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"COOPERATIVE FEDERALISM" AS A STRATEGIC INTERACTION: VOLUNTARY DECENTRALIZATION IN ENVIRONMENTAL POLICY

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ABSTRACT

Under most U.S. environmental laws and some health and safety laws, states may apply to implement and enforce the law, through a process known as authorization or primacy. The paper presents a simple model of the strategic interaction between the federal and state governments with such voluntary decentralization. The model suggests that the federal government may design the policy so that states that desire stringent regulation authorize, whereas other states remain under the federal program. We then test the implications of this model using data on U.S. water pollution and hazardous waste regulations, two of the most important environmental programs to allow authorization. Consistent with the results of our model, we find that states with stronger environmental preferences authorize more quickly and more fully under both policies. This evidence runs counter to concerns that states use control of their programs to undercut federal environmental standards.

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For decades, policy analysts have debated the optimal level of government to undertake environmental regulation and other government activities. These issues arise in the European Union as devolution of decision-making to member states and in the U.S as federalism. Oates (2002) argues that the optimal level of government depends on the type of environmental problem. For the many common pollutants with regional impacts, neither decentralized nor centralized regulations may be optimal. Recent theoretical literature has focused on concerns about destructive competition (possibly a "race to the bottom") that can result from decentralization and the distributional politics that may arise from centralized decision-making.[1]

In this paper, we explore the empirical implications of decentralization by examining a process in U.S. environmental policies through which states can voluntarily take control of their implementation and enforcement of environmental programs. The process is known as granting the state "authorization" or "primacy" and is available in most major U.S. environmental regulations and some other types of regulations. The resulting hybrid of state and federal regulation is an important aspect of the general approach known as "cooperative federalism." We build a simple model of the strategic interaction between the states and the federal government with endogenous federal regulatory stringency and state prerogative in authorization. This model suggests conditions under which states will want to authorize, which we test using data on two U.S. environmental policies. We also explore the empirical concern that states use authorization to undercut federal standards (Flatt, 1997; U.S. General Accounting Office (GAO), 1995).

[1] Destructive competition arises in models of local public goods in which redistributive taxes yield competition for scarce capital and excessively lenient regulations (Oates and Schwab, 1988; Wilson, 1996). For recent theory on destructive competition, see Levinson (2003) and Kunce and Shogren (2005). For the political economy of centralization, see Seabright (1996), Besley and Coate (2003) and Lockwood (2002).

We study decentralization under the Clean Water Act (CWA), which regulates water pollution, and the Resource Conservation and Recovery Act (RCRA), which regulates hazardous and solid waste. Under both of these acts, the federal government establishes uniform minimum standards, but states may decide to apply for authorization, which gives them the right to implement, monitor, and enforce their own standards. Despite the restrictions imposed by federal standards, authorized states have considerable discretion (U.S. GAO, 1996). Our empirical analysis evaluates the factors that explain whether a state receives authorization under each of the laws early, late, or not at all. Since both laws allow degrees of authorization, where states can be authorized for a subset of the regulations, we also briefly explore the determinants of the extent of authorization.

Our principal focus is on the role of preference heterogeneity in determining authorization. If, as some policy literature claims, authorized states use their discretion to weaken environmental protection, less "green" states would authorize earlier. However, in our incomplete contract model of authorization, states with stronger preferences for environmental control authorize sooner in response to endogenously set federal environmental stringency. This prediction is tested empirically. We also test for a "U-shaped" relationship in which states with median preferences are most content with centralized regulations, while those with preferences far from the median in either direction tend to authorize sooner.[2] Our empirical results are consistent with the effect predicted by our model: states with relatively high environmental preferences authorize sooner under both the CWA and the RCRA.

[2] Strumpf and Oberholzer-Gee (2002) test the hypothesis that preference heterogeneity across localities increases the likelihood of decentralized institutions, looking at the level at which liquor regulation occurs. We test a related proposition: the more a community's tastes differ from the average, the more they wish to have control of their policies.

In addition to exploring the role of environmental preferences, we test a few other hypotheses about the determinants of authorization. We do not find evidence that states authorize earlier to take advantage of economies of scale or of opportunities to free ride.

The rest of this paper is structured as follows. Section 1 gives background on authorization under the CWA and RCRA, as well as a discussion of previous literature. Section 2 develops a model that is consistent with some stylized facts of authorization. Section 3 describes the proposed main determinants of authorization and the variables chosen to represent them in our empirical analysis. Section 4 presents the empirical results of duration models of the time until authorization. Section 5 shows regressions in which the dependent variable is not when a state authorizes, but the intensity of authorization, measured by the number of sections of the CWA and RCRA for which a state is authorized. Section 6 concludes with policy implications and directions for future research.

1. Authorization under the CWA and RCRA

The CWA and RCRA are two of the most important policies that allow authorization.[3] Under both of these acts, the federal and regional EPA offices act as the default administrator; a state must take initiative to apply for authorization. If states can demonstrate to the EPA that they will adopt legislation that is at least as stringent as the federal standards and have the means to fund the implementation and enforcement of the policy, they can receive authorization. Since the EPA's criteria for acceptance are public knowledge, states will only incur the cost of applying for authorization if they have met all of the requirements. The EPA usually requires

[3] The Clean Air Act (CAA) also allows state delegation. However, the CAA differs from the CWA and the RCRA in that the default implementation responsibility lies with the states, which are required to develop State Implementation Plans. Other federal environmental regulations mostly follow the authorization approach (ECOS, 2006).

amendments to a state's proposed implementation plan and holds public hearings on the application throughout the state before it grants authorization (Freeman, 2000; Helland, 1998). A search of the *Federal Register* did not turn up any instances of a state's application being denied.

Once authorization is granted, it is seen as infeasible to retract, although the EPA is legally entitled to do so. For example, Arkansas refuses to impose federal discharge limits and monitoring requirements for municipal water pollution sources on the grounds that they are too strict. However, the regional EPA office says that taking responsibility back from Arkansas is "an unrealistic option" (GAO, 1996, p. 6). In addition, it is rare for the federal government to "overfile," that is, impose penalties on facilities in an authorized state where enforcement actions have been deficient (Helland, 1998).[4]

Cutter and DeShazo (2007) provide the first formal analysis of voluntary decentralization, studying a policy in which California counties could devolve responsibility for enforcement of an underground storage tank program (under RCRA) to cities.[5] They include a multi-equation model that explains cities' decision to seek and counties' decision to grant authority simultaneously with the intensity of enforcement effort. They conclude that higher enforcement effort in delegated cities is the result of selection by both parties (the counties and the cities) and that predictions about the effect of decentralization should consider this selection.

Our research differs in several ways. Most obviously, we address different decision-makers and policies. The strategic interaction we study is also fundamentally different. Unlike

[4] On September 16, 1999, the U.S. Court of Appeals for the Eight Circuit ruled that the federal EPA could not take enforcement action over Harmon Industries' violations of the RCRA where the State of Missouri had already acted, even though the EPA found the state penalties to be lax (http://www.troutmansanders.com/mc/a-83100-p.html).

[5] Similar questions have also been addressed in the political science literature. Meyer and Konisky (2007) find that a number of characteristics cause local communities to take control under a Massachusetts wetland protection program.

the counties in Cutter and DeShazo's model, the federal government does not seem to have veto power over delegation, complicating its strategic problem. We focus on the ways the federal government may use its discretion over the stringency to address this problem. In our model, spillovers are central to the central government's motivations, linking our research with the concerns of the federalism literature. Our empirical work examines only the decision to seek authority; this revealed preference provides a test of the model without the strong assumptions needed to identify separately the effects of authorization from its causes.

