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ASSESSING THE EMPIRICAL IMPACT OF ENVIRONMENTAL FEDERALISM*

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ABSTRACT. Many theoretical models analyze the effects of decentralized environmental policymaking. The predictions range from a race to the top, a race to the bottom, or no effect. However, little empirical evidence exists to resolve this ambiguity. This paper fills the void by examining the impact of decentralized environmental policymaking in the U.S. under Presidents Ronald Reagan and George H.W. Bush. For abatement expenditures, Reagan's decentralization had no discernible impact before the mid-1980s, but by the mid-1980s the data are consistent with decentralization leading to a race to the top. No statistically significant effect is found on nitrogen oxide or sulfur dioxide emissions.

1. INTRODUCTION

Does decentralized environmental policymaking in a federal system cause a race to the bottom? Although the theoretical literature examining the question is large, there is no consensus (e.g., Levinson, 1997). On the one hand, decentralized environmental regulations may be too lenient if jurisdictions compete for mobile capital (e.g., Cumberland, 1979, 1981; Esty, 1996; Esty and Geradin, 1997; and the models of strategic behavior in Barrett, 1994; Kennedy, 1994; Rauscher, 1994; Markusen, Morey, and Olewiler, 1995; Wilson, 1996).[1] On the other hand, greater decentralization may lead to a NIMBY (not-in-my-back-yard) phenomenon, whereby local governments raise environmental regulations above the optimal level to discourage polluting firms from locating within their jurisdiction (e.g., Markusen, Morey, and Olewiler, 1995; Wilson, 1996; Glazer, 1999). In addition, Oates and Schwab (1988) study decentralized environmental policymaking under majority rule voting and show that policy outcomes that are distorted by politics may be either too stringent or too lenient. Fredriksson and Gaston (1999) present a

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[1]The argument in favor of federal environmental legislation is analagous to the argument put forth by "old" institutional economists in favor of employment regulations to protect workers from "the deletorious effects of unrestrained self-interest and competition" (Kaufman, 1998, p. 349).

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model where decentralized policymaking may be distorted by fears of capital flight, but centralized policymaking is distorted by greater industrial lobbying; the result is no impact of decentralization on the level of environmental regulation.[2]

Despite the lack of consensus, fears of a race to the bottom have given rise to calls for regulatory harmonization across the European Union (EU) and the North American Free Trade Agreement (NAFTA) (Esty and Geradin, 1997). In addition, fears of a race to the bottom in the United States date back to Break (1967) and, as indicated in a congressional House Report (1979), were a significant factor leading to the formation of the Environmental Protection Agency (EPA) in 1968. Revesz (1992) also argues that capital competition considerations explain why the U.S. Clean Air Act is implemented at the federal level.

Although the appropriate level of governance for environmental policy has large and immediate consequences and theoretical arguments are ambiguous, empirical evidence is largely anecdotal. Fredriksson and Millimet (2002) find evidence of strategic environmental policymaking across U.S. states, but are unable to conclude if the evidence supports a race to the top or the bottom. Fredriksson and Gaston (1999), building on Calvert (1989), examine roll call votes on environmental legislation in the U.S. in state legislatures as well as at the congressional level, finding no increased propensity for state politicians to vote against environmental measures. Rose-Ackerman (1995) compares various measures of environmental quality across the U.S. (which is fairly centralized) and Germany (which is decentralized), concluding that the level of governance does not affect pollution levels. Paul (1994, 1995) studies the centralization of packaging-waste regulation in the EU and finds that due to heightened industrial lobbying, centralization did not significantly alter the level of regulation. Pashigian (1985) finds that northern U.S. states benefitted from federal air regulations and Crandall (1983) argues that these same states were not in favor of President Ronald Reagan's policy of environmental decentralization in the 1980s. In addition, Davies (1984, p. 151) argues that Reagan's decentralization created "some backlash in the business community" as industries did not want to face the complications that would arise from each state having a unique set of regulations.

A recent addition to this literature is List and Gerking (2000). Using state-level data from the U.S. and noting the shift in environmental policy under Reagan that granted greater freedom to the states (discussed below), the authors estimate a two-way fixed-effects model (state- and year-specific effects) for determining environmental quality and abatement expenditures. As a test for the race to the bottom, they examine the signs of the time fixed effects during the Reagan presi-

[2]Alternatively, Damania and Fredriksson (2000) argue that the ability of firms to engage in collusive behavior increases their incentive to form lobby groups. If firms are better able to collude at the local—rather than federal—level, their propensity to form a lobby group at the state level may be greater than their propensity to lobby at the national level. In other words, if geographic proximity encourages collusion (perhaps due to better monitoring), then similar firms within the same state may collude and therefore form lobby groups at the state level. However, if environmental policies are implemented nationally and firms cannot maintain collusive agreements across long distances, then firms may be less able to lobby at the national level.

dency. Finding the majority of the time effects to be either insignificant or significant and consistent with improved environmental quality, the authors conclude that "a 'race to the bottom' in environmental quality did not materialize in the 1980s" (p. 453).

The List and Gerking (2000) method, however, restricts the coefficients on the control variables in the regression model and the state fixed effects as constant pre- and postdecentralization. If this restriction is not valid, then at least a portion of the decentralization impact may be missed by simply examining the time effects. In other words, by pooling the data before and after Reagan's decentralization, the effects of the policy shift may be partially subsumed by other parameters of the model. In particular, consider the role of the state fixed effects. If the impact of state unobservables on environmental quality are not constant over the entire sample period, then the estimated state effect in the List and Gerking (2000) model will represent a weighted average of the pre- and postdecentralization fixed effect. The time effects will then capture only residual changes that occurred under Reagan's regime shift, net of the altered state effects. A more accurate estimate of the effects of decentralization should also incorporate its impact on the role of the state unobservables. A similar argument could be told for changes in the coefficients on the covariates in the model.

This paper provides a further assessment of the impact, if any, of Reagan's policy of environmental decentralization during the 1980s as well as the decentralization that occurred in other areas during the 1970s. Using panel data from U.S. states on nitrogen oxide and sulfur dioxide emissions from 1929–1994 and per capita pollution abatement and control expenditures (PACE) and PACE per unit of manufacturing output from 1973–1994 (except 1987), Chow tests are performed to test for structural breaks in the data. That the tests easily reject pooling the data before and after Reagan's policy shift shows the need for further analysis to assess the robustness of the List and Gerking (2000) results. However, simply allowing for a structural break in the List and Gerking model does not answer the question of whether a race to the top or the bottom materialized because the cumulative effect of the decentralization pursued under Reagan is contained in both the signs of the time effects and the change in the parameters. Thus, another method is needed.

To proceed, a two-way fixed-effects model—analogous to List and Gerking (2000)—is estimated using only the data from 1929–1979 or 1929–1971 and the results are used to predict the emissions levels in the 1980s and 1990s. Comparison of the predicted levels with the actual observed levels is then used to analyze the effect of Reagan's decentralization as well as contrast it to decentralization in other policy areas that had begun in the 1970s.[3]

[3]The logic behind this estimation strategy is similar to Meyer and Wise (1983), who use comparisons between predicted and actual wage distributions to analyze the impact of minimum wage laws, Cancian and Reed (1998), who alter levels of earnings by wives to estimate the impact of their earnings on family income inequality, and Bulte, Folmer, and Heijman (1995), who analyze the effect of government intervention on fish prices by predicting prices with data before the intervention. In addition, Schmalensee, Stoker, and Judson (1998) and Holtz-Eakin and Selden (1995) use a similar projection method to predict levels of CO_2 emissions through 2050 and 2100, respectively. However, in their studies the determinants of environmental quality (e.g., income and population) that form the projections had to be predicted as well; this is not the case in the present context.

