

Environmental Regulatory Competition: A Status Report and Some New Evidence

Abstract - Concerns about devolving environmental regulatory powers to lower levels of government permeate debates in the U.S. and Europe about the appropriate level of regulatory authority. In theory, given a long list of conditions, regulatory competition by local governments can be efficient in the same way that tax competition can be efficient: local welfare-maximizing governments set the same standards or taxes as would an omniscient welfare-maximizing central government. In practice, however, these conditions are improbable, especially in the case of environmental regulations, and local competition is potentially inefficient. In the past two years, evidence has begun to emerge regarding the empirical importance of these inefficiencies. In this paper, I describe this nascent literature, drawing parallels to the tax competition literature, suggest some avenues for empirical research, and present some new results.

INTRODUCTION

Whether environmental regulations are better set centrally or locally is a subject of debate both in the U.S., which in recent years has devolved some environmental authority from the federal government to the States, and in Europe, which is in the midst of centralizing authority for some environmental rules. Proponents of decentralized standards claim that local policymakers have better information about local concerns, while opponents claim that competition among jurisdictions will lead to a “race to the bottom” in environmental quality. This issue, whether decentralized authority results in inefficient standards, in theory and in practice, is the subject of this paper.

The theoretical literature on interjurisdictional regulatory competition is well established, has been well surveyed (Wilson, 1996, 1999; Oates, 2001), and has a long history in the parallel literature on fiscal federalism and tax competition. In the simplest economic models, in which local jurisdictions compete for mobile capital while at the same time taxing that capital to provide public goods or regulating that capital to protect the environment, the competition leads to Pareto-efficient outcomes. However, those models rely on a long list of assumptions without which outcomes are inefficient. As a consequence, the lesson I take from the theoretical literature is that under most pertinent real-world situations, local standard setting will in theory lead to inefficient environmental regulatory competition.

Arik Levinson
Department of
Economics, Georgetown
University,
Washington, DC 20057

National Tax Journal
Vol. LVI, No. 1, Part 1
March 2003

The empirical question then is how important is this potentially inefficient regulatory competition? How strategically do local governments behave when they set their environmental standards? While some research has been conducted in recent years in the area of tax competition, for environmental regulatory competition this question has been left almost completely unanswered, for several obvious reasons. First, in order to document the degree to which states take other states' regulations into account when setting their own standards, we need information on regulatory stringency across states and over time. Until the last few years, no such data existed. Second, we need to be able to differentiate strategic behavior from correlations caused by unobserved phenomena affecting groups of neighboring states.

In this paper I briefly summarize the theoretical literature on tax and regulatory competition, and the few articles in this emerging empirical literature. Then I describe two new data sets that document regulatory stringency in U.S. states over time, and present some new empirical work that tries to measure the extent of strategic interstate environmental regulatory competition. Along the way I point out conceptual and econometric hurdles that anybody tackling this problem will need to address in future work.

A BRIEF OVERVIEW OF THE THEORY

The 1971 *Economic Report of the President* (CEA, 1971) seemed to inaugurate the debate by arguing that

Many . . . pollution problems are local in character, and therefore determination of the appropriate level of environmental quality is likely to be more accurate if it is done locally rather than by the Federal Government.

The merits of this assertion were debated in several subsequent issues of the *American Economic Review* (Stein, 1971; Peltzman and Tideman, 1972). Most of that debate, however, compared the benefits of decentralized policies against the costs of a *uniform* federal policy. Proponents of federal standard-setting argued that compliance with a patchwork of different local regulations would be expensive for businesses that manufacture or market their products nationally.

If these were the only issues at stake, then choosing the optimal degree of devolution would be a purely empirical exercise, though admittedly complicated. We would need to weigh the information advantage enjoyed by local regulators against the compliance costs associated with heterogeneous local regulations. There are, however, two important caveats. First, nothing dictates that a federal regulation be uniform. Sigman (2003) notes in this volume that virtually all states are authorized to implement the federal Clean Water Act at the state level, leaving them room to interpret and enforce the national law with different degrees of enthusiasm. Even the federal Clean Air Act, which sets uniform national air quality standards, imposes starkly different costs on individual counties, depending on the ease with which counties can meet the standards. Moreover, even if we allow heterogeneous federal regulations, and grant the federal regulator the same information as the local regulators, there remains the potential for regions to compete with one another to attract investment on the basis of their environmental costs.

In 1972, Oates' book *Fiscal Federalism* provided a model designed to examine federalism, tax competition, and local public good provision. He considered a world in which citizens are immobile, but capital moves freely among jurisdictions, and in which local governments provide

local public goods financed by taxes.¹ Oates's key insight is that under federalism, given the proper assumptions, all taxes become benefits taxes, and that redistributive policies are impossible at the local level. "Attempts to tax the relatively wealthy more heavily than the poor will fail to some degree because of the departure of those on whom the tax places the largest liability" (Oates, 1972). A nice intuitive explanation for this result is in McLure (1986). Imagine what would happen if Gloucester, Massachusetts attempted to finance its school lunch program with a property tax on fishing boats docking there. No matter how meritorious the lunch program, boats would likely seek to dock in nearby ports that did not appropriate their income and redistribute it to school children.

Though not explicitly addressing environmental competition, Oates's model of tax competition is directly applicable. Relabel the local public good "environmental quality," and reconfigure the tax as a Pigouvian tax, and tax competition becomes environmental regulatory competition, with local officials regulating local environments. Described this way, environmental competition seems even less likely to result in efficiency than tax competition. Environmental problems involve externalities, and correcting those externalities redistributes welfare from polluters to the victims of pollution. If under fiscal federalism, redistributive policies are impossible due to tax competition, then under environmental federalism, efficient environmental regulations will be equally impossible due to regulatory competition.