Earlier theoretical research on federal-state authorization has focused on the question of which functions should be undertaken by the federal government and which should be undertaken by the states. CBO (1997) provides an informal analysis, and Lin (2006) a formal analysis, of who should have control of standard-setting versus monitoring and enforcement.

A few empirical previous studies have explored federal-state authorization. Sigman (2003) reviews the literature on authorization and provides informal analysis of some of the hypotheses tested formally here. Woods (2006) conducts a factor analysis of authorization dates in a cross-section and concludes that they are not related to the "innovativeness" of states environmental policies. Helland (1998) finds an insignificant effect of authorization on the probability of inspection of paper and pulp facilities under the CWA. Sigman (2005) presents evidence that authorization under CWA allows free riding between states. Outside the environmental area, Morantz (2007) finds delegated states laxer at enforcing federal employment safety laws than the federal government.

Other studies look indirectly at the effects of authorization. List and Gerking (2000) and Millimet (2003) look at the changes before and after 1980, when the Reagan Administration scaled back the central government's role in U.S. environmental policy, implicitly providing the states more authority. List and Gerking conclude that no change in environmental spending or air pollution arose after 1980, whereas Millimet finds an increase in spending (but not air pollution) by the mid-1980s. Using this same break in federal policy, Levinson (2003) finds that regulatory competition between states became more aggressive after 1980.

1.1 The Clean Water Act (CWA)

Under the Water Pollution Control Act of 1948, individual states had sole responsibility for setting, implementing and enforcing standards, while the federal role was one of oversight. Over time, this arrangement became viewed as problematic for a number of reasons. One of them was that "states varied enormously in their commitment to pollution control objectives" (Freeman 2000, p. 173). The 1972 Federal Water Pollution Control Act (which later became known as the CWA) gave the federal government control over establishing minimum effluent limits (restrictions on quantities, rates and concentrations of chemical, biological and physical pollutants that can be discharged into navigable waters) and issuing permits under the National Pollutant Discharge Elimination System (NPDES). Industrial facilities and publicly owned treatment works (POTWs) need a NPDES permit to discharge pollutants into navigable waters. The 1972 act also included a provision allowing authorization. Once a state is granted the right to issue NPDES permits, it follows the guidelines it has established under its authorizing legislation, rather than the federal standards.

The EPA allows partial state delegation of its policies. In 1972 the only section of the CWA for which states could be authorized was base NPDES permitting. As new sections were added to the CWA, state authorization became available for them as well. Currently there are five sections of the CWA for which a state can receive delegation: base NPDES permitting, general permitting, regulation of pretreatment programs and standards for POTWs, NPDES permits for federal facilities, and the management of biosolids (sewage sludge) disposal. At a minimum, all authorized states have responsibility for base NPDES permitting. States can apply for additional authorization under any combination of the remaining four sections. If a state is not already authorized under a certain section it can apply to do so at any time in the future. As shown in Table 1A, all of the forty-five states with some delegation under the CWA have authorization over NPDES and general permitting. New Mexico, Alaska, Massachusetts, New Hampshire and Idaho are not currently authorized under any sections of the CWA. The distribution of the authorization duration, defined as the number of years from 1972 (when state delegation was first allowed) until authorization for the base NPDES, is shown in Table 2A. Over half of the states were authorized under the base NPDES policy in the first three years.

1.2 Resource Conservation and Recovery Act (RCRA)

The RCRA first emerged as amendments to an older law (1965 Solid Waste Disposal Act) in 1976 and was substantially strengthened by Congress with the Hazardous and Solid Waste Amendments (HSWA) in 1984. The EPA first allowed state delegation under the base RCRA program in 1982. This base program governs the permitting of hazardous waste facilities and establishes requirements for safe recycling, composting, storage and disposal of waste. Permits issued under RCRA are more standardized than NPDES permits, as they rely more heavily on federal technology standards. Thus authorization under RCRA gives states less discretion than under the CWA to adjust permit emission limits. Authorization still provides control over the inspections of facilities and the enforcement of penalties in the case of wrongdoing.

In addition to the base program, states can be authorized under other components of the RCRA, such as HSWA and Corrective Action, a program for clean up of active hazardous waste facilities. Instead of measuring the number of sections, the EPA reports the percentage of total RCRA regulations for which the state has received authorization. The distribution of this percentage across states is given in Table 1B. Two states, Alaska and Iowa, are not currently authorized under any part of the RCRA, although they may have state programs that are similar to the federal statutes. As with the CWA, this paper focuses on the initial decision to seek authorization under the base RCRA policy. Table 2B tabulates the number of years from 1982 until states first received base authorization (the authorization duration). The vast majority of the states (80%) sought authorization in the first 4 years.

Certain states are authorized under the RCRA but not under the CWA and vice versa. The correlation between the authorization duration under the CWA and RCRA is only 0.04. The number of sections for which a state is authorized under CWA and the percentage of the RCRA for which it is authorized have a correlation of 0.20. These low correlations indicate that policy-specific factors determine authorization. It will therefore be necessary to study the two acts separately.

2. A Model of Authorization

To provide a background for our empirical analysis, we consider a model of authorization as a strategic interaction between the EPA and the states. For simplicity, there are only two states, labeled i and j, and one central official, the EPA.[6] The EPA and each of the states play the following two-stage "game" repeatedly until the state decides to authorize.

In the first period, the EPA chooses a uniform level of regulatory stringency for states that do not authorize, $R_{N,t}$, and a fixed cost of applying for authorization, C_t^A. $R_{N,t}$ represents not just the regulatory standards, but also the effective stringency resulting from policy implementation, monitoring, and enforcement. As under the pure form of the Decentralization Theorem, the central regulation and authorization costs are uniform across states, perhaps because the EPA has limited information or faces other political or legal constraints. However, the EPA does have some information about states, such as the distribution of environmental preferences.

In the second period, each state simultaneously and independently decides whether or not to apply for authorization. In deciding to apply for authorization, the state will compare its expected utility under the centralized regulation to its expected utility under authorization. If the latter is greater, the state will choose to authorize.

2.1 State decision-making

If a state does not authorize, it accepts the federal stringency and does not incur any monitoring costs, although it still incurs some compliance costs. The utility function for state i if it does not authorize (N) is as follows:

$$U_i^N(R_{N,t}, \delta E[R_{j,t}], X_{i,t}) = \gamma_{i,t}V(q(R_{N,t} + \delta E[R_{j,t}]), X_{i,t}) - C^I(R_{N,t}, X_{i,t})$$

where $\gamma_{i,t}$ is state i's preference for environmental regulation, and $V(q(R_{N,t} + \delta E[R_{j,t}]), X_{i,t})$ is state i's benefit from regulation, and $C^I(R_{N,t}, X_{i,t})$ is the compliance cost associated with the regulatory stringency. The benefit of regulation, $V(q(R_{N,t} + \delta E[R_{j,t}]), X_{i,t})$, is increasing and

[6] Assuming only one central official simplifies the model greatly and prevents the interesting, although complex, analysis of the interaction between various branches of government, such as between the executive and legislature.

concave in each argument and depends upon q, the quality of the environment, and $X_{i,t}$, a matrix of state and time-varying characteristics. The quality of the environment, q, in turn depends on the stringency of regulation, $R_{N,}t$, the expected regulation in the other state, $E[R_{j,t}]$, and the level of spillover effects (externalities) from state j to state i, δ ($0 \leq \delta \leq 1$). If $\delta = 0$, regulation provides a local public good; if $\delta = 1$, regulation provides a pure public good; and if $0 < \delta < 1$, regulation has local spillover effects.[7] The compliance cost function, $C^I(R_{N,t}, X_{i,t})$, is increasing and convex in the stringency of the relevant regulation and other state characteristics.

