that the Brundtland effect is small. In most specifications that include $Years$, states where residents can expect to live many years spend more on cleanup than states where residents can expect to live fewer years. That is what Hypothesis 5 predicts. But the effect is substantial only in the full model of jurisdictions closest to their terminal dates (Model 7, Table 2). Moreover, the substitution of educational for hazardous waste spending, in per capita terms, is trivial (Model 4, Table 1). An interpretation consistent with these results is that states seek to control hazardous wastes more to protect property values than to protect the interests of future generations. Of course, pursuit of the first goal might, as a by-product, secure the second.

Test results contradict the hypothesis that policymakers relax their environmental demands in order to create manufacturing jobs. The unemployment and jobs coefficients ($Unem8688$ and $ManSh$) relate positively to spending in all specifications. In several, the t-statistics well exceed 1. This may partly reflects attempts by policymakers to create cleanup jobs to substitute for lost manufacturing jobs.

Two other interpretations are consistent with these results. Perhaps state policymakers make their careers by pursuing highly visible but weak prey. A state with a large and troubled manufacturing sector would have high values for $ManSh$ and $Unem8688$, implying a high value for $Spend$. Or perhaps state environmental officials effectively manage a cartel of manufacturers. When the local manufacturing sector is large and troubled, state officials might try to protect it from competition by stiffening regulatory barriers to entry.

All of the hazardous waste models suggest that an increase in federal aid leads to a net gain in state environmental spending (the "flypaper effect"). Evaluated at the means, the point elasticity of net state spending with respect to federal Superfund aid is .19 in Model 1. Federal aid operates with particular power upon jurisdictions nearest their terminal dates, however. A dollar of Superfund aid is associated with a net increase of $1.11 in net state spending (Model 7, Table 2). Across all models, the standard estimates of the coefficients suggest that federal aid has almost the same impact on state environmental spending as the presence of nonworkers ($Retired$) – and less impact than house values ($House$).

The results are consistent with this informal story: In hazardous waste policy, the states are influenced by property owners, nonworkers and federal incentives, in that order. The states might also try to protect manufacturers from competition, but the effect is small and uncertain. The states seem more concerned with this generation than with future ones, but land markets and federal aid can offset the effects of present-oriented behavior. Indeed, the response to federal stimulus is strongest for those states nearest their terminal dates; the Brundtland hypothesis suggests that these are the states that would act with the least regard for the future.

3.4.1 Study of early 1960s

Federal policy might affect state policies in ways that the hazardous waste models do not control. As a check against this possibility, I studied state and local expenditures in 1963, when the federal role in environmental policy was minuscule. Data are scant for the early 1960s on hazardous waste expenditures. I instead use state and local expenditures on air pollution control per 1000 residents ($AllSpend$).[41]

The variable *Air* controls for the initial level of pollution. It gives the geometric mean of the concentration of particulates from 1957 through 1961. *ManSh* proxies for blue- collar political power. This is the percentage of nonagricultural jobs that were in manufacturing in 1961. $Unem60$ gives the unemployment rate for the civilian labor force in 1960.[42]

$House$ gives the median value of an owner-occupied, single-family house in 1960. I prefer the median to the lowest-quartile value since air pollution diffuses more rapidly than does hazardous waste through its most common medium of groundwater contamination.

Despite differences in time periods, policy environments and independent variables, the air pollution models 5 and 9 (Table 2) conform to the pattern of the hazardous waste models. The F-tests, though, suggest that the basic model might not outperform a constant function. In the simpler, sturdier models 6 and 10, an increase in house values is associated with a growing increase in pollution expenditures, given the historic level of air pollution.

4 Conclusions and reflections

Ehrenhalt argues that the rise of the professional politician in the United States led to short-sighted policy; the careerist cannot see beyond his own career [12]. This paper tested a model of the argument in the environmental arena. To stay in office, the politician must do the voters' bidding. If voters fail to look beyond their own lives, then a population that expected to live only a little longer would spend less to control persistent pollutants than a population that expected to live much longer.

I do not find persuasive evidence of this relationship in studies of state expenditures on hazardous waste in the 1980s and on air pollution in the 1960s. Instead, I find a relationship between housing values and public expenditures on pollution control that is positive, statistically significant and relatively strong. I infer from the relationship that land markets might be able to discipline the temptation of current generations to shift environmental damages onto future generations.[43]

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[41] The localities spent more than twice as much on air pollution control as the states in 1963, so I summed state and local expenditures.