In the face of this logic, Oates and Schwab's (1988) paper seems contradictory. They describe many jurisdictions competing to attract a fixed amount of

capital. Capital benefits the jurisdictions by raising the local wage, but degrades the local environment. To limit pollution, regulators set emissions caps that reduce the return to capital. This lowers the quantity of capital attracted to the jurisdiction, in turn lowering the marginal product of labor and local wages. Faced with a trade-off between environmental quality and wage income, regulators maximize local welfare by setting regulations so that the marginal gain from attracting capital equals its marginal environmental cost. This decentralized outcome is then shown to be socially efficient from the perspective of all jurisdictions.

How can Oates (1972) conclude that redistributive local policies are impossible under federalism, and Oates and Schwab (1988) conclude that local environmental policies are efficient? The trick is that Oates and Schwab's basic model internalizes all externalities. All of the citizens of a region work in its polluting industry. Each suffers equally from pollution. Capital is supplied competitively, and labor is fixed in the jurisdiction, so all production rents are earned by labor. Each citizen effectively decides how much to tax himself to reduce pollution that he alone suffers. Without these simplifying and externality-internalizing assumptions, the efficiency result evaporates.

Later in the paper Oates and Schwab consider three complications, each of which revives the inefficiency of redistributive local policies. First, they place constraints on the tax instruments available to the local government. If some public good must be financed with a tax on mobile capital, this is analogous to financing school lunches by taxing fishing boats. The local government can compensate for the capital tax that exceeds the

¹ Before Oates, most models of local public good provision stemmed from Tiebout (1956), which modeled mobile citizens who, by "voting with their feet," force local governments to provide efficient quantities of public goods. More relevant to tax and regulatory competition, however, is Oates' example, where citizens are associated uniquely with states, and states compete to attract investment.

benefits to capital by easing environmental controls.² By easing the environmental regulation sufficiently to offset the capital tax, the locality redistributes no welfare from capital to local citizens, suffers no loss of investment, and effectively “pays” for the public good by incurring environmental damage.

Second, Oates and Schwab consider local governments with goals other than maximizing local welfare. If the objective is maximizing tax revenue (a so-called “Leviathon” model), the government will want to ease environmental regulations in order to attract capital and inflate the tax base. These arguments always seem tautological to me: governments that do not maximize welfare impose inefficient policies, where efficiency is defined by welfare-maximization.

Third, Oates and Schwab consider local jurisdictions populated by heterogeneous citizens: some work in the polluting industry, as before, while others simply collect exogenous income. Under majority rule, if the median voter works in the polluting industry, environmental regulations will be overly lax, while if the median voter does not, the regulations will be too strict. This result stems from the fact that the local government is no longer welfare-maximizing—instead it maximizes the welfare of only the larger group. A potential Pareto-improving trade would make both groups better off. However, the welfare maximizing environmental regulation involves redistributing some welfare from mobile capital and factory workers to the victims of pollution. As before, this type of redistribution is not possible at the local level. In each of these three versions of the basic model, some constraint (tax instrument limitations, Leviathon local governments, majority rule) forces the local government

to enact redistributive environmental policies, which under federalism turn out to be inefficient.

Oates and Schwab model many competing jurisdictions, but what if there are only a few? In an alternative model with only two jurisdictions, a polluting manufacturer decides whether to locate in one jurisdiction and export goods to the other, or to locate in both jurisdictions (Markusen, et al., 1995). The firm trades off transport costs against the fixed costs of building a second factory. The jurisdictions trade off the consumer surplus from hosting the factory against the pollution generated by the factory. If the consumer surplus is large (shipping costs are large), both jurisdictions compete for a factory, driving down environmental regulations below globally optimal (Pigouvian) levels. If the pollution costs are large, both jurisdictions compete to avoid hosting the factory by raising environmental regulations above the globally optimal (Pigouvian) levels. This latter case has been described as a “race to the top” in standard stringency.

The inefficiency results of Markusen, et al. depend on two phenomena. First is the “small numbers” case. With only two jurisdictions, each has monopoly power if it can attract the only manufacturer. The host jurisdiction can appropriate some of the monopoly rents for its citizens by taxing output, or by imposing an environmental tax that exceeds the marginal social damage of pollution. Second, in Markusen et al. the polluting manufacturer’s monopoly rents are earned by the outside “world” and thus disappear from the model altogether.³ The only way that a region can retain those rents is by taxing the output of the polluting producer. The tax thus serves two purposes: to raise revenue from the monopolist and

² This result parallels the international trade literature on strategic substitution between environmental regulations and tariffs (Ederington, 2001; Ederington and Minier, 2002).

³ See footnote 7 of Markusen et al. (1995).

to reduce pollution. Competing to attract plants, the regions bid down the amount of the monopolist's profits they retain, impeding their ability to tax pollution. Regulatory competition thus has two adverse effects on the regions' welfare: tax revenues fall and pollution increases.

While both regions are worse-off in the Nash equilibrium, relative to if immobile plants had been assigned to jurisdictions, the profits of the producer *increase* as a result of the lower taxes. Since these profits go to owners outside the model, the regional regulators ignore them. Unlike the Oates and Schwab model, where regulators trade off pollution damage against rents earned by immobile local labor, the Markusen et al. regulators tax profits that would otherwise vanish outside of their region.