If the state applies for and receives authorization, it may implement a different level of regulatory stringency but will incur the monitoring costs. (If the state is not authorized, this cost is borne by the EPA.) The state's utility under authorization (A) has nearly the same form as above:

$$U_i^A(R_{i,t}, \delta E[R_{j,t}], X_{i,t}) = \gamma_{i,t} V(q(R_{i,t} + \delta E[R_{j,t}]), X_{i,t}) - C^I(R_{i,t}, X_{i,t}) - C^M(X_{i,t}),$$

except that the state's own regulation, $R_{i,t}$, substitutes for the federal one and we add the monitoring cost, $C^M(X_{i,t})$, which can depend on state characteristics.

State i will decide to apply for authorization if its utility under authorization, which is its authorized utility minus the cost of achieving authorization, is greater than its utility with no authorization:

$$U_i^A(R_{i,t}, \delta E[R_{j,t}], X_{i,t}) - C_t^A \geq U_i^N(R_{N,t}, \delta E[R_{j,t}], X_{i,t}), \quad (1)$$

If equation (1) holds, the state will apply for authorization by sending the EPA its proposed regulation under authorization: $\check{R}_{i,t}$. This proposed policy may or may not equal the actual regulation it will set once granted authorization, $R_{i,t}$. The states know that the EPA will only authorize a state whose proposed policy is at least as stringent as the EPA's. States whose

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[7] Spillovers are common for water pollution because interstate rivers carry pollution into downstream states. Hazardous waste can also cause interstate environmental spillovers, for example through air pollution or migration

preferred regulation under authorization is less stringent ($R_{i,t} < R_{N,t}$) could apply for and receive authorization by sending the appropriate proposal to the EPA ($\check{R}_{i,t} \geq R_{N,t}$). As discussed in Section 1, authorization has never been rescinded, and authorized states are not typically punished for lax implementation and enforcement. Thus, states have no incentive to tell the truth when applying. The EPA may not be able to differentiate $\check{R}_{i,t}$ from the expected $R_{i,t}$ or may face political constraints on doing so.

2.2 The EPA's behavior

Although the EPA cannot control who receives authorization through the application process, it does control the centralized alternative $R_{N,t}$ and the authorization cost C_t^A. Through these variables, it can prevent certain types of states from applying for authorization if it has some knowledge of the distribution of state preferences.

A variety of motivations might underlie the EPA's decisions, but we start by assuming that it seeks efficiency. The EPA faces two conflicting effects in designing an efficient policy (Oates, 2002). On the one hand, pure decentralization (or a very low C_t^A so that every state authorizes to adjust its stringency even slightly from $R_{N,t}$) provides the usual flexibility advantages and is efficient in the absence of spillovers ($\delta = 0$). On the other hand, pure centralization (or a very high C_t^A) provides a response to spillovers and would be efficient with $\delta > 0$ if all states are identical.

By providing an intermediate policy between pure centralization and pure decentralization, the authorization process can provide some of the advantages of each extreme. To reduce the costs of spillovers, the EPA can force states that create the highest interstate external costs to have more stringent regulation than they would choose for themselves: it can

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of contaminants in groundwater.

choose an $R_{N,t}$ somewhat greater than $R_{i,t}$ of the worst free riders and a C_t^A high enough to prevent them from applying for authorization. However, a high C_t^A may raise costs by imposing too much uniformity; to avoid these costs, the EPA may have to limit its controls on spillovers, by setting $R_{N,t}$ not too much above $R_{i,t}$ of these states.

For a simple case, consider a model in which there are two types of states that differ only in environmental preferences, $\gamma_{i,t}$: some states desire a high level of environmental protection (high type) and the other desire a low level of protection (low type). With no other heterogeneity and pure decentralization, the low type states are the source of the greatest external costs, both because they produce the highest pollution and because their high type neighbors experience higher disutility for any given amount of pollution when $\delta > 0$. Thus, the EPA might wish to set $R_{N,t}$ and C_t^A such that only the high type authorizes. In this simple example, it would set $R_{N,t}$ such that $R_{L,t} < R_{N,t} < R_{H,t}$, where $R_{L,t}$ and $R_{H,t}$ represent the privately-optimal regulation of the low and high type states, respectively. In particular, it could set the $R_{N,t}$ at the globally optimal level for the low type state (conditional on $R_{H,t}$, which will be lower than optimal because of free riding) and C_t^A just slightly above the gains that a low-type state could achieve with authorization:

$$U_L^A(R_{L,t}, \delta E[R_{j,t}], X_{i,t}) - U_L^C(R_{N,t}, \delta E[R_{j,t}], X_{i,t}) < C_t^A$$

If the high type still wants to authorize, i.e. if

$$U_H^A(R_{H,t}, \delta E[R_{j,t}], X_{i,t}) - U_H^C(R_{C,t}, \delta E[R_{j,t}], X_{i,t}) \geq C_t^A$$

then the decision to set $R_{N,t}$ at its efficient level for the low type state may be optimal. If, however, the required C_t^A to keep the low type state from authorizing (and thus free riding) is so high that it also keeps the high type from authorizing, $R_{N,t}$ may need to be lowered below its optimum. Alternatively, if the externalities are severe enough, the EPA may choose an effectively centralized system by keeping a high C_t^A and suitably adjusting $R_{N,t}$.

With real-world heterogeneity, the strength of externalities and environmental preferences are not directly linked, but tend to be correlated for the same reasons as above. Thus, it seems likely that the most efficient policy will target lower type states for federal control and allow “greener” states to authorize. This division is accomplished by shifting the federal stringency, $R_{N,t}$, toward the low end of the range of $R_{i,t}$ that states would choose under pure decentralization, so that the gains to authorization are small for these states and C_t^A may be kept low. The chosen level of $R_{N,t}$, is probably lower than the level the EPA would set under pure centralization for similar reasons.

With low correlation between external costs and desired stringency or great diversity in state preferences, authorization may not be monotonic in environmental preferences. Even with endogenously set $R_{N,t}$ and C_t^A, states may authorize on either side of the preference distribution because the gains to doing so exceed C_t^A for both extremely high and low type preferences. This sort of pattern underlies the “U-shaped” hypothesis tested later.[8]

Even if the EPA does not pursue efficiency, several other objectives might lead to it to create conditions in which “greener” states selectively authorize. Such goals include an effort to increase the stringency of regulation above what would arise with pure decentralization or to ensure a certain level of environmental protection at a lower cost to the central government than pure centralization. Assuming that the central government wants to establish minimum standards at the lowest cost to itself may be realistic. For example, Freeman (2000) argues that

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[8] A U-shape might also arise if the federal stringency, $R_{N,t}$, is set — for example, by a federal legislature — to embody simply median voter preferences, without attention to the effects of the authorization game.

one of the goals of the 1972 CWA was to combat variation in the levels of water pollution regulation under the earlier decentralized policies.

All of the variables in the model can depend upon time. If equation (1) does not hold for a state in period 1 (t = 1), the state chooses not to apply for authorization. In the next period, those states that have not yet authorized will play the same two-stage game with the EPA. For this reason, all of the variables in the model can depend upon time. The decision of a state to authorize at time t depends upon its preferences and costs, as well as the centralized alternative at that time. Preferences at the federal level may also change over time, resulting in more stringent or more lenient central standards. Changes in these variables and in state characteristics could cause some previously unauthorized states to apply for authorization. These changes explain the timing of the authorization decision.

3. Empirical implementation

The discussion above shows that the decision to apply for authorization at time t depends crucially on several variables: the centralized alternative to authorization ($R_{N,t}$), the cost of applying for authorization (C_t^A), state characteristics ($X_{i,t}$) and environmental preferences ($\gamma_{i,t}$). Since these variables can change over time, their paths will determine both if and when a state chooses to apply for authorization. Therefore, we employ a duration model with time-varying covariates for our empirical analysis. The Appendix discusses the duration model in detail. This section describes the empirical representations of the variables $\gamma_{i,t}$ and $X_{i,t}$ from the model.