[42] Reliable estimates of state unemployment rates by industrial sector for the early 1960s were not available to me.

[43] To me, the empirical work suggests that land markets might discipline intertemporal externalities, regardless of the direction of causality between pollution control and property values. States with high housing values might seek to protect valuable property by spending a lot to control pollution; or pollution control expenditures might raise property values by increasing the expected value of environmental services. In either case, the property owner has an incentive to take into account future environmental damages.

Even when controlling for housing values, I do not find evidence that Brundtland behavior matters much. The relationship between spending and length of remaining life is usually positive but weak.[44]

A jurisdiction where the average resident can expect to live many years spends more on pollution control than other jurisdictions. Brundtland behavior might occur in areas where land markets do not work well, but its impact on state policy seems small.

The empirical results raise questions about the pervasiveness of an "environmental war between the states." The case for national environmental standards rests partly on the fear that the states, left to their own devices, will vie for industry by relaxing environmental regulations. I do not find persuasive evidence that the states have tried systematically to trade off environmental quality for jobs.[45]

Perhaps the average state doesn't use environmental regulations to compete for jobs, because it senses that the effort would be futile. Econometric studies by McConnell and Schwab as well as by Bartik find little evidence that subnational variations in environmental regulations strongly affect the locational decisions of firms in the United States.[46]

I find evidence that federal aid strongly affects state policy on hazardous waste. The results suggest a need to go beyond the model of horizontal competition that shaped much of the theory of environmental federalism and to explore a vertical model of the federal government and the states.

Finally, I infer from the empirical results that perhaps intragenerational equity is a more pressing issue for research than intergenerational equity. States with low housing values – impoverished states – spend less on pollution control than wealthy states. The apparent influence of federal aid suggests that it might be able to redress some inequity in subnational expenditures on pollution control.

Questions remain. To what extent do housing values affect environmental expendi-

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[44] An international test will also be desirable, partly because it will introduce more variation into the Years variable. For the 50-state samples, the ratio of the standard deviation to the mean is .05 for the 1980s data and .046 for the 1960s data.

In addition, my test for Brundtland myopia is indirect. My estimations approximate a necessary condition of Brundtland myopia, as presented by the model. I assume the prerequisites for sufficiency – most critically, the nonconvexity of the relevant segment of the labor demand function, as policymakers perceive it.

[45] Yandle [40] as well as Quinn and Yandle [20] find a negative and significant relationship between subnational expenditures on environmental regulation and the number of workers in polluting industries. They view this relationship as evidence that jurisdictions try to trade off environmental quality for jobs. I posit that if public officials sense a tradeoff between environmental expenditures and jobs, then they will be most sensitive to that tradeoff where the unemployment rate is high. One will observe a negative relationship between expenditures and the unemployment rate in pollution-intensive industries, ceteris paribus.

[46] Bartik estimates a conditional logit model, at the state level, for new manufacturing plants opened by the Fortune 500 companies between 1972 and 1978. He infers that tightening environmental regulations is unlikely to have a large effect on the location decisions of the average industry [4]. McConnell and Schwab estimate a conditional logit model, at the county level, for firms in the motor vehicles industry during the 1970s. From most results, they inferred that environmental regulations did not systematically affect location decisions. But they found some evidence that the marginal firm might avoid cities with the highest levels of ozone [15].

I might inject a speculative note. Consider the industries for which pollution control costs comprised large shares of expenditures on new plant and equipment in 1987: electric utilities (7.1 percent); stone, clay and glass (5.3); chemicals (5.2) and paper (5.0) ([24], Table 20.1). They tend to be resource-intensive, immobile. Questions for future research: Are such industries in a position to extract environmental rents from subnational governments? Or do they face high relative costs because governments do the extracting?

tures – and vice versa? Do environmental agencies prey upon immobile manufacturers – or do they try to protect them? The empirical work here suggests a “tripod model” of the state and federal policymakers as well as the property owner; but in that model, who makes the decisions? Environmental federalism is a subfield with rich soil.