An example may clarify this distinction. Oates and Schwab model many small states competing for investment on an efficient global capital market. They play a zero-sum game—investment that goes to state *i* is attracted away from state *j*. Markusen et al. depict the type of tax breaks and regulatory waivers states have offered to attract foreign automobile plants. With the investment coming from abroad (outside the model), the regions seek to capture through taxation economic rents that would otherwise disappear, and by competing the regions decrease their ability to do so. As a consequence, the regions lower their ability to regulate efficiently the pollution from such plants.⁴

One way to summarize the theoretical literature on environmental regulatory competition, and tax competition more broadly, is to list the conditions under which local authority leads to the same Pareto-optimal environmental regulations as would a welfare maximizing centralized authority.

- i. No cross-border externalities.
- ii. Many jurisdictions.
- iii. All economic rents earned locally by the competing jurisdictions.
- iv. Welfare-maximizing local regulators.
- v. No constraints on available policy instruments.
- vi. No redistributive policies. (All taxes are benefits taxes.)

If these conditions are violated, then in theory interjurisdictional competition can lead to inefficient taxation, public good provision, and environmental policies. For the case of public good provision, I can imagine particular local programs where these conditions might be met: local parks, public libraries, police and fire services, etc. For environmental regulations, however, it is hard to imagine a situation meeting all six conditions. This is why my one-sentence summary of this theoretical literature is that under most pertinent real-world situations, local standard setting has the potential to lead to inefficient environmental regulatory competition.

How important is this potential inefficiency? That depends on how strategically local governments behave when setting their environmental standards, an empirical question.

EVIDENCE TO DATE

In order for the theoretical inefficiency to matter empirically, two things must happen: (1) investment must react to environmental regulatory differences across jurisdictions, and (2) governments must react strategically to their neighbors' regulations. The environmental regulatory competition literature contains numerous papers estimating the first of these: the effect of regulations on economic outcomes (investment, plant locations, FDI,

⁴ In Levinson (1997), I rewrite the Markusen et al. model so that the monopoly rents are earned locally, leaving only one source of inefficiency, the monopoly deadweight loss.

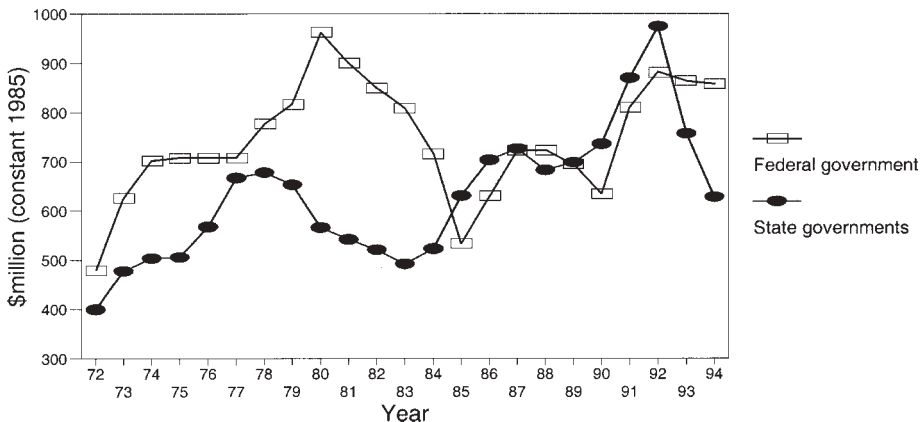
employment, etc.). Until recently, economists found very little evidence that any of these activities responded to environmental regulations (Jaffe et al., 1995). In the last few years, though, papers using panels of data, controlling for unobserved heterogeneity and the endogeneity of regulations, have begun to measure statistically significant, economically meaningful effects of environmental regulations.

Among recent papers that find measurable large effects of environmental regulations, Becker and Henderson (2000) is perhaps the most notable. They use the federal 1977 Clean Air Act as a natural experiment to study the effect of stringent pollution regulations. The act imposes uniform national ambient air quality standards (NAAQS), and requires counties whose air quality does not meet the federal NAAQS to impose strict regulations on new sources of pollution. Counties whose air quality meets the federal standards face much less stringent regulations. Becker and Henderson show that counties with “non-attainment” status saw 26 to 45 percent fewer new plants births in four heavily polluting industries between 1963 and 1992. Greenstone (2001), follows a similar strategy and finds that between 1972 and 1987, non-attainment counties

lost 590 thousand jobs and \$75 billion (1987\$) worth of output from polluting industries, relative to attainment counties that faced less stringent compliance costs. Keller and Levinson (2002) use a continuous measure of environmental compliance costs in individual U.S. states (as opposed to the zero-one measure of attainment status). They demonstrate that states with relatively higher compliance costs saw a decline in both the value and count of new, polluting foreign investment projects between 1977 and 1994.

Almost no papers, however, estimate the second empirical component of regulatory competition: the effect of environmental regulations on the regulations of neighboring jurisdictions. Three recent papers attempt to do so indirectly by using the Reagan administration’s policy of devolving environmental regulatory authority to the states as a natural experiment in federalism (Millimet, 2001; List and Millimet, 2002; List and Gerking, 2000). In 1981 and 1982 state governments were delegated responsibility for the vast majority of hazardous air pollution standards and New Source Performance standards, and from 1981 to 1984 federal appropriations to the national EPA fell by 11.5 percent (Millimet, 2001). Evidence for this shift can be seen in Figure 1, which

Figure 1. Environmental Regulation and Monitoring 1972–1994



plots real (1985) expenditures on environmental regulation and monitoring by states and the federal government from 1972 to 1994. The early 1980s saw a sharp decline in federal spending on environmental regulations, relative to state spending. The assumption of these three papers, therefore, is that if regulatory competition results in a race to the bottom, we should see a decline in environmental quality starting in 1981.