The principal hypotheses to be tested concern environmental preferences, $\gamma_{i,t}$. The model presented in Section 2 indicates that the EPA may establish an authorization policy such that only the high $\gamma_{i,t}$ states want to authorize if it wants to control free riding or ensure a certain level of environmental protection at a lower cost. If so, empirically we should find that characteristics indicative of high-type states (those with high environmental preferences) lead shorter durations. However, the model also suggests the possibility that states with extreme preferences (very high and very low) should authorize quickly.

To measure the level of concern about the environment, γ_{it}, the estimated equations use the average League of Conservative Voting (LCV) score of the state's delegation in the House of Representatives.[9] The LCV score is the percentage of times a legislator voted with the LCV's position on environmental legislation in that particular year.[10] The average LCV score is time varying and, because it results from elections, may represent the preferences of influential voters in the state. The specifications include either the level of LCV scores or dummy variables for high LCV (top third of the distribution) and low LCV scores (bottom third of the distribution).

Descriptive statistics for the LCV scores and other covariates are shown in Table 3 separately for the CWA and RCRA datasets. To weight each state equally, means of the variables were first taken over all of the years each state is in the dataset and then the presented statistics were calculated from these state means. The levels of variables can differ between the CWA and RCRA datasets because a given state is in each data set during different periods. In particular, states were often candidates for CWA authorization only in the 1970s, rather than the 1980s for RCRA.

We also examine a number of other possible determinants of the authorization decision. Similarity between the state's preferences and that of the federal government may affect the desire of states to control their environmental programs. This hypothesis is addressed above by

[9] The House rather than Senate delegation is chosen because it has the potential for more rapid adjustment to changes in preferences and because for most states the House offers a larger number of individual legislators, reducing noise in the average.

[10] An alternative measure of environmental preferences is membership in three major national environmental organizations. However, it is difficult to get this data at high frequency. In addition, this measure may capture the thickness of the tail of the preference distribution rather than the position of influential voters.

looking for authorization in states that deviate most from median environmental preferences. To look at this hypothesis from another angle, we consider the match between federal and state political parties. For example, if Republicans control Congress and the White House, previously unauthorized Democratic states may choose to authorize. The variable "Match" equals one if the President's political party is the same as the majority party in the state legislature and zero otherwise.[11]

The model emphasizes the importance of interstate spillovers as a motivation for the federal government to retain control over state programs. We consider two variables that might indicate the extent of spillovers. First, almost all watersheds in interior states are upstream of another state, so interior states have more opportunity to free ride under the CWA than coastal states. As a result, the CWA equations include a dummy variable that equals one for states on the coast and zero otherwise. Second, the potential for spillovers is greatest in border regions (Kahn, 2004; Helland and Whitford, 2003). States with larger land areas have a smaller share of border regions and thus may be less likely to free ride.

The equations also include variables for the income and population of the state. Both of these measures are included to control for the availability of resources within the state which might facilitate the state taking control of environmental programs. Large and wealthy states may have better organized state governments and thus shorter times to authorization. We would like to separate these effects from the effects of environmental preferences, with which they may be correlated. In Table 3, income is much higher for the RCRA than the CWA data set, largely reflecting the later period of the RCRA data set.

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[11] Match is based on biennial data on political parties from the U.S. Statistical Abstract (www.census.gov). Nebraska has only one chamber of 49 members that are elected without party designation. Match equals 0 for all years for Nebraska.

The equations also include a measure of manufacturing industry concentration in the state, a Herfindahl index of income from manufacturing by two-digit SIC. This variable may affect the desire to authorize for several reasons. First, a higher concentration could mean that the manufacturing industry exerts more influence on local politicians. If they can persuade local governments to establish more lenient standards, states with higher Herfindahl indices may authorize sooner. Second, the diversity of a state's industry may be a measure of the state's informational advantage over the federal government and thus its desire to seek authorization. For example, a state with one major industry may wish to set regulations suitable for the conditions in that industry. Third, more diverse states may be more representative of the country as a whole and thus desire average level regulations, whereas a more homogenous state's preferences may be more likely to deviate from the country as a whole.

Two final control variables are the number of permits outstanding and the number of new permits issued. Both of these variables attempt to capture the size of the regulated industry in the state. A larger number of permits means higher monitoring and enforcement costs, $C^M(X_{i,t})$. As these costs increase, states could choose to authorize later. Alternatively, a larger number of permits could indicate a large lobbying organization for (or against) authorization, influencing the local government's decision. In Table 3, the average number of permits per state is very small for both programs because many states authorized before a lot of permits had been issued; the large standard deviations reflect much higher numbers of permits by end of the period.

Each estimated equation includes dummies for the EPA region. The ten regional EPAs undertake implementation and enforcement when states are unauthorized and oversight when they are. The dummies may thus capture heterogeneity across the regions in the "centralized" alternative to authorization, as well as more general geographic heterogeneity.[12]

Log transformations of the land area and population variables are used in all of the regression models to address substantial skewness in the levels of these variables. A large number of zero values, especially in early years, precluded the use of the log transformation for the number of permits outstanding and the number of newly issued permits. In the OLS and ordered logistic regressions discussed in Section 5, where only the most recent value for each covariate is used, we explore specifications that include the log of the number of active permits.

4. Empirical Results on Time to Authorization

This section presents estimates of duration models for the time until initial state authorization of the base policies under the CWA and RCRA. State delegation was first allowed in 1972 under the CWA and in 1982 under the RCRA. The underlying dependent variable is the authorization duration, calculated as the number of years from 1972 or 1982 until either the state receives authorization for the base policy or the observation period ends in 2002.[13] No states have authorized under either policy since 2002. The frequency tables for CWA and RCRA initial durations, along with the states authorizing at each duration, are shown in Tables 2A and 2B, respectively.

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[12] Several possible covariates were excluded from the empirical specification of the model because of endogeneity concerns. One example of an excluded variable is the state budget for environmental regulation. If a state is preparing to apply for authorization or has already received authorization, it will have to increase the resources devoted to environmental policy. Thus the path of this variable will depend upon the duration.

[13] Although the state applies for authorization some time before it actually receives it, we use the time until the state receives authorization as the dependent variable because it is more readily available. The delay is usually short, within the year that we use as the period for our analysis. For example, according to the *Federal Register*, Florida submitted its application for authorization under the CWA on November 21, 1994 and it was accepted on May 1, 1995 (http://www.epa.gov/fedrgstr/EPA-WATER/1995/May/Day-12/pr-116.html). Texas submitted its CWA authorization application on February 2, 1998 and it was approved on September 14, 1998 (http://www.epa.gov/EPA-WATER/1998/September/Day-24/w25314.htm)

The base model for both the CWA and RCRA datasets was first estimated using the Cox proportional hazard model (see Appendix). The Cox proportional hazard model makes the rather strong assumption that the ratio between the hazards for any two states should be constant over time. Even with time-varying covariates, the Schoenfeld residuals from the Cox model should be uncorrelated with time. Performing a global test of that assumption in Stata, the null hypothesis of a proportional baseline hazard is rejected for the CWA dataset (Chi-Square statistic = 69.36; p-value = 0), whereas it is not rejected for the RCRA dataset (Chi-square statistic = 17.97; p-value = 0.33). As a result, a more flexible specification of the baseline hazard is needed for the decision to authorize under the CWA.[14]

4.1 CWA Initial Authorization Models

Since the proportional hazard is not the correct specification for the CWA dataset, the base model was re-estimated using a dynamic, multiperiod discrete choice model.[15] The results shown in Table 4 are from maximizing a multiperiod probit model that assumes a normal cumulative distribution function. Using other parametric specifications does not alter the results. Standard errors have been adjusted for clustering at the state level.