In addition, the same exercise is performed using data on PACE. The difference between the predicted and actual levels reflects the cumulative effect of the decentralization policy because the deviations from the predicted levels reflects the later time effects as well as changes in the coefficients of the model.

While there may be alternative explanations for the deviation of actual levels from predicted levels besides Reagan's policy changes, given the magnitude of the regime shift (discussed below) over such a short time, one is pressed to find an alternative explanation.[4] Moreover, even if such alternatives exist, the results serve as a useful companion to those in List and Gerking (2000) because the time effects in their analysis will capture other policy changes that occurred during the Reagan presidency. In any event, the results should be interpreted with this caveat in mind.

The results are intriguing. First, Chow tests overwhelmingly reject pooling the data before and after the decentralization of environmental regulations under Reagan. Second, whereas per capita nitrogen oxide and sulfur dioxide emissions levels deteriorated during the 1970s when decentralization began in other policy areas (as emissions levels during the 1970s exceeded projections based on data through 1971), there is mild evidence suggesting that Reagan's environmental decentralization during the 1980s reversed this trend. Thus, the data are not consistent with Reagan's decentralization leading to a race to the bottom. For pollution control expenditures, relative to the projected levels of per capita PACE and PACE per dollar of manufacturing output, Reagan's decentralization had no discernible impact before the mid-1980s when states were facing extreme financial hardships. By the mid-1980s, however, the data are consistent with decentralization leading to a race to the top in abatement expenditures. Thus, despite a structural break during the 1970s, these results are generally consonant with those reported in List and Gerking (2000).

The remainder of the paper is organized as follows. Section 2 provides a recent history of environmental decentralization in the U.S. Section 3 details the empirical methods. Section 4 presents the data. Section 5 discusses the results. Section 6 concludes.

2. ENVIRONMENTAL DECENTRALIZATION UNDER REAGAN

The changes in environmental policymaking by President Reagan are widely studied by political scientists because much of the institutional

[4]Other significant national changes occuring at much the same time include the rise in energy prices (which may have had long-lasting impacts as individuals switched to more fuel-efficient cars and home insulation, for example) and implementation of the 1970 Clean Air Act (which, due to lags, may not have fully taken effect until the late 1970s or early 1980s). Selden, Forrest, and Lockhart (1999) conclude that emissions reductions between 1970 and 1990 were mainly due to increased abatement expenditures, rather than composition effects or changes in energy usage. The authors attribute the increased abatement to the Clean Air Act; however, they did not examine the role of decentralization as an alternative.

structure that had been established in the previous decade was undone over such a short time. Vig (1994, p. 76) stated: "Not since the New Deal had any president tried to reorient American government in so fundamental a manner. But in contrast to Franklin D. Roosevelt, Reagan believed government was the problem rather than the solution."

After assuming office, Reagan cut the size of the Executive Office's Council on Environmental Quality (CEQ) from 60 to 6. In addition, between 1981 and 1983, Reagan reduced employment at the EPA by more than 22 percent. Reagan's environmental policy also included shifting responsibilities to the states "whenever feasible" (Vig and Kraft, 1984; Lester, 1994). According to the CEQ (1982, p. 75): "By the end of 1982 state governments had been delegated enforcement responsibilities for over 95% of applicable National Emissions Standards for Hazardous Air Pollutants, and over 90% of applicable New Source Performance Standards, up from 64% at the beginning of the year." Moreover, while the burden of environmental protection increasingly fell on the states, Reagan cut federal aid to the states at a time when, according to Davies (1984, p. 150), states were in "deep financial trouble" and political pressure limited the "ability of states to raise taxes or pass bond issues."

Budget allocations to federal environmental agencies were reduced under Reagan as well. Over the period 1981–1984, federal appropriations to the EPA declined by 11.5 percent; 13.8 percent for the National Park Service; 18.7 percent for the Forest Service; 19.4 percent for the Soil conservation Service; 64.0 percent for the CEQ; 16.2 percent for the Corps of Engineers; and, 2.6 percent for the National Oceanic and Atmospheric Administration (Bartlett, 1984). The EPA's research and development budget alone was reduced by more than 45 percent between 1981 and 1983. The cuts resulted in sharp declines in federal environmental research, information gathering and dissemination, monitoring, and enforcement (Vig and Kraft, 1984).

In light of the states' financial constraints, one might suspect that fears of capital flight should have prompted a race to the bottom if the argument is valid. However, Reagan's environmental policy was not without its critics. Membership in environmental groups grew dramatically during the early 1980s and in March 1982, 10 leading environmental conservation organizations released a formal statement detailing 227 examples of alleged subversion of environmental policies by the federal government (Vig and Kraft, 1984). In addition, several congressional candidates won the 1982 elections due to strong backing by environmental groups (Vig, 1984). Thus, heightened local political pressure may have impeded state governments' ability to act on fears of capital flight.

Despite the backlash, the shift toward decentralized environmental decision making did not end during Reagan's tenure. The first President George Bush maintained Reagan's decentralized environmental policy and substantial budget cuts in federal aid to states. Lester (1994, p. 52) wrote: "As a part of the legacy of the Reagan and Bush presidencies, states and local communities are assuming many responsibilities for protecting the environment that had previously been undertaken by the federal government." The only difference between the decentralization of the late 1980s and early 1990s relative to Reagan's first term was that between 1985 and 1992 many states were able to replace lost federal funds with state revenues (Lester, 1994).

3. EMPIRICAL METHODS

To examine the effect of Reagan's decentralization policy, the first model estimated tests for a structural break in the determination of environmental quality. The two breaks examined are in 1980, when Reagan took office, and 1972, when the federal government began to decentralize in nonenvironmental policy areas.[5] The model estimated is

$$E_{it} = [\alpha_{i0} + I_t\alpha_{i1}] + \gamma_t + [\mathbf{X}_{it}\beta_0 + \mathbf{X}_{it}I_t\beta_1] + \epsilon_{it} \quad (1)$$

where E_{it} is a measure of environmental quality in state i at time t, α_i are state fixed effects, γ_t are time fixed effects, $\mathbf{X}_{it}$ is a vector of state attributes with associated parameter vector β, ε_{it} is an error term that is uncorrelated over time and across observations, and

$$I_t = \begin{cases} 0 & \text{if } t < 1980 \ (1972) \\ 1 & \text{if } t \geq 1980 \ (1972) \end{cases}$$

In the empirical work below, the state characteristics included in $\mathbf{X}$ are a measure of per capita income along with higher-order terms, population, population density, and percentage of the population living in urban areas. The specification in (1) is similar to models used to test for the environmental Kuznets curve (e.g., Grossman and Krueger, 1995) and estimated in List and Gerking (2000), with the addition of the possible structural break. Including state fixed effects controls for time invariant unobservable state attributes that may affect environmental quality as well as be correlated with the observed characteristics in $\mathbf{X}$ (e.g., climate or levels of political activism). The time fixed effects capture period-specific shocks common across all states (e.g., federal legislation or environmental disasters such as the Exxon Valdez, which increase nationwide focus on environmental issues).

For comparison, List and Gerking (2000) estimate a restricted version of (1), imposing $\alpha_{i1} = \beta_1 = 0$. Thus, their model is written as

$$E_{it} = \alpha_i + \gamma_t^{LG} + \mathbf{X}_{it}\beta + \nu_{it} \quad (2)$$

where $\nu_{it} = \varepsilon_{it} + [\widetilde{\alpha}_{i1} + X_{it}\widetilde{\beta}_1]$, $\widetilde{\alpha}_{i1} = I_t\alpha_{i1} + (\alpha_{i0} - \alpha_i)$, and $\widetilde{\beta}_1 = I_t\beta_1 + (\beta_0 - \beta)$.[6] To test the effect of Reagan's policy shift, the authors examine the signs of the time fixed effects, γ_t^{LG}, during Reagan's presidency. A natural question

[5]For completeness, a third model allowing for breaks in 1972 and 1980 was estimated. The results, not reported, are available from the author upon request. However, the results are generally consonant with those reported.