All three papers estimate NO_x and SO₂ emissions as a function of state characteristics and test whether the post-1980 Reagan era of federalism yields different results. None of the three find evidence that these two measures of air pollution worsened during the post-1980 period, which the authors interpret as evidence that devolving authority to the states did not result in a race to the bottom. And one of the papers (Millimet, 2001) finds evidence that NO_x emissions declined after 1980, which is taken as possible evidence for a “race to the top.”

If, however, we understand inefficient regulatory competition to mean that local jurisdictions set inefficient standards, then there is no presumption that regulatory competition will cause environmental quality to either improve or decline over time. The important question is more subtle than whether emissions go up or down. It is whether interjurisdictional competition and the Reagan decentralization caused regulations to be laxer than if they had been set by a welfare maximizing central planner. Put slightly differently, there are a lot of reasons why emissions of NO_x and SO₂ might have increased or decreased during the 1980s, including oil price fluctuations, the implementation of the 1977 Clean Air Act, and changes in automobile emissions standards. A more direct theoretical implication of the 1990s environmental devolution is that after 1990, environmental stan-

dard stringency in individual states should have become more responsive to the stringency of neighboring states.

To get at this more direct implication of regulatory competition, we need a panel of data on states’ regulatory stringency. For previous projects, I have created two such panels that can be used for this purpose. The first is an index of relative state-level pollution abatement costs from 1977 to 1994, controlling for differences in states’ industrial compositions (Levinson, 2001). The second is a panel of state hazardous waste disposal tax rates from 1989 to 1995 (Levinson, 1999a).

One previous paper in this literature (Fredriksson and Millimet, 2002a) has used my (2001) index in a test of regulatory federalism. Briefly, the index is greater than 1 for a given state if pollution abatement costs in that state are higher than would be predicted based on its industrial composition, and less than 1 otherwise. A more complete description is in the appendix.

Fredriksson and Millimet estimate an environmental regulatory reaction function that is the analog to a tax reaction function:

$$[1] \quad E_{it} = \alpha_i + \gamma_t + \delta \sum_{j \neq i} \omega_{jt} E_{jt} + x_{it} \beta + \varepsilon_{it}$$

where E_{it} is my index of environmental regulatory stringency for state i at time t , α_i are state fixed effects, γ_t are time dummies, ω_{jt} are weights assigned to other states’ regulatory indices E_{jt} , and x_{it} are a set of state characteristics.⁵ The coefficient of interest, δ , tells us the degree to which changes in environmental stringency are correlated with changes in neighboring states’ environmental stringency, all else equal.

Two econometric problems arise in trying to estimate [1]. First, neighboring states are likely to have unobserved regional characteristics in common that are correlated with regulatory stringency (E).

⁵ See Brueckner (2001) and Altshuler and Goodspeed (2002) for estimations of analogous tax reactions functions.

This will bias estimates of δ in favor of finding a spurious relationship. One could easily mistake regional correlations for strategic behavior. A partial solution to this problem is to include state fixed effects, which control for time invariant regional heterogeneity. Doing so requires a panel of regulatory stringency across jurisdictions over time, which until recently was unavailable.

The second econometric problem with estimating [1] is the endogeneity of regulatory stringency (E). If E_i is a function of E_j , then E_j must also be a function of E_i , and OLS estimates of δ will be biased. The standard solution to this problem is to instrument for E_j in [1] using the weighted characteristics of the neighboring states. In particular

$$[2] \quad \sum_{j \neq i} \omega_{ijt} E_{jt} = a + b \sum_{j \neq i} \omega_{ijt} X_{jt} + \mu_{it}$$

where $\sum_{j \neq i} \omega_{ijt} X_{jt}$ is a weighted average of a vector of state j 's neighbors' characteristics. The fitted values of $\sum_{j \neq i} \omega_{ijt} E_{jt}$ can then be used as instruments in [1]. This technique is used in the context of tax competition by Altshuler and Goodspeed (2002) and Heyndels and Vuchelen (1998), for example, and in the context of environmental regulatory competition by Fredriksson and Millimet (2002a).

Fredriksson and Millimet estimate versions of equation [1] and [2] with lags, various weighting schemes, regional partitions of the data, asymmetric responses to increases and decreases in regulatory stringency, and instrumental variables for other states' stringency to control for simultaneity and unobserved regional variations. They find that changes in compliance costs are correlated spatially (the coefficient δ is positive and statistically significant), suggesting that states respond to increases in neighboring states' environmental regulations by increasing their own regulations. Furthermore, these reactions appear stronger to neighbors

with high costs than to those with low costs, and many of the measured responses are greater than one-for-one ($\delta > 1$).

Moreover, Fredriksson and Millimet are careful to note that while evidence of correlated compliance costs may demonstrate regulatory competition, it is not sufficient to ascertain whether competition leads to inefficiently high or low environmental regulations.

SOME NEW EVIDENCE.

This section presents two extensions of Fredriksson and Millimet's work. First, I combine their idea of looking at correlations among states' compliance costs with List and Gerking's idea of treating the Reagan administration's devolution of environmental authority as a natural experiment. Fredriksson and Millimet estimate conditional correlations among state standards, but cannot ascertain how much is due to regulatory competition. List and Gerking estimate the effect of the Reagan devolution on environmental quality, but not on regulatory competition. If regulatory competition increased starting in 1981, the slopes of the regulatory reaction functions, measured by Fredriksson and Millimet, will also have increased.