Because a multiperiod discrete choice model is not intrinsically dependent upon time, it is necessary to include functions of time as control variables. We include a fifth-order polynomial of the number of years the state has been at risk for authorization. This specification allows the hazard to vary non-monotonically over time. As Table 4 shows, the time controls are highly

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[14] Graphs of the hazard, cumulative hazard and survival functions estimated by the CWA Cox model also differed greatly from nonparametric estimations (i.e. Kaplan-Meier).

[15] For theory and application of such models, see Gross and Souleles (2002), Hoynes (2000) and Shumway (2001). Our appendix discusses this econometric approach in more detail.

significant indicating that the probability of authorizing does depend upon time in a non-linear way.

In Model 1 the LCV score is positive but insignificant at the 5% level, which neither confirms nor denies any of the main hypotheses. However in Models 2 and 3 the high LCV dummy (top third of the distribution) is positive and significant, whereas the low LCV dummy (bottom third) is not. States with relatively high environmental preferences authorize sooner (increases the hazard by 0.52%). Having relatively low environmental preferences does not affect the decision to authorize. Thus, there is no evidence that states authorize under the CWA to undercut federal regulations.

The coastal dummy is significant and positive in all three regressions, which means that states on the U.S. coasts are more likely to authorize sooner. This coefficient would be consistent with the view that the federal government erects fewer barriers to authorization when free riding is not a concern. On the other hand, states with greater land area and thus fewer border regions are slower to authorize, suggesting that states may authorize to free ride; a one standard deviation increase in the log of land area decreases the hazard by about 0.22%.

The number of active NPDES permits in the state has a statistically significant and positive effect on the hazard in all the specifications. A one standard deviation increase in the number of active permits leads to a 0.03% (Model 1) to a 0.20% (Model 3) increase in the conditional probability of authorizing in the next year. Thus, states with programs that are more costly to run authorize earlier. One possible explanation is that, with sufficient numbers, regulated facilities lobby for authorization, expecting it to yield more acceptable controls and enforcement policies.

The last specification in Table 4, Model 3, includes the number of newly issued permits. Since authorization under the CWA is not retractable in practice, a state's choice of when to apply depends in part on what is expected to happen in the future. A large number of newly issued permits indicates an increase in the number of facilities to inspect and monitor at least over the next five years (the typical length of NPDES permits). The significantly negative coefficient on this variable could mean that if states think monitoring costs are going to be high, they may delay authorizing to avoid these costs. A one sigma increase in the number of new permits issued that year decreases the hazard by 0.15%.

Across all models, increasing the income per capita in the state decreases the hazard, or increases the duration. This result is somewhat surprising because higher income states would seem likely to have more resources and be able to afford to manage programs tailored to their own needs.

4.2 RCRA Initial Authorization Models

The standard Cox proportional hazard model is used for the RCRA equations because the proportional hazard assumption is not rejected for these data. The covariates are the same as those used in the CWA, except that the coastal indicator variable is excluded because interior states are no more likely to free ride than coastal states under RCRA. As before, standard errors are adjusted for clustering at the state level.

Results for the base RCRA model are presented in Table 5, Model 1R. The key variable, the LCV score, is positive and significant at the 5% level. As environmental preferences increase, the conditional probability of authorizing in the next period also increases; a one standard deviation increase in the LCV score leads to a 0.43% increase in the hazard. Model 2R tests the "U-shaped" hypothesis, which is whether having a relatively high or low LCV score affects the decision to authorize. Neither dummy variable is significant but the coefficient is positive for the high LCV dummy and negative for the low LCV dummy, consistent with monotonicity.

The models presented in Table 5 show substantial differences between the decision to authorize under the base policies of the RCRA and the CWA, perhaps indicating that the sources of voluntary decentralization are fairly program-specific. None of the explanatory variables are statistically significant in the RCRA models. An explanation for insignificant coefficients could be that RCRA authorization provides less flexibility to states. Since RCRA permits are more constrained by federal standards than NPDES permits, states may see less benefit to RCRA authorization and it could occur in a more haphazard fashion.

5. Empirical Results on the Extent of Authorization

In addition to studying the timing of authorization, we study the determinants of the extent of authorization, measured by the number of CWA policies and percentage of RCRA regulations for which a state is authorized. The correlation between the duration of CWA authorization and the number of sections for which a state is authorized is -0.41, and the correlation between the duration of RCRA authorization and the percentage of the RCRA for which a state is authorized is -0.44. These negative correlations suggest that some of the same factors that lead to a state's decision to authorize early (shorter duration) could also lead a state to become more fully authorized under that policy. More sections of the CWA and RCRA have become open to authorization over time. Therefore a state that chooses to wait a longer time before authorizing will have more options to choose from. Once a state decides to undertake the fixed costs of applying for authorization and implementing the base policies of the CWA or RCRA, the incremental cost of adding another regulation is most likely small.

To test whether the initial decision of when to authorize is similar to the decision of how fully to authorize, we estimate regressions of the number or percent of authorized policies on the same covariates as the duration models. Each regression only uses a cross-sectional dataset containing variables measured in the last period of data. An ordered logistic regression is used for the CWA data since the dependent variable can only take on values 0 to 5. Since each authorized state has control over at least two policies, the possible values are 0, 2, 3, 4, or 5. Table 1A shows the frequency of this variable.[16] An OLS regression is used for the percent of RCRA policies for which a state is authorized. This variable takes values between 0 and 104.[17] Table 1B shows the breakdown of this variable across states.

Models 1 and 2 in Table 6A include the same covariates as Models 1 and 2 in Table 4. The covariates in Model 1 of Table 6A are not jointly significant even at the 10% level (p-value of Wald Chi-square is 0.12), indicating that this base specification is not adequate to explain the number of sections for which a state is authorized under the CWA. However, Models 2 and 3 do reject the Wald test that the coefficients are jointly zero. As in the base model for the initial decision to authorize under the CWA (Model 1, Table 4), the LCV score is positive but insignificant. In Model 2 of Table 6A, both the high and low LCV dummies are positive and significant. This supports the "U-shaped" hypothesis. Once they decide to authorize under the base policy of the CWA, states with relatively high and low environmental preferences authorize more fully. States with strong preferences may want the power to establish regulation consistent

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[16] Ordered probit models yield basically the same results and are not reported.
[17] New Mexico has 104% authorization; this may be a data entry error or may represent state policies that extend beyond RCRA requirements.

with those preferences across the board, whereas states in the middle may prefer authorization for only some sections of the CWA.

Income per capita is significantly negative in all three models presented in Table 6A. This relationship is the same as the one found for the decision to authorize. Wealthier states tend to authorize later and for fewer sections of the CWA, despite having more options available to them at the time of authorization. In Models 2 and 3, states with larger populations authorize for more policies under the CWA. No significant relationship was found between population and the timing of the decision to authorize. Both the level and the log of the number of active permits have negative coefficients that are not statistically insignificant. It seems that the number of active permits in the state only matters for the initial decision to authorize and not for the extent of authorization.

Results of the OLS regressions of the percent of RCRA regulations for which a state is authorized are shown in Table 6B. Comparing the Model 1R presented here with the one shown in Table 5, the results are quite different. The coefficient on the LCV score in Model 1R is negative and insignificant, as are the high and low LCV dummies in Model 2R. Thus, we find no relationship between any level of environmental preferences and the percent of authorized RCRA regulations. Income per capita seems to be the only factor in Models 1R and 2R that can explain the depth of authorization under the RCRA (significant at 10% level). Wealthier states tend to authorize for fewer RCRA regulations, a finding that is similar to authorizing under the CWA. One interesting result comes from the third model presented in Table 6B. The log of the number of active permits in the state is positive and statistically significant. Perhaps, after a state receives authorization, permitted facilities lobby state officials to assume an even greater amount of control.