[6]If α_{i1} in (1) is nonzero, then α_i in (2) will not in general be equal to α_{i0} in (1). Consequently, $\widetilde{\alpha}_{i1}$ is not equivalent to α_{i1}.

arises. If one rejects the null hypothesis of no structural break (H_o: $\alpha_{i1} = \beta_1 = 0\ \forall i$), how do the time fixed effects compare across Models (1) and (2)? Clearly, if the decentralization that occurred during the Reagan presidency also affected the state-specific unobservables or the exogenous covariates in **X**, then the time effects in (2) will be correlated with the error term. In addition, not all state-specific unobservables will be removed (α_i will represent a weighted average of the "true" state unobservables α_{i0} and α_{i1}). Finally, the ν's will be heteroskedastic (as the variance depends on **X**) and autocorrelated (as αs are correlated over time).

To proceed then, Equation (2) is estimated for each of four measures of environmental quality using only the data before 1980. The measures are per capita sulfur dioxide and nitrogen oxide emissions, per capita pollution abatement and control expenditures (PACE), and PACE per dollar of manufacturing output. The coefficient estimates are then used to construct out-of-sample estimates, $\widehat{E}_{it}$, for the years 1980–1994. Given that states were more constrained financially in the early 1980s, one might expect the effects of decentralization to be greater during this time. In addition, despite that increased state revenues were available for environmental protection post-1984, it is worthwhile to compare the effects of decentralization during these later years as well.

One possible source of concern is that although the movement to greater environmental decentralization began with Reagan's election in 1980, states were gaining larger responsibilities in other policy areas prior to 1980. The shift toward greater state reliance began in earnest with the State and Local Fiscal Assistance Act of 1972. In addition, one may argue it was possible for states to foresee Reagan's election and a general emphasis on decentralization and act on this information before 1980. Thus, using the data though 1979 to form predictions may not be accurate if greater state competition or anticipation of Reagan's presidency and subsequent environmental agenda affected state environmental decision making before 1980. However, Reagan's previous environmental record while governor of California (1967–1975) was an enigma and Reagan's biographer characterized his attitudes on the environment as a "bundle of contradictions" (Vig, 1984, p. 85). Nonetheless, in an attempt to delineate the effects of Reagan's policy change from the effects of previous decentralization during the 1970s, two sets of predictions are used based on different truncation points: one on the data through 1971 and one on the data through 1979.

A second source of concern is the treatment of the time fixed effects, γ_t, when generating the predicted values. As in Schmalensee, Stoker, and Judson (1998), the time effects must be forecasted and then incorporated into the predictions, $\widehat{E}_{it}$. Five different specifications are used to predict the time effects during the 1980s and 1990s: (i) linear time trend, (ii) cubic time trend, (iii) linear spline model, (iv) AR(1) model, and (v) AR(2) model.[7] In

[7]Second-, fourth-, fifth-, and sixth-order polynomials were also tried, but did not add any unique insight beyond the specifications presented. In the linear spline models, the number and location of the kink points are chosen based on Figure 1 (discussed below).

other words, using the estimated fixed effects from (2), the following models are estimated and used to project future values of the time effects, $\widehat{\gamma}_t$:

$$
\begin{aligned}
\text{linear time trend} &: \gamma_t = \gamma + \gamma_0 t + \upsilon_{1t} \\
\text{cubic time trend} &: \gamma_t = \widetilde{\gamma} + \gamma_1 t + \gamma_2 t^2 + \gamma_3 t^3 + \upsilon_{2t} \\
\text{linear spline} &: \gamma_t = \begin{cases} \widetilde{\widetilde{\gamma}} + \gamma_4 t * 1[t \le 1943] + \gamma_5 t * 1[1943 \le t \le 1961] \\ \quad + \gamma_6 t * 1[1961 \le t \le 1973] \\ \quad + \gamma_7 t * 1[1973 \le t] + \upsilon_{3t}, \qquad \text{for } NO_x \\ \widetilde{\widetilde{\gamma}} + \gamma_4 t * 1[t \le 1962] + \gamma_5 t * 1[1962 \le t \le 1973] \\ \quad + \gamma_6 t * 1[1973 \le t] + \upsilon_{3t}, \qquad \text{for } SO_2 \end{cases} \\
\text{AR(1)} &: \gamma_t = \gamma + \gamma_8 \gamma_{t-1} + \upsilon_{4t} \\
\text{AR(2)} &: \gamma_t = \gamma + \gamma_9 \gamma_{t-1} + \gamma_{10} \gamma_{t-2} + \upsilon_{5t}
\end{aligned}
$$

where $1[\cdot]$ is an indicator function taking on the value one if the statement in the brackets is true, zero otherwise.[8] The predicted time effects, $\widehat{\gamma}_t$, are then incorporated into the predicted values, $\widehat{E}_{it}$, using Equation (2). Figure 1 shows the "actual" time effects, γ_t, from the beginning of the data through the cut-off year (either 1971 or 1979) for each of the four measures of environmental quality. In addition, the predicted time effects from each of the five specifications are included.[9]

Not surprisingly, although the cubic time trend model is fairly flexible and fits the "actual" time effects quite well, it does not yield overly reliable predictions, particularly far out of sample. Thus, in the remainder of the paper, we focus on the remaining four specifications. One should note that the linear spline model uses only data from the last segment in the forecast and also requires the assumption (as in Schmalensee, Stoker, and Judson, 1998) that there are no kink points in the future.

After constructing the predicted values, the annual means of E_{it} and $\widehat{E}_{it}$ across states are plotted by year, and 90 percent empirical confidence intervals are obtained via 1,000 bootstrap repetitions.[10] The bootstrap samples are obtained by resampling states, rather than state–year observations, to maintain the time structure in each bootstrap sample. Bootstrap confidence intervals enable one to make inferences robust to possible temporal or spatial autocorrelation or heteroskedasticity of the error term in (2).

[8]In the models using data only through 1971, the final spline segment does not exist for both nitrogen oxide and sulfur dioxide.

[9]For the two measures of abatement costs, the results based on a cubic time trend are not reported given the small sample size of actual time effects used in the forecasts.

[10]To be clear, the entire estimation procedure is bootstrapped. For each bootstrap sample, the time effects are estimated and forecasted out-of-sample. Then, predicted emissions and abatement expenditures are based on the bootstrap regression results and estimated time effects.