Table 1 presents some regressions of this type. The dependent variable is my index of state compliance costs. The index is based on a measure of the pollution abatement compliance costs in each state, gathered from the U.S. Census Bureau's published Pollution Abatement Costs and Expenditures Survey (PACE). It is the ratio of actual pollution abatement costs in a state, to predicted pollution abatement costs, where the prediction is based solely on each state's industrial composition. The index is greater than 1 if manufacturers in the state spend more on pollution abatement than would be

TABLE 1
STATE ENVIRONMENTAL REACTION FUNCTIONS: OVERALL RELATIVE STATE STRINGENCY
1977–1994

	Mean (st. dev.)	2SLS estimates	
		Base model	With Post–1981 interactions
		(1)	(2)
Other states' regulations wtd by (1/distance) ² —instrumented.	0.99 (0.13)	0.919* (0.230)	0.954* (0.257)
Post 1981 dummy			0.084 (0.295)
Post 1981 dummy X Other states' stringency—instrumented.			-0.088 (0.301)
Unemployment rate (%)	6.61 (2.09)	0.012* (0.006)	0.013 [†] (0.007)
Land value (\$1,000 per acre)	0.887 (0.775)	0.027 (0.028)	0.023 (0.032)
Production worker wage	9.12 (2.84)	-0.031* (0.012)	-0.031* (0.013)
Gross state product per capita (\$ millions)	0.0167 (0.0059)	-14.13 (10.78)	-13.74 (10.85)
Population (millions)	4.95 (5.15)	-0.000 (0.016)	0.000 (0.016)
Personal income per capita (\$1,000s)	14.2 (5.0)	0.031* (0.014)	0.031* (0.014)
Constant		0.077 (0.257)	0.036 (0.293)
Post 1981 reaction function slope			0.866* (0.004)
R ²		0.66	0.66
n	816	816	816

*Statistically significant at 5 percent. [†]Statistically significant at 10 percent. Standard errors are in parentheses. Regressions contain 48 state fixed effects and 816 observations (48 states, 17 yrs.).

Data sources: state regulatory stringency from Levinson (2001); population and unemployment rates from the Census Bureau's Statistical Abstract of the United States; land values from USDA Economic Research Service, Farm Real Estate Value; gross state product and personal income from Bureau of Economic Analysis' Regional Account Data; wages from author's calculations using the current population survey.

expected given industries represented in the state.⁶

In Table 1, I weight other states' compliance cost indices with the inverse of the squared distance between the states. (In terms of equation [1], $\omega_{ij} = 1/d_{ij}^2$, where d_{ij} is the distance in miles from state i to state j .) Other right-hand side variables in col-

umn (2) include state unemployment rates, state agricultural land values, production wages, gross state product, population, and per capita personal income.⁷ A first-stage estimation of equation [2] generates fitted weighted averages of other states' environmental regulatory stringency. The coefficient on this instru-

⁶ See the appendix for a brief summary, or Levinson (2001) for details.

⁷ The index of compliance costs is normalized to 1.0 every year, so there is no need for the year fixed effects. (When included they are statistically insignificant and tiny.)

mental variable is 0.92, suggesting that when nearby states' regulatory stringency rises, the state in question is likely to raise its stringency by nearly the same amount. Changes in environmental compliance costs appear highly correlated among neighboring states, even after controlling for unobserved state heteroskedasticity, and for the endogeneity of the regulations.

In similar specifications, Fredriksson and Millimet find elasticities in the range of 1.9. A 10 percent increase in neighbors' abatement costs leads to a 19 percent increase in one's own costs. Reaction function elasticities in Table 1 are slightly less than unity. (The mean of both the dependent variable and the other states' indexes is 1.0.) One explanation for Fredriksson and Millimet's stronger findings is that they focus on contiguous neighbors, while I have taken a weighted average of all states, weighted by the inverse of the squared distance. It remains to be explained however, why a state might raise its stringency more than one-for-one in reaction to a neighbor's stringency increase.

To combine Fredriksson and Millimet's approach with the insight of List and Gerking, column (3) of Table 1 interacts the weighted average of other states' environmental regulations with a dummy variable for the post-1981 era, in which the Reagan administration devolved much environmental policy to the states. After 1981, the coefficient on neighboring states' regulations seems to decrease, suggesting that reaction functions got a tiny bit less steep, though the coefficient estimate on the interaction term is not statistically significant.⁸ This could be for a variety of reasons. The Reagan administration reduced federal transfers to states for

the purposes of environmental regulations (Millimet, 2001), perhaps decreasing the ability of states to compete. The 1977 Clean Air Act amendments included a provision called "prevention of significant deterioration" designed specifically to prevent states whose air quality was cleaner than the national standards from attracting industry away from states whose air quality failed to meet the national standards, and in the process degrading their own environments (Pashigian, 1985). Whatever the case, it does not appear from Table 1 that these environmental reaction functions steepened significantly after 1981.

As a second expansion of Fredriksson and Millimet, I examine a particular measure of regulatory stringency, hazardous waste (HW) disposal taxes. I have collected data on state HW tax rates from 1989 to 1995. Hazardous waste has been among the fastest growing components of environmental compliance costs in the U.S. (Council on Environmental Quality, 1992), and in recent years many states have substantially increased the rate at which they tax disposal of hazardous waste, and a few have imposed higher taxes on waste imported from other states. Moreover, hazardous waste disposal imposes large perceived costs and few benefits on local jurisdictions, and can be expected to result in regulatory competition to deter pollution activities—a "race to the top" in environmental stringency.⁹

One curious feature of HW taxes that may be useful here is that states have attempted to tax disposal of waste by out-of-state generators at higher rates than for in-state generators. This tax asymmetry takes two forms. Before 1992 when the Supreme Court ruled the practice unconstitutional, many states explicitly imposed

⁸ The reaction function slope after 1981 remains large (0.866) and statistically significant. That calculation is at the bottom of Table 1.