6. Conclusion

This paper attempts to explain the factors that cause states to seek control of their environmental policy. It focuses on the CWA and RCRA, the two most important environmental policies that allow state authorization. Because little research addresses authorization, the paper presents a simple model of the authorization process as a strategic interaction between the federal government and the states. This model predicts that a state's decision to authorize will depend upon the centralized alternative to authorization and the level of regulation the state expects to implement under authorization. The latter is modeled primarily as a function of state environmental preferences. The central government also consults the distribution of these preferences across states as it adjusts its standards to control which type of states want to authorize. Thus, the factors that determine whether or not a state authorizes, and when it chooses to do so, can also determine the effects authorization can have on the state's environmental standards. The paper then uses econometric models of duration to explore the determinants of authorization, focusing particularly on the role of environmental preferences.

The results support the model's prediction that the stronger the environmental preferences are in the state, the sooner the state will authorize. This association arises for authorization under both the CWA and RCRA. However, authorization under the CWA depends upon the relative strength of environmental preferences (high LCV dummy) while authorization under the RCRA depends upon the absolute preferences (continuous LCV score). The results contradict the conventional wisdom that authorization worsens the environment, but are consistent with other empirical literature, which often fails to find evidence that decentralization in the U.S. harms the environment (List and Gerking, 2000; Millimet, 2003). In terms of the intensity of authorization (the number CWA or RCRA policies for which a state authorizes), a

"U-shaped" hypothesis is supported. Both states with relatively high and low preferences authorize more fully.

Some other state characteristics can explain the decision to authorize under the CWA. States on the coasts of the U.S. authorize earlier, which might be inconsistent with strategic actions by the EPA to reduce free riding. Surprisingly, larger and wealthier states authorize later. The higher the number of active NPDES permits in a state, but the fewer the number of new permits issued, the faster that state chooses to authorize.

Future research should address the effects of authorization on the stringency of regulation. However, an empirical analysis of the effects of authorization presents two difficulties. First, there is no unambiguous measure of stringency for either CWA or RCRA regulation in the literature or in practice. Second, our results point to endogeneity in the timing and intensity of authorization, raising an identification problem.[18] For example, an authorized state may conduct more stringent inspections because authorization increases stringency or because states that desire more stringent standards receive authorization. Our revealed preference approach provides an opportunity to understand the likely effects of authorization that sidesteps these identification issues.

[18] Cutter and DeShazo (2007) do estimate a multi-equation model to examine simultaneously the causes and consequences of decentralization.

References

Amemiya, T. *Advanced Econometrics*. Cambridge: Harvard University Press, 1985.

Beasley, Timothy and Stephen Coate. Centralized vs. decentralized provision of local public good: a political economy analysis. *Journal of Public Economics* 87 (2003), 2611–2637.

Congressional Budget Office (CBO), *Federalism and Environmental Protection: Case Studies for Drinking Water and Ground-Level Ozone,* Washington, DC: U.S. Congress, 1997.

Cutter, W. Bowman and J.R. DeShazo. The environmental consequences of decentralizing the decision to decentralize, *Journal of Environmental Economics and Management* 53 (2007), 32–53.

Environmental Council of States. http://www.ecos.org .

Flatt, Victor B. A dirty river runs through it (The failure of enforcement in the Clean Water Act). *Boston College Environmental Affairs Law Review* 25 (1997), 1–45.

Freeman, A. Myrick. III. "Water Pollution Policy," In *Public Policies for Environmental Protection*, edited by P.R. Portney and R.N. Stavins. Washington, DC: Resources for the Future, 2000, pp. 169–213.

Gross David B. and Nicholas S. Souleles. An empirical analysis of personal bankruptcy and delinquency, *Review of Financial Studies*. 15 (2002), 319–347.

Helland, Eric. The revealed preferences of state EPA's: Stringency, enforcement, and substitution. *Journal of Environmental Economics and Management* 35 (1998), 242–261.

Helland, Eric and Andrew B. Whitford. Pollution incidence and political jurisdiction: Evidence from the TRI, *Journal of Environmental Economics and Management* 46 (2003), 403–24.

Hoynes, Hilary Williamson. Local labor markets and welfare spells: Do demand conditions matter? *Review of Economics and Statistics* 82 (2000), 351–68.

Kahn, Matthew. Domestic pollution havens: Evidence from cancer deaths in border counties. *Journal of Urban Economics* 56 (2004), 51–69.

Kunce, Mitch and Jason F. Shogren. On interjurisdictional competition and environmental federalism, *Journal of Environmental Economics and Management* 50 (2005), 212--224.

Lancaster, Tony. *The Econometric Analysis of Transition Data*. Cambridge, UK: Cambridge University Press, 1990.

Levinson, Arik. Environmental regulatory competition: A status report and some new evidence, *National Tax Journal* 56 (2003), 91–106.

Lin, C.-Y. Cynthia. How should standards be set and met?: An incomplete contracting approach to delegation in regulation, mimeo, Harvard University, 2006.

List, John A. and Shelby Gerking. Regulatory federalism and environmental protection in the United States. *Journal of Regional Science*, 40 (2000), 453–71.

Lockwood, Ben, Distributive politics and the costs of centralization, *Review of Economic Studies* 69 (2002), 313–337.

Meyer, Stephen M. and David M. Konisky. Adopting local environmental institutions: Environmental need and economic constraints, *Political Research Quarterly* 60 (2007), 3–16.

Millimet, Daniel L. Assessing the empirical impact of environmental federalism, *Journal of Regional Science* 43 (2003), 711–733.

Morantz, Alison D., Examining regulatory devolution from the ground up: A comparison of state and federal enforcement of construction safety regulations, Stanford Law and Economics Olin Working Paper No. 308, 2007.

Oates, Wallace E. A reconsideration of environmental federalism. in *Recent Advances in Environmental Economics*, John A. List and Aart de Zeeuw (eds.), Cheltenham, U.K.: Edward Elgar, 2002, pp. 1–32.

Oates, Wallace E. *Fiscal Federalism*. New York: Harcourt Brace Jovanovich, 1972.

Oates, Wallace E. and Robert M. Schwab. Economic competition among jurisdictions: Efficiency-enhancing or Distortion-inducing? *Journal of Public Economics*, 35 (1998), 333–54.

Seabright, Paul, Accountability and decentralisation in government: An incomplete contracts model, *European Economic Review* 40 (1996), 61-89

Shumway, Tyler. Forecasting bankruptcy more accurately: A simple hazard model, *Journal of Business* 74 (2001), 101–124.

Sigman, Hilary. Letting states do the dirty work: State responsibility for federal environmental regulation, *National Tax Journal* 56 (2003), 107–122.

Sigman, Hilary. Transboundary spillovers and decentralization of environmental policies, *Journal of Environmental Economics and Management* 50 (2005), 82–101.

Stumpf, Koleman S. and Felix Oberholzer-Gee. Endogenous policy decentralization: Testing the central tenet of economic federalism, *Journal of Political Economy* 110 (2002), 1–36.

U.S. General Accounting Office. *EPA and the States: Environmental Challenges Require a Better Working Relationship*. Washington, D.C.: U.S. General Accounting Office, 1995.

U.S. General Accounting Office. *Water Pollution: Differences among the States in Issuing Permits Limiting the Discharge of Pollutants*. Washington, D.C.: U.S. General Accounting Office, 1996.

Wilson, John D. "Capital Mobility and Environmental Standards: Is There a Theoretical Basis for a Race for the Bottom?" In *Harmonization and Fair Trade*, volume 1, edited by J. Bhagwati and R. Hudec. Cambridge: MIT Press, 1996, pp. 395-427.