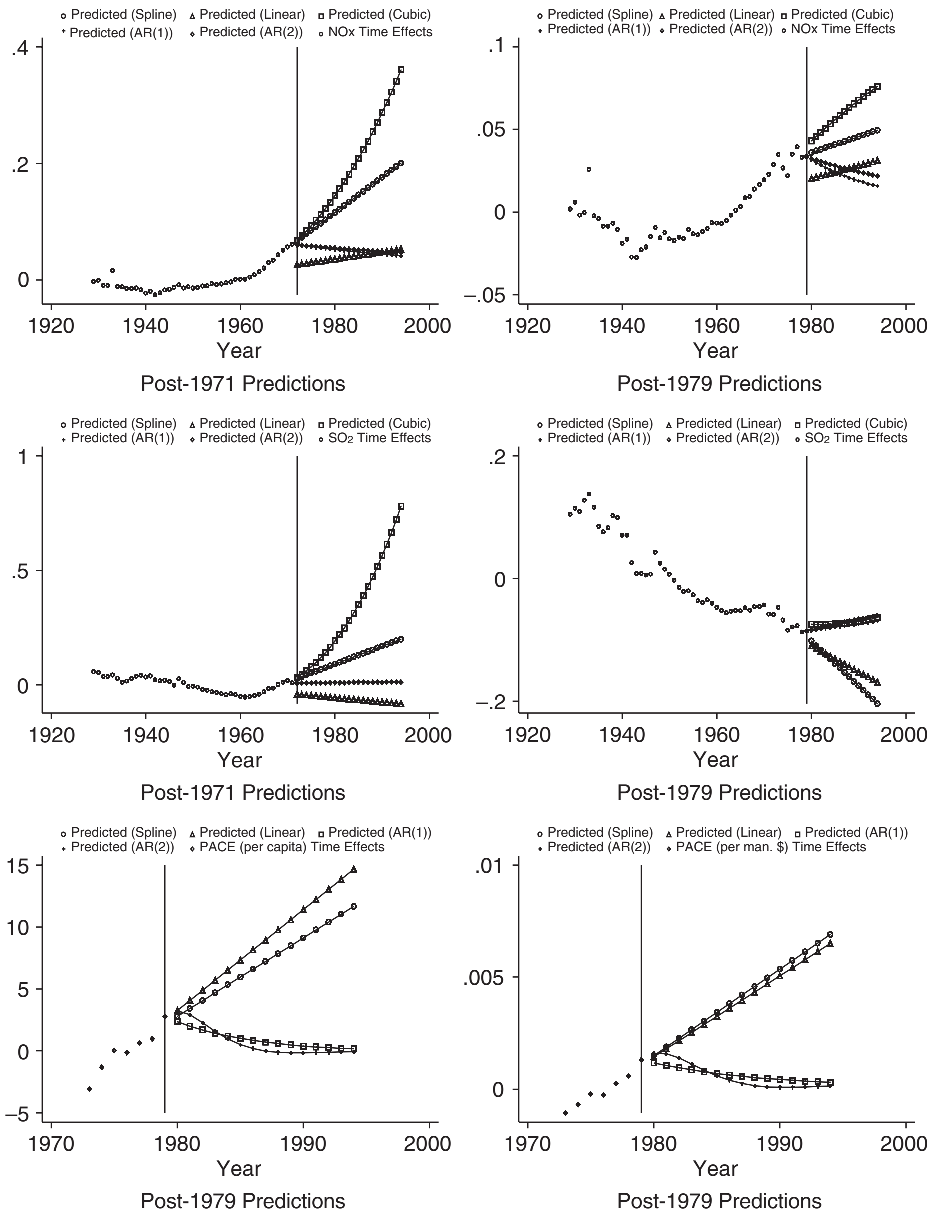

FIGURE 1: Actual and Projected Time Fixed Effects.

4. DATA

Four measures of environmental quality assess the robustness of the findings. The first two are per capita emissions of nitrogen oxide and sulfur dioxide. The data are obtained from the EPA's *National Air Pollutant Emissions Trends, 1900–1994* and span the years 1929–1994. For further details, refer to List (1999). The final two measures pertain to industry expenditures to improve environmental quality. Per capita PACE and PACE per dollar of manufacturing output reflect expenditure on pollution abatement and are (at least somewhat) related to regulatory stringency. The data are collected by the U.S. Census Bureau as part of the Annual Survey of Manufacturers and are available for 1973–1994, except 1987. A major shortcoming of using PACE data is that high-polluting, and hence high-PACE, industries may cluster in certain states. As a result, although these states may have relatively high levels of abatement expenditures, this gives no indication of the level of environmental regulation. However, to the extent that the industrial composition of states changes slowly over time and largely reflects historical patterns (e.g., Henderson, Kuncoro, and Turner, 1995), differences in composition across states will be captured by the state fixed effects. The final measure of environmental quality is PACE per dollar of manufacturing output which proxies for the regulatory intensity of a particular state.[11] The remaining state attributes are from the U.S. Bureau of Economic Analysis (BEA). Summary statistics are given in Table 1.

5. RESULTS

Chow Tests

The first set of results examine the validity of the restrictions imposed in (2). Table 2 presents estimates of the more flexible specification in (1) for per capita nitrogen oxide and sulfur dioxide emissions, allowing for a possible structural break in 1971 or 1979. Table 3 contains similar results for the two measures of abatement costs, allowing for a structural break in 1979. Although some of the interaction terms are significant in Table 2 when the break is assumed to occur in 1971, the vast majority of the interaction terms in Tables 2 and 3 are insignificant when the break is thought to occur in 1979. However, allowing for a structural break also permits the state fixed effects to change postdecentralization. Table 4 presents the p-values associated with the null hypotheses that the coefficients on the interaction terms (i.e., α_{i1} and β_1 in [1]) are jointly zero.

For the two pollution and two abatement models permitting a structural break in 1979, the null hypothesis H_o: $\beta_1 = 0$ cannot be rejected in three of the four models (the exception being per capita sulfur dioxide emissions). However, the null H_o: $\beta_1 = 0$, $\alpha_{i1} = 0$ is easily rejected in all four models. Thus, estimation of the restricted version in (2) does not adequately control for changes in both observable and unobservable state attributes. As a result,

[11]One could argue that differences in PACE per unit of manufacturing output is a poor indicator of regulatory intensity if some states are simply less efficient about pollution abatement. However, this scenario seems unlikely and, if there are persistent differences in abatement efficiency across states, these unobserved attributes will be captured by the state fixed effects.

TABLE 1: Summary Statistics[†]

Variable	Pre-1980 *N*	Pre-1980 Mean (Standard Deviation)	Post-1980 *N*	Post-1980 Mean (Standard Deviation)	All Years *N*	All Years Mean (Standard Deviation)
Sulfur Dioxide (per capita)	2448	0.14 (0.13)	720	0.09 (0.09)	3168	0.13 (0.12)
Nitrogen Oxide (per capita)	2448	0.08 (0.05)	720	0.09 (0.05)	3168	0.09 (0.05)
PACE (millions, 1987 dollars)	333	35.04 (41.10)	672	103.36 (189.71)	1005	80.72 (160.14)
PACE (per capita, 1987 dollars)	333	8.19 (6.70)	672	20.88 (28.64)	1005	16.68 (24.47)
PACE (per dollar of manufacturing output)	333	3.0E-03 (3.0E-03)	672	0.01 (0.02)	1005	0.07 (0.01)
Personal Income (per capita thousands, 1987 dollars)	2448	8.55 (3.342)	720	15.45 (2.29)	3168	10.62 (4.41)
Population (millions)	2448	7.15 (5.29)	720	10.50 (8.05)	3168	8.15 (6.42)
Population Density	2448	67.51 (72.24)	672	82.22 (83.57)	3168	71.93 (76.10)
% Urban Population	2448	0.67 (0.17)	672	0.74 (0.13)	3168	0.69 (0.16)

[†]Weighted by population. $N =$ the number of observations.