⁹ For more detail, see Levinson (1999a, 1999b).

higher taxes on disposal of waste by out-of-state entities than they imposed on local waste generators. Since 1992 the asymmetry has taken more subtle forms. Some states charge waste generation taxes on in-state polluters and then impose those generation taxes on waste imported into the state for disposal. Other states charge disposal taxes that are the higher of local disposal costs or what those fees would have been had the destination state shipped waste back to the origin state. Either way, these represent *prima facie* evidence that states are behaving competi-

tively when setting at least one environmental regulation. It remains to be seen whether they are also behaving strategically.

Table 2 estimates equation [1] for hazardous waste taxes. In column [2] I present the analog to column (2) of Table 1. The key regressor is a weighted average of other states' HW taxes, and the weights are the inverse of the square of the distance ($\omega_{ij} = 1/d_{ij}^2$). Table 2 also includes industry and year fixed effects. Here the year fixed effects are important because HW taxes change year-to-year, unlike the

TABLE 2
STATE ENVIRONMENTAL REACTION FUNCTIONS: HAZARDOUS WASTE DISPOSAL TAX RATES
1989-1995

	Mean (st. dev.)	2SLS estimates			
		Base model		With Post-1992 interactions	
		(1)	(2)	(3)	(4)
Other states' HW taxes, weighted by $(1/\text{distance})^2$ —instrumented	13.62 (6.82)	0.170 (0.284)		0.157 (0.279)	
Other states' HW taxes, weighted by tons exported—instrumented	20.27 (12.50)		0.078 (0.119)		-0.052 (0.127)
Post 1992 dummy X Other states' HW taxes—instrumented.				0.57* (0.27)	0.52* (0.18)
Unemployment rate (%)	5.82 (1.45)	-1.52* (0.75)	-1.75* (0.61)	-1.64* (0.74)	-1.79* (0.61)
Land value (\$1,000 per acre)	1.08 (1.10)	-2.41 (2.39)	-2.22 (2.41)	0.23 (2.67)	0.23 (2.56)
Production worker wage	12.01 (1.70)	-0.38 (0.90)	-0.23 (0.94)	-0.46 (0.90)	-0.25 (0.93)
Gross state product per capita (\$millions)	0.023 (0.004)	1035 (840)	983 (826)	1435 [†] (848)	1119 (824)
Population (millions)	5.29 (5.63)	-1.37 (2.00)	-1.09 (1.93)	-2.31 (2.02)	-4.10 [†] (2.20)
Personal income per capita (\$1,000s)	19.80 (0.61)	-1.20 (1.59)	-1.32 (1.57)	-1.93 (1.60)	0.60 (1.59)
Post 1981 reaction function slope				0.714 [†] (0.062)	0.467* (0.010)
R ²		0.86	0.86	0.86	0.86
n	336	336	336	336	336

*Statistically significant at 5 percent. [†]Statistically significant at 10 percent. Standard errors are in parentheses. Regressions contain 48 state dummy variables, 7 year fixed effects, and 336 observations (48 states, 7 yrs.). Data sources: hazardous waste taxes from *Tax Day*, a Commerce Clearing House publication. For other state characteristics see footnote to Table 1.

stringency index used in Table 1, which averages 1.0 every year by construction. The coefficient on other states' HW taxes (0.17) in column (2) is positive but not statistically significant.

Column (3) of Table 2 estimates a version of equation [1] in which the weights are the total amount of HW shipped from state i to other states over the seven-year period for which I have data. The idea is that states' competitors may not necessarily be their closest neighbors (Case et al., 1993). Consequently, I estimate tax rates as a function of the tax rates of states with whom each state trades most. When the ω 's in equation [1] are a function of distances among states, as in Table 1 and the first columns of Table 2, they are clearly exogenous. However, when the ω 's are a function of the tonnage of state-to-state shipments they are likely to be endogenous. Here again the asymmetry is of use. Consider estimating the tax charged by state i as a function of the tax charged on other states j . If the weight on state j 's tax rate is shipments from state j to state i , then it will be endogenous. However, if the weight on state j 's tax rate is shipments from state i to state j , then it should not be. (State i 's tax should not affect shipments from i to j .) The coefficient in column (3), 0.078, however, remains small and statistically insignificant.

The reaction functions look somewhat different, however, when we compare them before and after the 1992 Supreme Court decision prohibiting discriminatory taxation. One way to view this is that before 1992 there was no particular reason to raise one's own disposal tax in response to a neighbor. Instead, states could simply raise the tax they charge other states for disposal, while leaving disposal taxes low for waste generated locally. Column (4) of Table 1 estimates a version of column (2), with neighbors' taxes weighted by the inverse of their squared

distance, and interacted with a post-1992 dummy variable. Note that there is no need for a post-1992 dummy alone because the regression includes individual year dummies. While the reaction function coefficient for the period as a whole (0.157) is statistically insignificant, for the post-1992 period it is positive and statistically significant. (The sum of the two coefficients (0.714) is presented at the bottom of the table, along with its standard error.) Moreover, a back-of-the-envelope calculation puts its elasticity at 1.10, slightly larger than for the stringency indices in Table 1.

Column (5) of Table 2 does exactly the same exercise with the neighbors' taxes weighted by tons of waste exported. Again the reaction function slope for the period as a whole is not statistically different from zero, while post-1992 it is statistically significant, and of approximately the same magnitude in elasticity terms as for column (4).