Woods, Neal D. Primacy implementation of environmental policy in the U.S. states, *Publius: The Journal of Federalism* 36 (2006), 259–276.

Appendix: Econometric models of duration

This Appendix provides background on the econometric methods used to analyze duration. The hazard at time t is the probability that a state applies for authorization at time t, conditional on the state not already being authorized at the end of time t-1 and on the value of the covariates up until time t. Let d be the duration of time (or the number of years) the state waits until applying for authorization. Then the hazard, $\theta(x,t)$ is defined as:

$$\theta(x,t) = P(d = t \mid d \geq t, X(t)) \qquad \text{(A1)}$$

The argument X(t) represents the path of the covariates from time 0 until time t, but can include variables that are forward-looking as long as the expected future values of the variable do not depend upon the length of the duration.

The Cox proportional hazard model is one of the most widely used duration models. Following the notion in Lancaster (1990), a version of this type of hazard function with time-varying covariates is:

$$\theta(x,t) = k_1(X(t))*k_2(t). \qquad \text{(A2)}$$

The first function, k_1, is parametric and usually log-linear: $k_1(X(t)) = \exp\{\beta`X(t)\}$. The function k_2 is called the baseline hazard and is the same across all states. It is usually left unspecified thereby classifying equation (A2) as a semiparametric hazard model. A duration model is proportional if the hazard ratio for two states in the sample is the same for all t. That would be the case here if $k_1(X_i(t)) / k_1(X_j(t)) = C_{ij}$, for two states i and j and for all t. Technically speaking, the assumption of proportionality would only hold if the X variables were time invariant. Nonetheless, the literature refers to all multiplicative hazard models as proportional, independent of the type of covariates used.

Under general assumptions, duration models can be identified as long as the covariates are either time invariant or exogenous to the duration process itself. The latter condition means that the path of the covariate between time t and time t + 1 does not depend upon whether the duration is longer than t:

$$Pr(X(t, t + 1) \mid X(t), d > t) = Pr(X(t, t + 1) \mid X(t)). \qquad (A3)$$

This exogeneity condition restricts the covariates used in the empirical specification of the model in Section 4.

The relevant sample for duration models with time-varying covariates consists of an unbalanced panel that includes for each state i all of the covariates for the periods in which the state remained unauthorized and for the period in which the state authorized (denoted by t_i for state i). The likelihood function for a continuous hazard model can be written as:

$$L^{Cox} = \prod_{i \text{ in } [1,M]} \{\theta(X_i(t_i), t_i)^{yi}\, S(X_i(t_i), t_i) * \prod_{k=[1,j]} P(X(t_{k-1},t_k) \mid X(t_{k-1}))\} \qquad (A4)$$

where the sample [1,M] represents those states that have not yet authorized by time t.

$\theta(X_i(t_i), t_i)$ is specified as in equation (A1).

$y_i = 1$ if state i authorizes at time t_i and 0 otherwise.

$S(X_i(t_i), t_i) = \prod_{k=[1,i-1]} [1 - \theta(X_i(t_k),t_k)]$ = the survival function at time t_i, which is the probability that the state did not authorize in all periods prior to t_i.

As the last term in equation (A4) shows, the likelihood function depends upon the entire path of the covariates, X(t). Alternatively, the timing of the decision to seek authorization can be modeled as a dynamic, multiperiod discrete choice model. It has been shown that a system of dynamic probit or logit models is equivalent to a discrete-time hazard model (Gross and Souleles, 2002, Hoynes, 2000 and Shumway, 2001). Thus, it is possible to get consistent estimates of β (the parameters of interest) by directly modeling the probability that a state authorizes at time t based solely on X_{it}, eliminating the need to include the entire path of X(t) in the regression. Let the cumulative distribution function of the error term be denoted by F(.). Shumway (2001) specifies the likelihood function for such a discrete choice model as follows:

$$L^{DC} = \prod_{i \text{ in } [1,M]} \{F(t_i, X_i(t_i))^{yi} \prod_{k=[1,i-1]} [1-F(X_i(t_k),t_k)] * \prod_{k=[1,j]} P(X(t_{k-1},t_k) \mid X(t_{k-1}))\} \quad (A5)$$

Since F(.) depends upon t, is strictly positive and bounded by 1, it can be interpreted as a hazard function. Substituting the hazard function from equation (A4) into equation (A5), the multiperiod discrete choice model has the same likelihood function as a hazard model. The key to this equality is the unbalanced panel data set described above. A multiperiod discrete choice model will consider each state-year to be a separate observation; that is, each observation consists of only one period of data for one state. This is why the second product term, which resembles a survival function, appears in equation (A5).

The equality of (A4) and (A5) implies that, instead of directly estimating a hazard model, one can estimate a discrete choice model. These models are easier to estimate since each observation will only depend upon the covariates in that year and state, rather than the entire path. More importantly, these multiperiod discrete choice models can be quite general. We do not have to rely upon the proportional hazard assumption as in the Cox hazard model. A nonlinear, non-monotonic baseline hazard can be specified by using polynomial functions of time in the X matrix. Since the likelihood functions are identical, the estimated coefficients from the discrete choice model and from the hazard model will have the same asymptotic variance-covariance matrix (Amemiya, 1985).

Table 1. Distribution of Authorization

Panel A: Authorized Sections of the CWA

Sections Authorized	Number of States	Percent of States
None	5	10%
Base NPDES permitting and General Permitting	2	4%
Base NPDES permitting, General Permitting and Pretreatment	3	6%
Base NPDES permitting, General Permitting and NPDES federal permitting	9	18%
Base NPDES permitting, General permitting, Pretreatment and NPDES federal permitting	25	50%
Base NPDES permitting, General permitting, Pretreatment, NPDES federal permitting and Biosolids	6	12%

Panel B: Authorized Percentage of the RCRA

Percent Authorized	Number of States	Percent of States
None	2	4%
Less than 25%	2	4%
25% - 50%	9	18%
50% - 75%	14	28%
Greater than 75%	23	46%

Sources: Authors' calculation based on data from the EPA (www.epa.gov) and the Environmental Council of States: (www.ecos.org).

Table 2. Number of Years until Initial Authorization

Panel A: Authorization for Base CWA

Years from 1972	Number of States	States
1	5	CA, CT, MI, OR, WA
2	13	DE, GA, HI, KS, MD, MN, MO, MS, MT, NE, OH, VT, WI
3	9	CO, IN, NC, ND, NV, NY, SC, VA, WY
5	2	IL, TN
6	2	IA, PA
7	1	AL
10	2	NJ, WV
11	1	KY
12	1	RI
14	1	AR
15	1	UT
21	1	SD
23	1	FL
24	2	LA, OK
26	1	TX
29	1	ME
30	1	AZ
Greater than 32	5	AK, ID, MA, NH, NM

Panel B: Authorization for Base RCRA

Years from 1982	Number of States	States
2	11	CO, DE, GA, MS, MT, NC, ND, SD, TX, UT, VA
3	19	AR, AZ, FL, KS, KY, LA, MA, MD, MN, MO, NE, NH, NJ, NM, NV, OK, SC, TN, VT
4	10	IL, IN, MI, NY, OR, PA, RI, WA, WI, WV
5	1	AL
6	1	ME
7	1	OH
8	2	CT, ID
10	1	CA
13	1	WY
19	1	HI
Greater than 22	2	AK, IA

Note: States were first allowed to authorize in 1972 for the CWA and 1982 for the RCRA.