Table 2: OLS Tests of Air and Land Pollution Models

	Air pollution model Dependent variable: AllSpend				Hazardous waste model Dependent variable: Spend		
Variable	Model 5	Model 6	Model 9	Model 10	Variable	Model 7	Model 8
Constant	-82.552653	-23.757873	-317.918665	-23.097002	Constant	-16.697856	-7.038734
(T-stat)	-0.67	-1.96	-0.6	-1.41	(T-stat)	-1.49	-1.34
Unem60	5.281138		9.211232		Unem8688	0.095637	0.084273
Beta	0.206		0.234		Beta	0.196	0.16
(T-stat)	2.18		1.72		(T-stat)	0.82	1.26
Income	0.001906				Income	-2E-05	
Beta	0.021				Beta	-0.063	
(T-stat)	0.17				(T-stat)	-0.13	
ManSh	0.228386		0.021046		ManSh	0.007906	0.011333
Beta	0.065		0.004		Beta	0.045	0.061
(T-stat)	0.69		0.04		(T-stat)	0.31	0.85
Air	0.054385	0.09118	0.060558	0.05088	LToxMile	0.000466	0.000322
Beta	0.048	0.08	0.044	0.037	Beta	0.292	0.166
(T-stat)	0.86	1.18	0.6	0.4	(T-stat)	2.49	2.22
House	0.00669		0.007547		House	2.4E-05	2.4E-05
Beta	0.469		0.447		Beta	0.716	0.694
(T-stat)	3.12		1.57		(T-stat)	1.86	4.59
Retire63	253.810967		207.316749		Retired	15.720635	14.955388
Beta	0.123		0.072		Beta	0.277	0.25
(T-stat)	1.23		0.63		(T-stat)	2.2	2.46
Years	-1.058683		4.391178		Years	0.337408	0.084188
Beta	-0.052		0.095		Beta	0.273	0.094
(T-stat)	-0.45		0.39		(T-stat)	1.41	0.75
HouseSq		0.000231		0.000289			
Beta		0.414		0.392			
(T-stat)		2.37		1.57			
					FedSites	0.156094	0.055087
					Beta	0.241	0.206
					(T-stat)	1.4	2.33
					Miles	-0.007666	-0.004582
					Beta	-0.142	-0.151
					(T-stat)	-1.97	-1.53
					FedSh	1.108719	0.673934
					Beta	0.333	0.454
					(T-stat)	7.22	5.75
N	50	50	37	33	N	25	40
R^2	0.098	0.139	0.066	0.103	R^2	0.559	0.631
Theil's	0.1045	-0.003	0.0059	0.0057	Theil's	0.4953	0.3139
SEE	37.221	36.352	42.653	43.976	SEE	0.694	0.633
F	1.758	4.968	1.422	2.831	F	4.046	8.419

Table 1: Table 1: OLS Tests of Hazardous Waste Models
Dependent variable: Spend

Variable	Model 1	Model 2	Model 3	Model 4
Constant	-4.546869	-2.590543	-3.211528	-3.194041
(T-stat)	-1.1	-0.83	-3.4	-3.3
House	2E-05	2.2E-05	1.9E-05	1.9E-05
Beta	0.56	0.613	0.538	0.539
(T-stat)	3.48	5.02	4.4	4.35
Retired	14.525065	12.884735	16.636879	16.60401
Beta	0.324	0.287	0.371	0.37
(T-stat)	2.36	2.15	3.25	3.39
FedSites	0.073691	0.076723	0.085739	0.086012
Beta	0.237	0.247	0.276	0.277
(T-stat)	4.38	4.1	4.36	3.58
Educate				-4.5E-05
Beta				-0.007
(T-stat)				-0.03
Years	0.001943	-0.02655		
Beta	0.003	-0.048		
(T-stat)	0.03	-0.46		
ManSh	0.025816	0.026142		
Beta	0.151	0.153		
(T-stat)	1.75	1.75		
Unem8688	0.080118	0.06261		
Beta	0.179	0.14		
(T-stat)	1.13	1		
Miles	0.002914	0.003145	0.003565	0.0036
Beta	0.414	0.447	0.507	0.512
(T-stat)	2.73	3.31	6.86	2.75
LToxMile	0.000303	0.000301	0.000233	0.000234
Beta	0.152	0.151	0.117	0.117
(T-stat)	5.74	5.8	3.85	4.02
FedSh	0.497291	0.502947	0.46329	0.462217
Beta	0.297	0.301	0.277	0.276
(T-stat)	4.13	3.95	3.31	3.19
Income	3.9E-05			
Beta	0.101			
(T-stat)	0.52			
N	50	50	50	50
$\bar{R}^2$	0.504	0.513	0.52	0.508
Theil's	0.2513	0.1361	-0.0374	0.0641
SEE	0.769	0.762	0.757	0.766
F	5.977	6.745	9.841	8.239