While certainly preliminary, the results in Tables 1 and 2 suggest that states behave strategically, reacting to other states' environmental standard stringency when setting their own. Combined with recent evidence that environmental regulations do affect industry locations, and the theoretical findings that interjurisdictional tax and regulatory competition is inefficient except under very specific circumstances, a strong case is emerging against devolving environmental authority to sub-national governments.

CONCLUSIONS AND DISCUSSION

Any paper such as this must contain appropriate caveats. Let me simply point out two of the most important. First, individual regions may not compete with one another but may instead follow one or two innovators. In the context of tax competition, Altshuler and Goodspeed (2002) test for whether European countries set capi-

tal tax rates in response to U.S. rates in a Stackleberg model. In the context of environmental regulatory competition, Fredriksson and Millimet (2002b) test for whether U.S. states all follow California's lead when setting their environmental standards.

Second, the specifications in Tables 1 and 2 control for unobserved state heterogeneity with fixed effects. This works so long as the source of heterogeneity is time-invariant. If all states experience common time-varying shocks, those will be absorbed by the year fixed effects in Table 2, and they will be irrelevant in Table 1 where the regulatory stringency measure averages 1.0 each year. However, if regional blocs of states experience unobservable time-varying regional heterogeneity, that will bias the reaction function coefficient, providing spurious evidence of strategic behavior. This problem is also present in Fredriksson and Millimet's work and in the empirical tax competition literature. One obvious means to control for this would be to include separate regional trends. That implies, however, that the researcher knows which groups of states have coordinated policies, and that the correlated movements are unidirectional. Future research in this area will need to confront the potential for regional time-varying heterogeneity to bias our measurements of environmental reaction functions.

Despite the fact that much of this empirical literature is still forming, it is safe to draw some preliminary conclusions. The theoretical literature on interjurisdictional environmental regulatory competition is well established, and presents a laundry list of conditions necessary for local regulations to be efficient. The conclusion must be that under most practical circumstances, local environmental authority will lead to inefficient regulations. In practice, however, it is unclear how strategically U.S. states behave with re-

spect to each others' environmental regulations. Recent evidence, including that presented here, suggests that states' environmental regulations are strongly dependent on neighboring states' regulations. By itself, this competitive behavior is not inefficient. However, given the long list of necessary conditions for such competition to lead to efficiency, it is highly unlikely that the strategic behavior we observe results in Pareto-efficient standard setting.

Acknowledgments

The author thanks Sjamsu Rahardja for research assistance, and Rosanne Altshuler, Daniel Millimet, and Hilary Sigman for particularly insightful comments.

REFERENCES

- Altshuler, Rosanne, and Timothy J. Goodspeed. "Follow the Leader? Evidence on European and U.S. Tax Competition." Cuny. Mimeo, 2002.
- Becker, Randy, and Vernon Henderson. "Effects of Air Quality Regulations on Polluting Industries." *Journal of Political Economy* 108 No. 2 (February, 2000): 379-421.
- Brueckner, Jan. "Strategic Interaction Among Governments: An Overview of Empirical Studies." University of Illinois. Mimeo, 2001.
- Brueckner, Jan, and L.A. Saavedra. "Do Local Governments Engage in Strategic Tax Competition?" *National Tax Journal* 54 No. 2 (June, 2001): 203-30.
- Case, Ann, Jim Hines, Jr., and Harvey S. Rosen. "Budget Spillovers and Fiscal Policy Interdependence: Evidence from the States." *Journal of Public Economics* 52 No. 3 (October, 1993): 285-307.
- Council on Environmental Quality. *Environmental Quality*. Washington, D.C.: U.S. Government Printing Office, 1992.

- Ederington, Josh.
 "International Coordination of Trade and Domestic Policies." *American Economic Review* 91 (December, 2001): 1580-93.
- Ederington, Josh, and Jenny Minier.
 "Is Environmental Policy a Secondary Trade Barrier? An Empirical Analysis." *Canadian Journal of Economics* (forthcoming).
- Fredriksson, Per G., and Daniel L. Millimet.
 "Strategic Interaction and the Determination of Environmental Policy Across US States." *Journal of Urban Economics* 51 No. 1 (January, 2002a): 101-22.
- Fredriksson, Per G., and Daniel L. Millimet.
 "Is There a 'California Effect' in U.S. Environmental Policymaking?" *Regional Science and Urban Economics* 32 No. 6 (November, 2002b): 737-64.
- Greenstone, Michael.
 "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures." NBER Working Paper No. 8484. Cambridge, MA: National Bureau of Economic Research, 2001.
- Heyndels, B. and J. Vuchelen.
 "Tax Mimicking Among Belgian Municipalities." *National Tax Journal* 51 No. 1 (March, 1998): 89-101.
- Jaffe, Adam, Steven Peterson, Paul Portney, and Robert Stavins.
 "Environmental Regulations and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic Literature* 33 No. 1 (March, 1995): 132-63.
- Keller, Wolfgang, and Arik Levinson.
 "Environmental Regulations and Foreign Direct Investment to U.S. States." *Review of Economics and Statistics* 84 No. 2 (2002).
- Levinson, Arik.
 "A Note on Environmental Federalism: Interpreting Some Contradictory Results." *Journal of Environmental Economics and Management* 33 No. 3 (July, 1997): 359-66.
- Levinson, Arik.
 "State Taxes and Interstate Hazardous Waste Shipments." *American Economic Review* 89 No. 3 (June, 1999a): 666-77.
- Levinson, Arik.
 "NIMBY Taxes Matter: The Case of State Hazardous Waste Disposal Taxes." *Journal of Public Economics* 74 No. 1 (October, 1999b): 31-51.
- Levinson, Arik.
 "An Industry-Adjusted Index of State Environmental Compliance Costs." In *Behavioral and Distributional Effects of Environmental Policy*, edited by Gilbert Metcalf and C. Carrero. Chicago: University of Chicago Press, 2001.
- List, John A., and Shelby Gerking.
 "Regulatory Federalism and Environmental Protection in the United States." *Journal of Regional Science* 40 No. 3 (2000): 453-71.
- List, John A., and Daniel L. Millimet.
 "A Natural Experiment on the 'Race to the Bottom' Hypothesis: Testing for Stochastic Dominance in Temporal Pollution Trends." Southern Methodist University. Working Paper, 2002.
- McLure, Charles E.
 "Tax Competition: Is What's Good for the Private Goose Also Good for the Public Gander?" *National Tax Journal* 39 No. 3 (September, 1986): 341-8.
- Markusen, James, Edward Morey, and Nancy Olewiler.
 "Noncooperative Equilibria in Regional Environmental Policies When Plant Locations are Endogenous." *Journal of Public Economics* 56 No. 1 (1995): 55-77.
- Millimet, Daniel L.
 "Assessing the Empirical Impact of Environmental Federalism." Southern Methodist University. Working Paper, 2001.
- Oates, Wallace E.
 "A Reconsideration of Environmental Federalism." Resources for the Future Discussion Paper 01-54, 2001.
- 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 No. 3 (1988): 333-54.