TABLE 2: Determinants of Pollution Levels: with Structural Breaks†

	Nitrogen Oxide				Sulfur Dioxide			
	Break = 1971		Break = 1979		Break = 1971		Break = 1979	
Variable	Coefficient	Interaction	Coefficient	Interaction	Coefficient	Interaction	Coefficient	Interaction
Population	−2.3E-09	−1.4E-09	−5.6E-09	−1.3E-09	6.7E-09	−9.0E-09	7.0E-09	−4.6E-09
	(−2.672)	(−0.753)	(−6.815)	(−0.326)	(3.467)	(−2.096)	(4.049)	(−0.551)
Population Density	−2.0E-06	−1.0E-04	−4.3E-04	5.9E-04	0.001	−2.3E-04	4.8E-04	−5.7E-04
	(−0.027)	(−0.292)	(−6.156)	(0.819)	(5.899)	(−0.287)	(3.184)	(−0.372)
% Urban	−0.105	0.319	−0.067	0.242	−0.360	0.697	−0.642	0.874
	(−6.286)	(3.937)	(−3.773)	(1.720)	(−9.523)	(3.806)	(−17.025)	(2.920)
Income	2.5E-05	−6.1E-05	3.2E-05	−1.6E-05	7.3E-05	−4.4E-05	1.4E-04	7.4E-06
	(5.700)	(−2.865)	(6.805)	(−0.310)	(7.275)	(−0.916)	(14.282)	(0.069)
Income^2	−1.3E-09	3.3E-09	−2.2E-09	9.5E-10	−4.0E-09	−3.1E-09	−9.3E-09	9.1E-10
	(−2.310)	(2.225)	(−4.343)	(0.293)	(−3.211)	(0.908)	(−8.762)	(0.132)
Income^3	−2.8E-14	−1.1E-14	5.3E-14	−2.8E-14	−3.3E-14	4.8E-14	1.8E-13	−1.8E-14
	(−1.117)	(−0.285)	(2.736)	(−0.397)	(−0.571)	(0.540)	(4.488)	(−0.124)
$\bar{R}^2$	0.85		0.77		0.90		0.86	

†Notes: All regressions include state fixed effects, the state effects interacted with a dummy variable equal to 1 if $t > 1971$ (>1979), and time fixed effects. "Coefficient" reports the coefficient on the variable listed. "Interaction" gives the coefficient on the listed variables interacted with a dummy variable equal to one if $t > 1971$ (>1979). T-statistics in parentheses.

TABLE 3: Determinants of Abatement Costs: with Structural Breaks†

	PACE (Per Capita)		PACE (Per Dollar of Manufacturing Output)	
	Break = 1979		Break = 1979	
Variable	Coefficient	Interaction	Coefficient	Interaction
Population	−2.8E-06	1.1E-06	−2.1E-11	−1.2E-09
	(−0.350)	(0.134)	(−0.004)	(−0.224)
Population Density	0.722	−0.539	1.7E-04	−4.1E-04
	(0.490)	(−0.356)	(0.170)	(−0.406)
% Urban	−207.348	156.215	−0.082	0.038
	(−0.867)	(0.627)	(−0.511)	(0.220)
Income	0.003	0.018	1.0E-05	−8.3E-06
	(0.036)	(0.184)	(0.166)	(−0.128)
Income^2	−7.6E-08	−1.3E-06	−7.6E-10	3.9E-10
	(−0.010)	(−0.166)	(−0.152)	(0.077)
Income^3	−3.4E-12	2.6E-11	1.6E-14	−7.8E-15
	(−0.017)	(0.132)	(0.122)	(−0.059)
$\bar{R}^2$	0.49		0.34	

†Notes: All regressions include state fixed effects, the state effects interacted with a dummy variable equal to 1 if $t > 1971$ (>1979), and time fixed effects. "Coefficient" reports the coefficient on the variable listed. "Interaction" gives the coefficient on the listed variables interacted with a dummy variable equal to one if $t > 1971$ (>1979). T-statistics in parentheses.

the time fixed effects will miss that portion of the decentralization effect that is captured by the state fixed effects. When the break is assumed to occur in 1971, we clearly reject the nulls H_o: $\beta_1 = 0$ and H_o: $\beta_1 = 0$, $\alpha_{i1} = 0$.[12]

Forecast Comparisons

Table 5 presents the results from the first-stage estimation of (2), using data only from 1929–1971 or 1929–1979. The estimates shown are those used to forecast emissions and abatement expenditures during the period of decentralization. Figures 2–7 have the graphical results. Each panel depicts actual mean emissions or abatement costs across the states, as well as the predicted values under the various specifications of the time effects. Figures 2 and 3 display the results for per capita nitrogen oxide emissions, assuming the break occurs in 1971 (Figure 2) or 1979 (Figure 3). Figures 4 and 5 contain

[12]To ensure the robustness of the Chow test results, several variants of (1) were estimated (results available upon request): a standard panel model with heteroskedasticity-consistent standard errors, a standard panel model with heteroskedasticity-consistent standard errors that also allow for serial correlation within states, a panel GLS model allowing for panel-specific heteroskedasticity, a panel GLS model allowing for panel-specific heteroskedasticity and cross-sectional correlation, and a panel GLS model allowing for panel-specific heteroskedasticity, cross-sectional correlation, and AR(1) errors. In all cases, inferences based on the Chow tests were unaltered.

TABLE 4: Chow Tests for Structural Breaks†

Year of Break	Subset of Variables	Nitrogen Oxide	Sulfur Dioxide	PACE (Per Capita)	PACE (Per Dollar of Manufacturing Output)
1979	Controls Only	0.82	2.73	0.12	0.15
		[$p=0.53$]	[$p=0.02$]	[$p=0.99$]	[$p=0.98$]
	Controls + State	26.66	55.20	2.01	1.56
	Fixed Effects	[$p=0.00$]	[$p=0.00$]	[$p=0.00$]	[$p=0.00$]
1971	Controls Only	5.79	4.49		
		[$p=0.00$]	[$p=0.00$]		
	Controls + State	76.71	101.29		
	Fixed Effects	[$p=0.00$]	[$p=0.00$]		

†Notes: F-statistic and p-values associated with the null hypotheses H_o: $\beta_1=0$ and H_o: $\beta_1=0$, $\alpha_{i1}=0$ in (1).

the analogous results for sulfur dioxide. Finally, Figures 6 and 7 present the results for per capita PACE and PACE per dollar of manufacturing output, respectively, under the assumption of a break in 1979.

Predicted emissions levels—for both nitrogen oxide and sulfur dioxide—based on the post-1971 projections are substantially lower than actual emissions using the linear time trend, AR(1), and AR(2) models to forecast the time effects (Figures 2 and 4). The linear spline model, on the other hand, indicates

TABLE 5: Determinants of Pollution and Abatement Costs: Restricted Sample†

	Nitrogen Oxide		Sulfur Dioxide		PACE (Per Capita)	PACE (Per Unit of Manufacturing Output)
Variable	1929–1971	1929–1979	1929–1971	1929–1979	1973–1979	1973–1979
Population	−1.6E-09	−5.1E-09	8.0E-09	7.6E-09	−2.8E-06	−2.1E-11
	(−1.813)	(−5.932)	(3.963)	(3.972)	(−1.412)	(−0.021)
Population Density	7.4E-05	−3.7E-04	0.001	0.001	0.722	1.7E-04
	(0.973)	(−5.150)	(6.587)	(3.469)	(1.981)	(0.898)
% Urban	−0.091	−0.058	−0.336	−0.630	−207.438	−0.082
	(−5.302)	(−3.070)	(−8.577)	(−15.153)	(−3.499)	(−2.698)
Income	3.5E-05	4.0E-05	9.1E-05	1.5E-04	0.003	1.0E-05
	(9.968)	(10.610)	(11.314)	(18.105)	(0.147)	(0.875)
Income^2	−2.3E-09	−3.0E-09	−5.9E-09	−1.0E-08	−7.6E-08	−7.6E-10
	(−4.681)	(−6.688)	(−5.244)	(−10.500)	(−0.041)	−0.803
Income^3	1.0E-14	7.9E-14	3.7E-14	2.2E-13	−3.4E-12	1.6E-14
	(0.430)	(4.367)	(0.675)	(5.420)	(−0.070)	(0.639)
$\overline{R}^2$	0.90	0.87	0.95	0.91	0.83	0.77

†All regressions include state and time fixed effects.