Table 3. Descriptive Statistics of Covariates

Explanatory Variable	**CWA dataset** Annual observations: 539			**RCRA dataset** Annual observations: 289		
	Mean	Standard Deviation	Median	Mean	Standard Deviation	Median
League of Conservation Voters (LCV) score	43.80	18.63	45.72	50.36	19.39	49.90
Coastal dummy	0.46					
Log(Area)	10.68	1.17	10.93	10.68	1.17	10.93
Log(Population)	14.82	1.03	14.94	14.89	1.01	14.99
Income per capita	7.82	4.18	5.90	13.47	3.14	12.88
Political party "match"	0.34			0.27		
Herfindahl index for concentration by 2-digit industry	12.54	5.98	9.73	11.40	4.18	9.83
Active permits	16.67	37.16	2.25	7.17	19.86	3.47
New permits	5.03	14.52	1.50	2.28	3.13	1.45

Notes: LCV score is the average League of Conservation Voters score for the state's delegation to the House. State population, personal income and land area from the U.S. Census (www.census.gov). Political party "match" equals 1 if the President's political party is the same as the dominant state political party and 0 otherwise. The Herfindahl index is the concentration of state income by 2-digit SIC code. Active Permits is the number of permits outstanding in the state in the given year. New Permits Issued is the number of new permits issued that year excluding renewal permits. NPDES (CWA) permit data and RCRA permit data are from EPA's website. Standard deviation and medians are shown for continuous variables only.

Table 4. Multiperiod Discrete Choice Hazard Models for CWA Initial Authorization Duration

	Model 1		Model 2		Model 3	
LCV Score	0.01018	(1.62)				
High LCV			0.51697	(1.95)	0.49621	(1.89)
Low LCV			0.02763	(0.09)	-0.01271	(-0.04)
Coastal	0.61569	(2.24)	0.53586	(1.91)	0.56063	(1.99)
Log Area	-0.18266	(-1.86)	-0.19806	(-2.14)	-0.19168	(-2.05)
Log Population	-0.00805	(-0.05)	0.02962	(0.18)	0.05185	(0.31)
Income Per Capita	-0.13874	(-2.50)	-0.11880	(-2.22)	-0.11859	(-2.28)
Match	-0.13538	(-0.71)	-0.15985	(-0.81)	-0.15157	(-0.77)
Herfindahl	-0.01689	(-0.74)	-0.01403	(-0.59)	-0.01212	(-0.50)
Num Permits	0.00072	(2.65)	0.00075	(2.63)	0.00529	(2.54)
Num New Issues					-0.01235	(-2.19)
Time	1.23080	(3.55)	1.26652	(3.63)	1.35843	(3.80)
Time^2	-0.20748	(-2.83)	-0.21709	(-2.96)	-0.24329	(-3.25)
Time^3	0.01499	(2.42)	0.01583	(2.56)	0.01838	(2.91)
Time^4	-0.00047	(-2.08)	-0.00050	(-2.22)	-0.00060	(-2.61)
Time^5	0.00001	(1.84)	0.00001	(1.98)	0.00001	(2.38)
Constant	-0.95857	(-0.41)	-1.35002	(-0.54)	-1.95439	(-0.77)
Region Dummies	Yes		Yes		Yes	
Observations	536		536		536	
-2 Log Likelihood	247.89		246.72		242.51	
Wald Chi-Square	300.16		321.28		115.75	
Pseudo R^2	0.20		0.20		0.22	

Notes: Multiperiod probit models, where the cumulative distribution function assumed to be normal. See text and Table 3 for variable descriptions. Dummies for EPA regions are included in each regression. T-statistics are in parentheses. All standard errors are adjusted for clustering at the state level. The Wald test statistic tests the joint significance of all of the covariates and is distributed as a Chi-Square random variable with degrees of freedom equal to the number of variables.

Table 5. Cox Proportional Hazard Models for RCRA Initial Authorization Duration

	Model 1R		Model 2R		Model 3R	
LCV Score	0.0220	(1.98)			0.0224	(1.98)
High LCV			0.2828	(0.93)		
Low LCV			-0.1850	(-0.57)		
Log Area	0.0344	(0.20)	-0.0816	(-0.52)	0.0318	(0.19)
Log Population	0.0530	(0.19)	0.1602	(0.60)	0.0475	(0.17)
Income Per Capita	-0.0660	(-0.81)	-0.0776	(-1.01)	-0.0705	(-0.88)
Match	0.0305	(0.09)	-0.0486	(-0.14)	0.0278	(0.08)
Herfindahl	-0.0474	(-1.45)	-0.0444	(-1.53)	-0.0471	(-1.43)
Num Permits	0.0006	(0.08)	-0.0005	(-0.07)	-0.0012	(-0.15)
New Issues					0.0167	(0.83)
Region Dummies	Yes		Yes		Yes	
Observations	289		289		289	
-2 Log Likelihood	299.64		301.53		299.49	
Wald Chi-Square	45.37		41.21		47.28	

Notes: See text and Table 3 for variable descriptions. Dummies for EPA regions 1 are included in each regression. T-statistics are in parentheses. All standard errors are adjusted for clustering at the state level. The Wald test statistic tests the joint significance of all of the covariates and is distributed as a Chi-Square random variable with degrees of freedom equal to the number of variables.

Table 6. Regression Results for Authorization Depth

Panel A: Ordered Logit Models
Dependent Variable: Number of Authorized Sections of CWA (0-5)

	Model 1		Model 2		Model 3	
LCV Score	0.0081	(0.64)				
High LCV			1.4147	(0.01)	1.3752	(0.02)
Low LCV			1.0710	(0.03)	1.1437	(0.02)
Coastal	0.6114	(0.21)	0.2484	(0.63)	0.2683	(0.61)
Log Area	-0.4417	(0.38)	-0.6065	(0.26)	-0.7314	(0.18)
Log Population	0.7219	(0.21)	1.2231	(0.06)	1.6003	(0.03)
Income Per Capita	-0.2764	(0.02)	-0.2791	(0.03)	-0.2950	(0.02)
Match	-0.1473	(0.68)	0.2571	(0.52)	0.1542	(0.70)
Herfindahl	-0.0933	(0.09)	-0.0985	(0.08)	-0.0806	(0.16)
Num Permits	-0.0005	(0.26)	-0.0003	(0.60)		
Log Num Permits					-0.3321	(0.22)
Regional Dummies	Yes		Yes		Yes	
Observations	50		50		50	
-2 Log Likelihood	106.29		98.45		97.21	
Wald Chi-Square	23.97 (NS)		31.80		33.04	
Pseudo R^2	0.41		0.51		0.52	

Panel B: OLS Models
Dependent Variable: Authorized Percentage of RCRA (multiplied by 100)

	Model 1R		Model 2R		Model 3R	
LCV Score	-0.0267	(0.89)				
High LCV			-2.5366	(0.82)	-3.1507	(0.77)
Low LCV			-1.0383	(0.91)	-0.1067	(0.99)
Log Area	-1.3348	(0.79)	-1.2750	(0.80)	1.6741	(0.73)
Log Population	6.1528	(0.28)	5.7925	(0.33)	2.5000	(0.68)
Income Per Capita	-2.2257	(0.08)	-2.2022	(0.09)	-1.7241	(0.17)
Match	3.5041	(0.65)	2.9122	(0.74)	3.0966	(0.71)
Herfindahl	0.6352	(0.30)	0.6226	(0.32)	0.5269	(0.38)
Num Permits	0.0045	(0.10)	0.0045	(0.10)		
Log Num Permits					7.4804	(0.02)
Regional Dummies	Yes		Yes		Yes	
Observations	50		50		50	
Adj. R-square	0.29		0.27		0.33	

Notes: The above panels show the results of OLS and ordered logistic regressions explaining the number or percentage of regulations for which a state is authorized. Covariates are measured in 2002, except the Herfindahl Index which is measured in 2000. P-values are in parentheses. Dummies for EPA regions and constant are included in all regressions, but not shown.