Table 3: Test Results for Full Samples

No.	Description of hypothesis	80s Test Results	60s Test Results
1	Manufacturing power cuts state pollution spending	Wrong sign; $T \approx 1.75$	Wrong sign; $T = 0.69$
2	(Manufacturing) unemployment decreases state pollution spending	Wrong sign; $T \approx 1.06$	Wrong sign; $T \approx 2.18$
3	High income increases state pollution spending	Right sign; $T \approx 0.52$	Right sign; $T = 0.17$
4	High pollution level increases state pollution spending	Right sign; $T \approx 4.1$	Right sign; $T = 1$
5	Long time horizon increases state pollution spending	Mixed signs; $T \approx -.43$	Wrong sign; $T \approx -.45$
6	Well-functioning land market increases state pollution spending	Right sign; $T \approx 4.31$	Right sign; $T \approx 3.12$

Table 4: Descriptive Statistics

Variables in hazardous waste study

Variable	Mean	Std Dev	Description
Educate	360.56	162.19	State spending on pri/sec education per capita
FedSh	0.4248	0.6525	Federal Superfund aid to state; dollars per capita
FedSites	2.3	3.5182	Number of federal facilities on NPL
House	57850	30901	Lowest-quartile value of occupied, one-family homes
Income	15542	2802	Personal income per capita
LToxMile	249.42	546.4	Pounds per sq mile of toxic chemical releases to land
ManSh	16.99	6.3865	Percent of nonfarm employees in manufacturing
Miles	50.1105	155.217	Square miles of land per capita
Retired	0.1541	0.0243	Percent of residents receiving Social Security benefits
Spend	1.0841	1.0921	State spending on hazardous waste per capita
Unem8688	6.502	2.44	Manufacturing unemployment rate, 3-yr average
Years	39.136	1.957	Years left in average resident's lifetime

Variables in air pollution study

Variable	Mean	Std Dev	Description
Air	104.14	34.48	Micrograms of particulates per cubic meter of air
AllSpend	16.1216	39.1851	State, local spending on air pollution/1000 residents
House	11142	2727	Median value of owner-occupied, one-family homes
HouseSq	131540	70255	Square of House variable ($1,000s)
Income	2082	430	Personal income per capita
ManSh	26.14	11.15	Percent of nonfarm employees in manufacturing
Retire63	0.0977	0.019	Percent of residents receiving Social Security benefits
Unem60	5.23	1.53	Percent of civilian labor force unemployed
Years	41.445	1.917	Years left in average resident's lifetime

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5 Appendix A: Derivations

5.1 Derivations for Theorem 1

Proposition 1 *In the simple myopic state,* $\partial m/\partial t \neq 0$ *for any interval* $[t^*, t^* + \varepsilon] \in [0, T]$, $\varepsilon > 0$.

Proof. Suppose that $\partial m/\partial t = 0$ over the interval $[t^*, t^* + \varepsilon]$. Then, in the simple myopic state, the multiplier equation (13) yields

$$m(t) = -\frac{\alpha\left(L_b \frac{\partial {U^0}_b}{\partial P} + (N_b - L_b)\frac{\partial {U^1}_b}{\partial P}\right) + (1-\alpha)N_w \frac{\partial U_w}{\partial P}}{r-d}, \tag{24}$$

for any $t \in [t^*, t^* + \varepsilon]$.

The right-hand side of (24) gives the current value of the marginal disutility of the pollutant stock over the interval $[t, \infty)$, with political weights. The left-hand side of (24) gives the marginal cost to the policymaker of the pollutant stock at time t. By construction of the problem, however, the policymaker cares only about the effects of the stock up to time T. So the right-hand side of (24) overstates the actual value of $m(t)$ in the model. It follows that $\partial m/\partial t$ is nonconstant over any interval $[t^*, t^* + \varepsilon] \in [0, T]$.

5.2 Deriving comparative statics for empirical tests

Hypotheses 1-4 apply the implicit function theorem to (11).