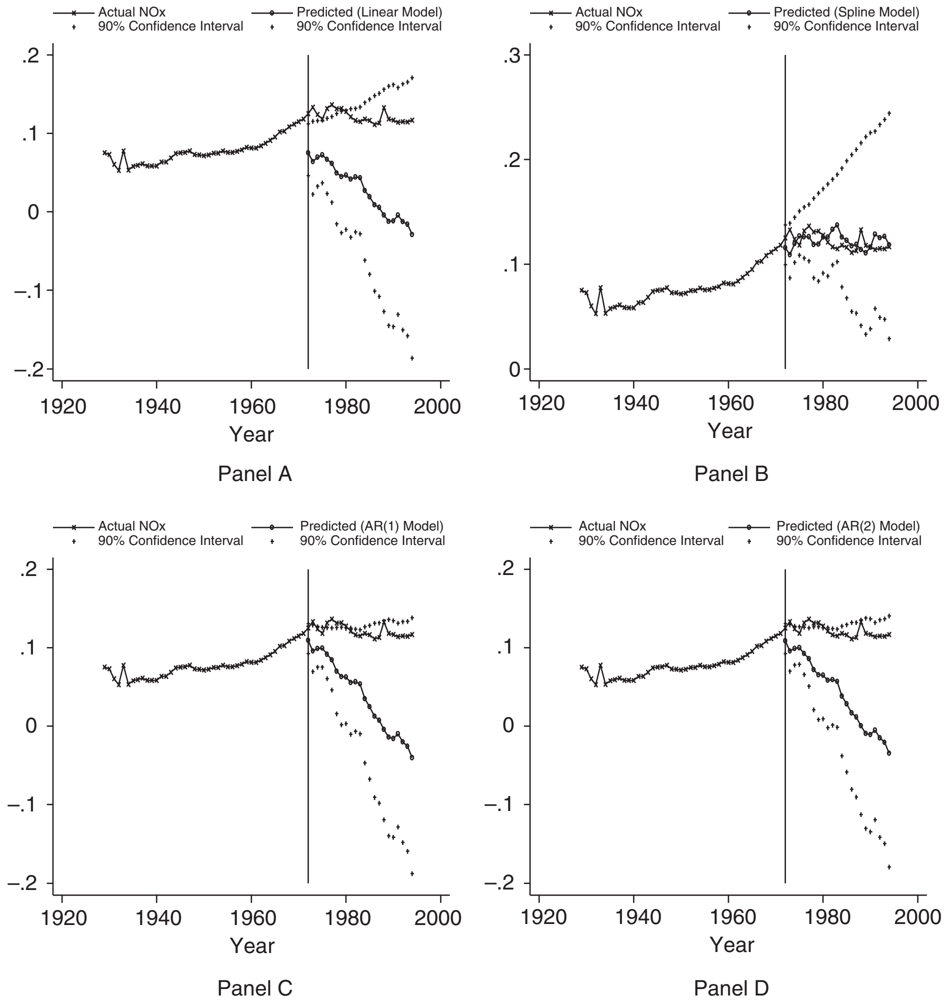

FIGURE 2: Actual and Predicted Mean per Capita NO_x Emissions by Year: 1972 Break.[†]

[†]Bounds represent 90% confidence intervals.

that actual and predicted emission levels were very similar. However, in all four specifications, rarely is the difference between actual and predicted emissions statistically significant. For nitrogen oxide emissions, actual emissions lie outside the confidence intervals for only a few years in the early 1970s in Panels A, C, and D (of Figure 2), corresponding to the linear time trend, AR(1), and AR(2) specifications, respectively. For sulfur dioxide, this happens only once (linear time trend model [Panel A, Figure 4] in 1973).

Analyzing the post-1979 projections (Figures 3 and 5), inferences about the effects of decentralization are more optimistic. For per capita nitrogen

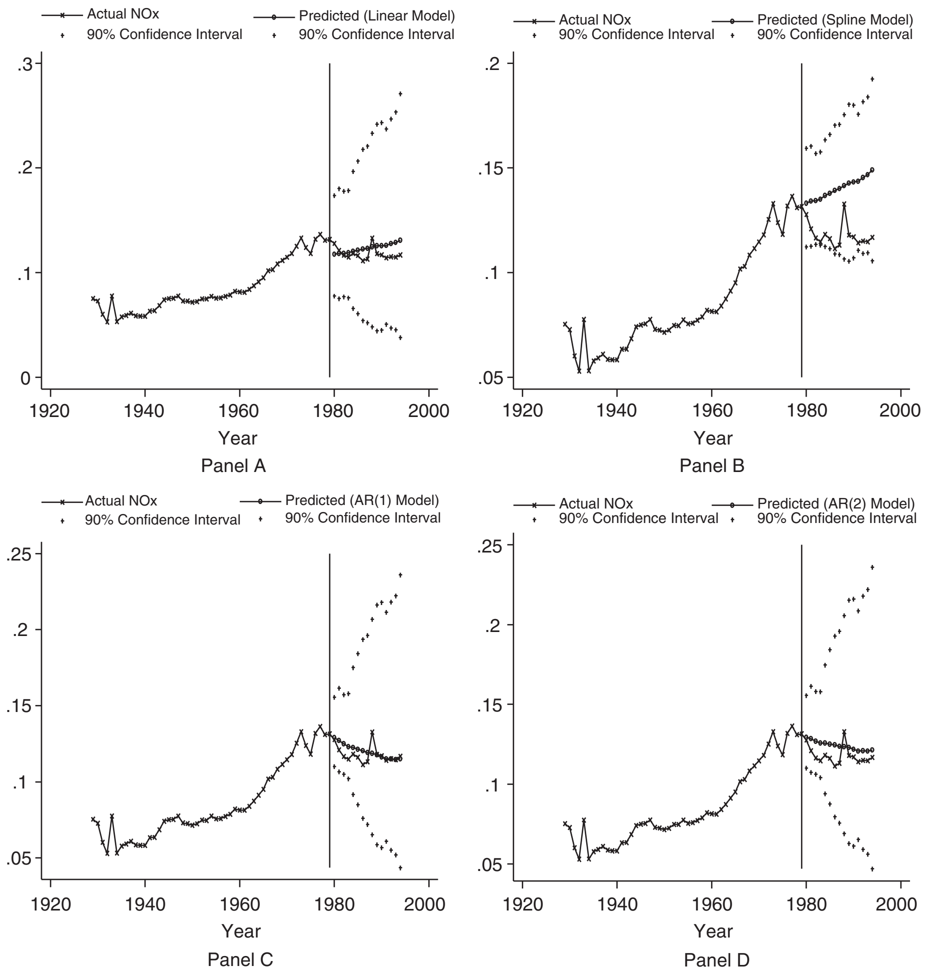

FIGURE 3: Actual and Predicted Mean per Capita NO_x Emissions by Year: 1979 Break.†

†Bounds represent 90% confidence intervals.

oxide, despite the wide confidence intervals, actual emissions were modestly below projected emissions regardless of the specification used to model the time effects. For sulfur dioxide, the linear spline and linear trend specifications show that actual per capita sulfur dioxide emissions were above forecasted levels under Reagan and Bush, especially by the late 1980s and early 1990s. However, the AR(1) and AR(2) models yield results consonant with the nitrogen oxide results; namely, actual emissions below projected levels (although, again, the width of the confidence intervals implies one cannot reject the null of equality between actual and predicted emissions in any given year).