Oates, Wallace E., and Robert M. Schwab.
 "The Theory of Regulatory Federalism: The Case of Environmental Management." In *The Economics of Environmental Regulation (Economists of the Twentieth Century)*, edited by Wallace E. Oates, 319–31. Brookfield, VT: Elgar, 1996.

Pashigian, B.P.
 "Environmental Regulation: Whose Self-Interests are Being Protected?" *Economic Inquiry* 23 (October, 1985): 551–84.

Peltzman, Sam, and T. Nicholas Tideman.
 "Local versus National Pollution Control: Note." *American Economic Review* (December, 1972).

Pollution Abatement Costs and Expenditures (PACE).
Current Industrial Reports. Washington, D.C.: U.S. Department of Commerce, Bureau of the Census, MA-200, various years.

Sigman, Hilary.
 "Letting States Do the Dirty Work: State Responsibility for Federal Environmental Regulation." *National Tax Journal* 56 No. 1, Part 1 (March, 2003): 107–122.

Stein, Jerome L.
 "The 1971 Report of the President's Council of Economic Advisers: Micro-Economic Aspects of Public Policy." *American Economic Review* (September, 1971).

Tiebout, Charles M.
 "A Pure Theory of Local Expenditures." *Journal of Political Economy* 64 (1956): 416–24.

U.S. Council of Economic Advisers (CEA).
1971 Economic Report of the President. Washington, D.C.: U.S. Government Printing Office, 1971.

Wellisch, Dietmar.
Theory of Public Finance in a Federal State. New York: Cambridge University Press, 2000.

Wilson, John D.
 "Capital Mobility and Environmental Standards: Is There a Theoretical Basis for a Race to the Bottom?" In *Fair Trade and Harmonization: Prerequisites for Free Trade*, Vol. 1, edited by J. Bhagwati and R.P. Hudec. Cambridge and London: MIT Press, 1996.

Wilson, John D.
 "Theories of Tax Competition." *National Tax Journal* 52 No. 2 (June, 1999): 269–304.

APPENDIX: INDEX OF STATE ABATEMENT COSTS

This discussion is taken from Levinson (2001). The state pollution cost index compares the *actual* pollution abatement costs in each state, unadjusted for state industrial composition, to the *predicted* abatement costs in each state, where the predictions are based solely on nationwide abatement expenditures by industry and each state's industrial composition. Let the actual costs per dollar of output be denoted

$$[A.1] \quad S_{st} = \frac{P_{st}}{Y_{st}}$$

where P_{st} is pollution abatement costs in state s in year t , and Y_{st} is the manufacturing sector's contribution to the gross state product (GSP) of state s in year t . By failing to adjust for the industrial composition of each state, equation [A.1] likely overstates the compliance costs of states with more pollution-intensive industries and understates the costs in states with relatively clean industries.

To adjust for industrial composition, compare [A.1] to the *predicted* pollution abatement costs per dollar of GSP in state s :

$$[A.2] \quad \hat{S}_{st} = \frac{1}{Y_{st}} \sum_{i=20}^{39} \frac{Y_{ist} P_{it}}{Y_{it}}$$

where industries are indexed from 20 through 39 following the 2-digit manufacturing SIC codes, Y_{ist} is industry i 's contribution to the GSP of state s at time t , Y_{it} is the nationwide contribution of industry i to national GDP, and P_{it} is the nationwide pollution abatement operating costs of industry i . In other words, \hat{S}_{st} is the weighted average pollution abatement costs (per dollar of GSP), where the weights are the relative shares of each industry in state s at time t .

To construct the industry-adjusted index of relative state stringency, S_{st}^* , divide actual expenditures in [A.1] by predicted expenditures in [A.2]:

$$[A.3] \quad S_{st}^* = \frac{S_{st}}{\bar{S}_{st}}.$$

When S_{st}^* is greater than 1, that indicates that industries in state s at time t spent more on pollution abatement than those same industries

in other states. When S_{st}^* is less than 1, industries in state s at time t spent less on pollution abatement. By implication, states with large values of S_{st}^* have relatively more stringent regulations than states with small values of S_{st}^* .