Hypothesis 1: Comparative statics yield

$$\frac{\partial S}{\partial N_b} = \frac{\frac{\partial m}{\partial N_b} - \frac{\partial \alpha}{\partial N_b}\frac{\partial L_b}{\partial S}\left[{U^0}_b - {U^1}_b\right]}{\alpha \frac{\partial^2 L_b}{\partial S^2}\left[{U^0}_b - {U^1}_b\right] - \frac{\partial m}{\partial S}}. \tag{25}$$

In interpreting (25), recall that the co-state variable m can be expressed as a function of parameters when evaluated at the solution to the Hamiltonian.

The denominator is negative. In the numerator, $\partial m/\partial N_b$ is negative: As the blue-collar group grows, the marginal cost to the policymaker of permitting the pollutant stock to increase will decrease, given that the flow is not so large as to cut the productivity of workers and to trigger layoffs ($S < S_0$). But the rest of the numerator is positive. So, signing $\partial S/\partial N_b$ requires more assumptions. The numerator is negative – and $\partial S/\partial N_b$ is positive – if and only if

$$\frac{\partial m}{\partial N_b} < \frac{\partial \alpha}{\partial N_b}\frac{\partial L_b}{\partial S}\left[{U^0}_b - {U^1}_b\right]. \tag{26}$$

In (26), the right-hand side represents the decrease in the political value (to blue-collar workers) of increasing the blue-collar group. Adding another member to the blue-collar group induces some free-riding by the average member of the group ($\partial \alpha/\partial N_b$). This free-riding reduces blue-collar political power. It becomes easier for the policymaker to tighten pollution controls, eliminating blue-collar jobs. The resulting loss in blue-collar welfare is the decrease in individual welfare due to losing a job (${U^0}_b - {U^1}_b$) times the number of jobs lost ($\partial L_b/\partial S$).

In sum, $\partial S/\partial N_b$ is positive if the free-riding incurred by adding a member to the blue-collar group is not too great.

Using (20) yields $\partial Spend/\partial N_b < 0$.

Hypothesis 2: Comparative statics yield

$$\frac{\partial S}{\partial(\frac{L_b}{N_b})} = \frac{\frac{\partial m}{\partial(\frac{L_b}{N_b})}}{\alpha\frac{\partial^2 L_b}{\partial S^2}\left[U^0{}_b - U^1{}_b\right] - \frac{\partial m}{\partial S}} < 0. \tag{27}$$

So

$$\frac{\partial S}{\partial\left(1 - \frac{L_b}{N_b}\right)} > 0. \tag{28}$$

Using (20) yields

$$\frac{\partial Spend}{\partial\left(1 - \frac{L_b}{N_b}\right)} < 0. \tag{29}$$

Hypothesis 3: Comparative statics yield

$$\frac{\partial S}{\partial Y_b} = \frac{\frac{\partial m}{\partial Y_b} - \alpha\frac{\partial L_b}{\partial S}\left(\frac{\partial U^0{}_b}{\partial Y_b} - \frac{\partial U^1{}_b}{\partial Y_b}\right)}{\alpha\frac{\partial^2 L_b}{\partial S^2}\left(U^0{}_b - U^1{}_b\right) - \frac{\partial m}{\partial S}} < 0. \tag{30}$$

and

$$\frac{\partial S}{\partial Y_w} = \frac{\frac{\partial m}{\partial Y_w}}{\alpha\frac{\partial^2 L_b}{\partial S^2}\left(U^0{}_b - U^1{}_b\right) - \frac{\partial m}{\partial S}} < 0. \tag{31}$$

Let Y be a linear combination of Y_b and Y_w. Then, from (30) and (31), $\partial S/\partial Y < 0$. Use (20) to obtain $\partial Spend/\partial Y > 0$.

Hypothesis 4: Comparative statics yield

$$\frac{\partial S}{\partial P_0} = \frac{\frac{\partial m}{\partial P_0} - \alpha\frac{\partial L_b}{\partial S}\left(\frac{\partial U^0{}_b}{\partial P} - \frac{\partial U^1{}_b}{\partial P}\right)\frac{\partial P}{\partial P_0}}{\alpha\frac{\partial^2 L_b}{\partial S^2}\left(U^0{}_b - U^1{}_b\right) - \frac{\partial m}{\partial S}} < 0. \tag{32}$$

Use (20) to obtain $\partial Spend/\partial P_0 > 0$.