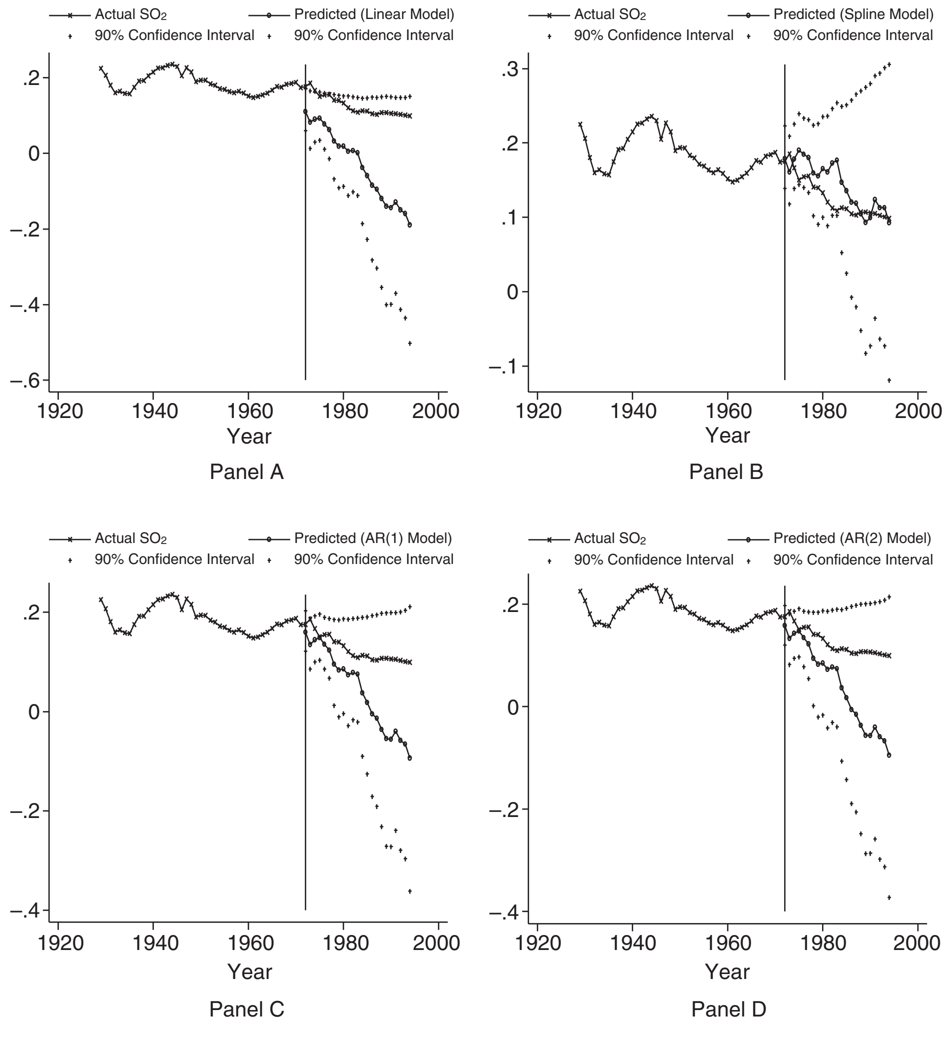

FIGURE 4: Actual and Predicted Mean per Capita SO_2 Emissions by Year: 1972 Break.†

†Bounds represent 90% confidence intervals.

Viewing the results from Figures 2 to 5 as a whole suggests that environmental quality (as measured by per capita nitrogen oxide and sulfur dioxide emissions) worsened in the 1970s, during the first phase of decentralization. However, decentralization in the environmental arena, which began after Reagan took office in 1980, appears to have slowed this deterioration, and may have even reversed it (although the reversal is not statistically significant).

Figures 6 and 7 depict the actual and predicted levels of per capita PACE and PACE per dollar of manufacturing income. For both measures of abatement

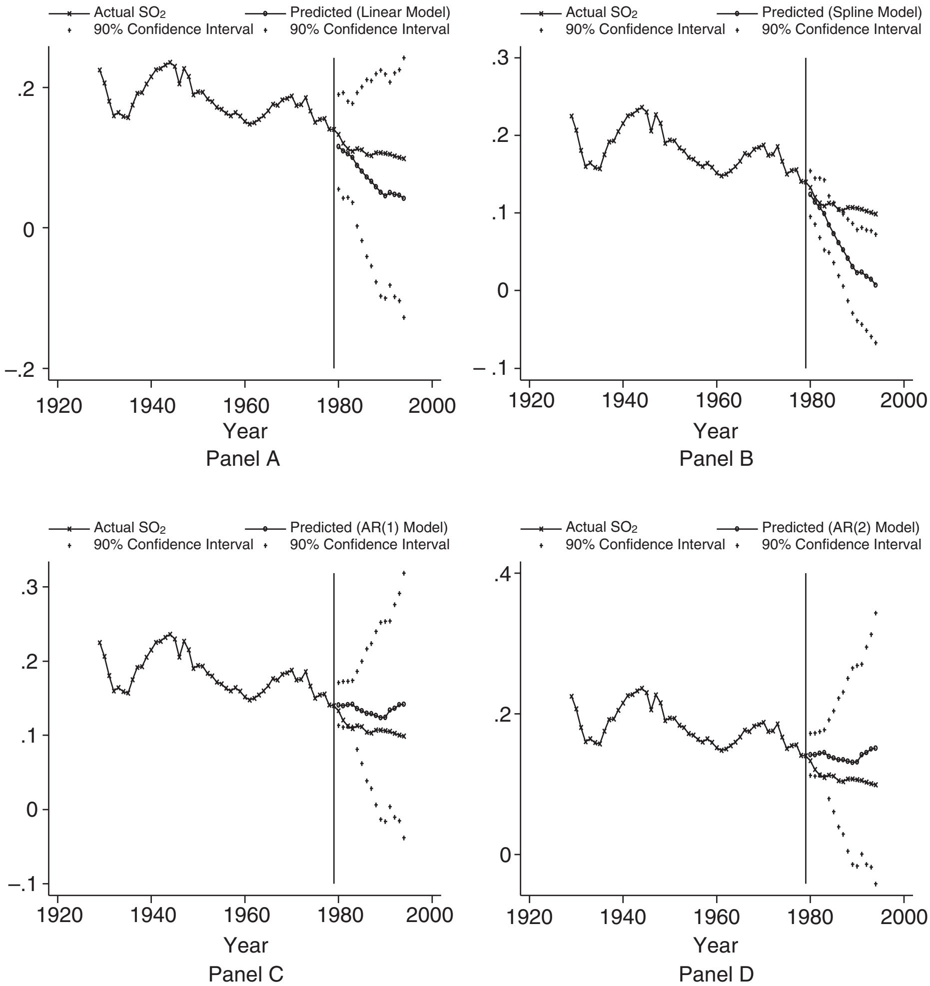

FIGURE 5: Actual and Predicted Mean per Capita SO_2 Emissions by Year: 1979 Break.†

†Bounds represent 90% confidence intervals.

costs, there is little difference between predicted and actual levels during the early and mid-1980s. From the late 1980s on, however, both measures of pollution abatement expenditures were above projected values, with the differences being statistically significant from about 1989 on. The results are consistent with the argument that states were initially constrained financially during Reagan's first term in office and, hence, there was little change in regulatory stringency during that time; subsequently, however, states strengthened regulations beyond their projected levels (the NIMBY effect). Thus, whereas the results based on emissions are not overly conclusive, this is