5.3 Effect of pollutant decay rate on emissions

Applying the implicit function theorem to (11) yields

$$\frac{\partial S}{\partial d} = \frac{\frac{\partial m}{\partial d}}{\alpha\frac{\partial^2 L_b}{\partial S^2}\left(U^0{}_b - U^1{}_b\right) - \frac{\partial m}{\partial S}} > 0. \tag{33}$$

6 Appendix B: Notes on the data

6.1 Hazardous waste study

Educate: State-source revenues per capita for primary and secondary education for state fiscal year 1988. Includes direct state aid as well as state contributions on behalf of local school systems. State-source revenues originate from state governments; they do not include federal aid. Source: [27], Table 9, page 13.

FedSh: Federal grants to state and local governments from the Hazardous Substance Response Trust Fund (Superfund) for federal fiscal year 1988. Expressed in terms of dollars per capita. Source: [26], Table 2, page 7.

FedSites: Federal-facility sites of uncontrolled hazardous waste on the National Priorities List, 1989. Includes final and proposed sites for the Superfund program. Source: [28], Items 624 and 626, page 240.

House: Upper limit of the lowest quartile of current values of owner-occupied, one-family homes in 1990. Owners estimated the values. The tracts are smaller than 10 acres, and they contain no business. Source: [29], Table 1228, page 718.

Income: Personal income per capita in 1988, expressed in current dollars. Source: [28], Item 807, page 251.

LToxMile: Pounds per square mile of toxic chemical releases to the land in 1987. Includes toxins released to landfills, ponds and pits; toxins released for land treatment or application as well as for farming; and toxic leaks or spills. Includes on- site releases and off-site transfers generated in the specific state. Roughly 40 percent of transferred wastes are disposed out of state. Discharges were reported by manufacturing facilities using or releasing at least 50,000 pounds of 322 chemicals, including 123 carcinogens. I exclude chemicals that EPA delisted by 1991, since typically their toxicity would have been in question years before their delisting. Source: [35], Table E-1, page E-3.

ManSh: Percent of all nonfarm employees that was in manufacturing in 1989. Source: [29], Table 668.

Miles: Square miles of land per capita in 1980 in the state. Source: [28], Item 590, page 238.

Retired: Percentage of the state population that received Social Security benefits on Dec. 31, 1988. Includes dependents of retired and disabled workers as well as other types of beneficiaries. Retired workers alone account for 62 percent of the recipients. Source: [28], Item 441, page 229.

Spend: State expenditures on hazardous waste per capita in state fiscal year 1988, which ended on June 30, 1988 for most states. Includes funds used to develop and maintain a comprehensive hazardous waste management program. This can include remediation of Superfund sites and of leaking storage tanks that are underground. From gross state expenditures, I subtracted federal Superfund aid (see the entry for *FedSh*). Source: [7], pp. 84-93.

*Unem*8688: The simple average of the annual unemployment rate in manufacturing from 1986 through 1988. Source: [32], Table 16.

This source provides no estimate for the 1988 unemployment rate in Alaska. I've estimated this rate with a linear interpolation of 1989 and 1987 data.

Years: Years left in average lifetime. Average lifetime in years, 1979-1981, taken from [28], Item 178, page 213. Mean age for 1989 calculated from [29], Table 28.

6.2 Air pollution study

Air: The geometric mean of the number of micrograms of suspended particulate matter per cubic meter of air for each state from 1957 through 1961. I use the geometric – not arithmetic – mean because particulates follow a log-normal distribution in concentration. Source: [31], Table 22, pp. 16-21.

AllSpend: State, city and county expenditures on air pollution in 1963 per 1000 residents. Source: [17].

House: Median value of owner-occupied, single-family house in 1960. Source: [25], Table 1, Item 61, page 5.

Income: State personal income per capita in 1960. Excludes wages and salaries received by federal military and civilian employees temporarily stationed abroad. Source: [29], 1962, Table 431, page 319.

ManSh: Percentage of nonagricultural jobs that were in manufacturing in 1961. Source: [29], 1961, Table 281, page 212.

*Unem*60: Percent of civilian labor force unemployed in 1960. Source: [25], Item 35, page 4.

Years: Number of years left in mean life in 1960s. Estimates of average lifetimes by state are from [30], page 8-6. I computed the mean age of the population by state in 1960 from [29], 1962, Table 19, page 27. To obtain *Years*, I subtracted the mean age from the estimated average lifetime.