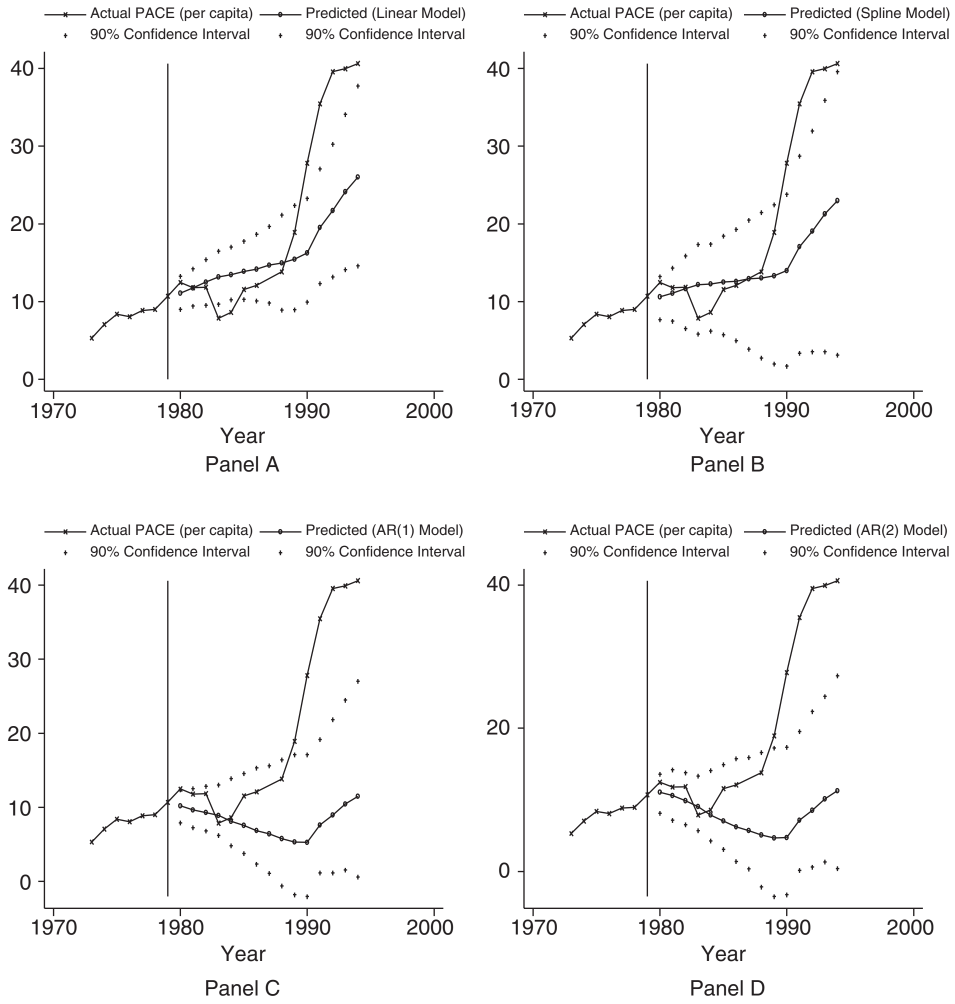

FIGURE 6: Actual and Predicted Mean per Capita Abatement Expenditures by Year: 1979 Break.†

†Bounds represent 90% confidence intervals.

strong evidence that decentralized environmental policy contributed to a race to the top in abatement expenditures.

6. CONCLUSION

The debate over the effects of decentralized policymaking on environmental quality has received a great deal of attention in the theoretical literature. Although the predictions of these theories are inconclusive and range from a race to the top, a race to the bottom, or no effect, little empirical research has

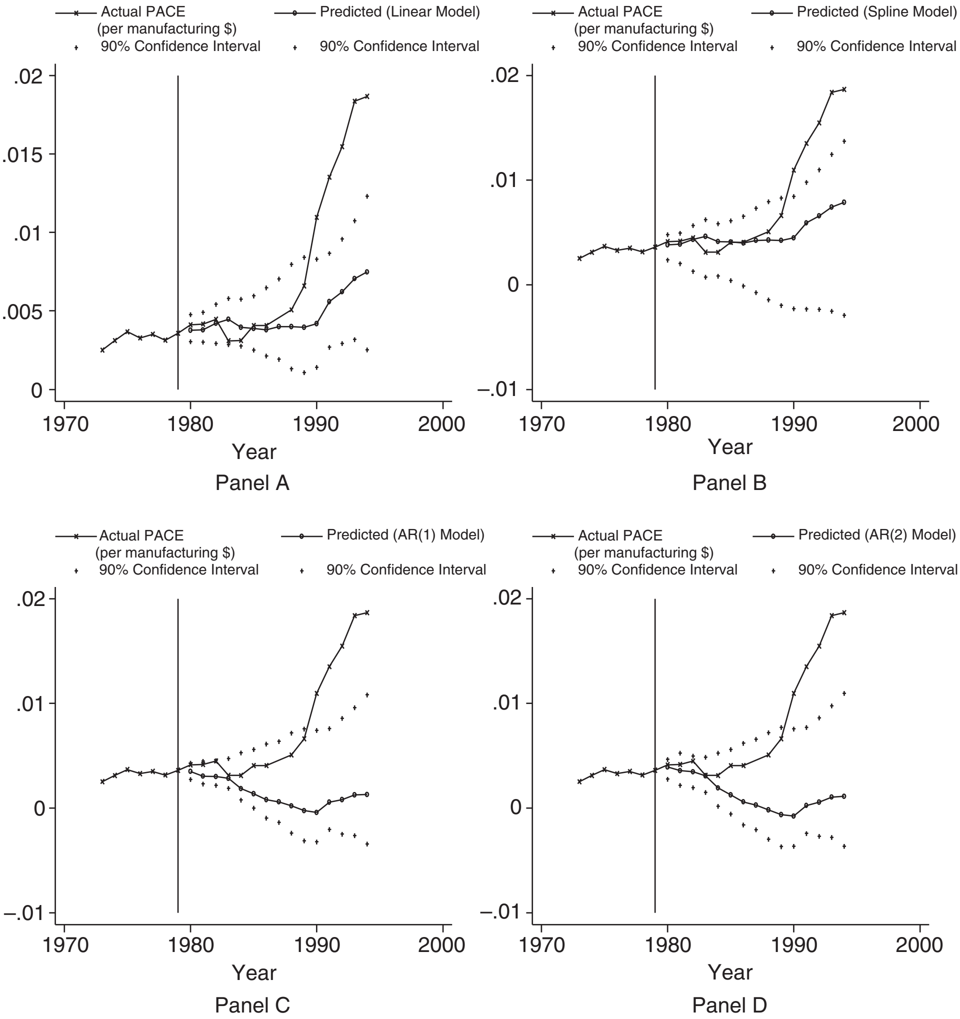

FIGURE 7: Actual and Predicted Mean Abatement Expenditures per Unit of Manufacturing Output by Year: 1979 Break.[†]
[†]Bounds represent 90% confidence intervals.

been conducted. Given the importance of understanding the optimal level of governance for environmental policymaking, this omission is surprising. In addition, the results may have implications for other policy areas such as welfare, where researchers have been wary of states engaging in a race to the bottom regarding benefit levels to discourage the in-migration of potential welfare recipients (see Brueckner [2000] for a nice review).

This paper fills the gap by examining the effect of Reagan's rapid decentralization of environmental policy on emissions levels and abatement expenditures by states. In a matter of months, Reagan substantially reduced federal involvement in environmental issues and cut federal grants that had supported states' pollution control efforts. By projecting environmental quality using data before Reagan's policy shift and comparing the predicted levels with the actual levels, one can infer the effects of this shift. Although there may have been other changes occurring at the same time that may explain deviations of actual levels from predicted levels, the magnitude of the changes under Reagan are assumed to dominate alternative explanations. However, decentralization in other policy areas had begun during the 1970s and, in an attempt to disentangle the effects of decentralization generally from Reagan's environmental decentralization, different predictions are formed based on different truncation dates in the data.

The results are striking, suggesting that environmental decentralization did instigate a race to the top in pollution control expenditures by the mid-1980s when the financial position of states improved. Nitrogen oxide and sulfur dioxide emissions results are less conclusive, but suggest that environmental decentralization may have halted the deterioration of air quality that began in the 1970s. Unfortunately, these findings may produce new questions. Future examination of decentralization on other measures of environmental quality appears warranted. Moreover, further analysis of the robustness of the positive effect of decentralization on abatement expenditures is also desirable. Nonetheless, that all four measures of environmental quality yield no statistically significant negative impact of environmental decentralization—consonant with the results in List and Gerking (2000)—suggests that many environmentalists and policymakers may be forced to view decentralization in a new light.

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