Environmental and Resource Economics **15:** 343–364, 2000.

The Missing Pollution Haven Effect

Examining Some Common Explanations

ARIK LEVINSON
Department of Economics, University of Wisconsin, 1180 Observatory Drive, Madison, WI 53706
(E-mail: amlevins@facstaff.wisc.edu)

Accepted 16 April 1999

Abstract. This paper examines the effect of recent increases in hazardous waste disposal taxes on employment growth in industries that generate hazardous waste. Most existing literature has found that interjurisdictional differences in environmental stringency have negligible measurable economic consequences. Common explanations for this lack of effect include claims that (1) measures of environmental stringency are poorly quantified, (2) compliance costs are modest, (3) variation in compliance costs among jurisdictions is small, and (4) cross-section data are insufficient to explore the consequences of increasingly stringent standards. This paper addresses these four concerns by quantifying hazardous waste disposal taxes, demonstrating that they are large and varied across jurisdictions in the United States, and showing that they have had a significant effect on hazardous waste shipping among states. The paper then uses a panel of state and county-level data to show that despite these findings, state hazardous waste disposal taxes do not impose large employment losses on industries that generate waste.

Key words: employment, hazardous waste, local environmental regulations, pollution tax

JEL classification: H7, Q2, R3

Introduction

A wide discrepancy exists between the intuitive perception that local environmental regulations inhibit local economic growth and the findings of economists that such effects are statistically and economically insignificant. Policymakers, confronted by two divergent views of the economic burden of environmental compliance costs, often appear to believe the conventional wisdom. The federal environmental policies enacted in the 1970s in the United States were meant to discourage "flight of industry and jobs . . . [to] areas requiring less controls on industry."[1] Pashigian (1985) notes that support for federal uniform emissions standards was strongest among Northeastern congressional delegations who feared losing industry to Southern and Western states with cleaner air and less stringent standards. And U.S. Senators David Boren (D-OK) and Ernest F. Hollings (D-SC) have worried publicly that environmental regulations have been detrimental to the United States' international competitiveness.[2]

For economists, the "jobs versus the environment" debate is an empirical question with two parts: (1) Will jurisdictions compete to attract or repel industry? and (2) how sensitive is industry to differences in environmental regulations among jurisdictions? The large and growing empirical literature has focused on the second question and is well summarized by Jaffe et al. (1995). They conclude that the "widespread belief that environmental regulations have a significant effect on the siting of new plants in the United States. . . . may not be well founded," and that overall, "there is relatively little evidence to support the hypothesis that environmental regulations have had a large adverse effect on competitiveness." They provide several possible explanations for this gap between economists' findings and the conventional wisdom that regulations hamper economic growth. First, there is a dearth of data quantifying the stringency of regulations. Second, environmental compliance costs are a relatively small percentage of total production costs for most industries. And third, the compliance cost variation across relevant jurisdictions may be too small to generate measurable industry responses.[3]

In addition to the above explanations, there is a fourth weakness with the existing literature. Studies of the effect of regulations on local economies almost exclusively rely on cross-section data.[4] As a consequence, this literature has had trouble distinguishing between the simultaneous effects of regulations on employment growth and that of employment growth on regulations. This problem is particularly troublesome where there are unobserved characteristics of jurisdictions that make them likely to attract manufacturing industry *and* pass stringent environmental regulations. Consider the case of a state with a natural resource that is valued by a highly polluting industry. In cross-section data, that state is likely to exhibit both high growth in the polluting industry and stringent regulations for that industry, relative to states with less of the requisite resource. If the existence of the resource is unobserved, then the cross-section data will likely exhibit a spurious positive relationship between regulatory stringency and economic growth.

This paper addresses these four criticisms of the existing literature by studying the economic effects of hazardous waste regulations in the United States. It begins by describing a unique panel of hazardous waste disposal tax data. It then demonstrates that these taxes represent large and varied compliance costs, and that these compliance costs have significantly affected the pattern of hazardous waste disposal shipments among states. Finally, the paper combines these tax data with employment data from the Annual Survey of Manufacturers to examine the effect of hazardous waste disposal taxes on employment growth among industries that generate hazardous waste. It concludes by concurring with most of the existing literature that such effects are small or nonexistent, and suggests a few alternative explanations for the conventional wisdom.

II. Data

Hazardous waste management has been one of the fastest growing components of environmental compliance costs in the United States.[5] In the early 1990s, total costs (excluding liability costs under Superfund) were projected to grow from $1.7 billion in 1987 to $22.3 billion by 2000 (in 1986 dollars).[6] In 1987 fewer than one-half of the states taxed off-site disposal of hazardous waste, and the average tax for those states was $17 per ton. By 1995, 10 more states assessed such taxes, and the corresponding average was over $23 per ton.[7]

This paper uses a panel of hazardous waste disposal taxes for each of the 48 contiguous U.S. states for 1988–1993. These tax data rely on several assumptions. First, I approximate annual tax rates by averaging the number of months each tax was in effect. A few states express their tax rates per gallon of waste (e.g. Maine), I convert these to per-ton rates by multiplying by the number of gallons in a ton of water (239.7). Several states impose taxes on the gross revenue earned by hazardous waste disposal facilities. Because these taxes are small relative to disposal taxes, I ignore them here.[8] I also ignore taxes that may be imposed by counties or other local jurisdictions. In addition, states have a wide variety of license fees that affect firms involved in hazardous waste transport or disposal. Because these fees are small relative to the disposal taxes, I omit these licensing fees.

The focus on off-site disposal taxes overlooks a number of other variables that affect the compliance costs associated with hazardous waste disposal. These include the stringency of state Superfund laws, the pre-tax price of hazardous waste disposal, and the enforcement efforts of state environmental agencies (Jarvinen 1995). For this reason, I explore an alternative indicator of hazardous waste disposal costs: the average distance hazardous waste is shipped. This proxies for compliance costs because firms facing higher local disposal compliance costs will ship waste farther. The farther waste is shipped, the higher the costs to local generators.

The data for shipping distances comes from the U.S. EPA's Toxics Release Inventory (TRI). The TRI is collected annually as a result of the Emergency Preparedness and Community Right to Know Act of 1986. It is a census of manufacturing establishments with 10 or more full-time employees that manufacture or process more than 25 thousand pounds of any toxic chemical. Each facility reports its location, type of business, and the quantity of each chemical released into the air or water systems, stored or disposed of on-site, or transferred off-site, and the location to which it was transferred. While the TRI is limited to manufacturing establishments, the manufacturing sector made up 58 percent of generators, and accounted for 98 percent of the hazardous waste generated in 1989 (EPA 1993). And while the TRI is limited to toxic wastes, omitting those that are exclusively corrosive, reactive or explosive, most of the hazardous waste generated in the United States fits this classification.[9]

Because the TRI is self-reported and publicly available, and because some states have begun using it to assess taxes, firms may have incentives to misrepresent their emissions. Two audits of the TRI data conducted by the United States General Accounting Office have been only partially reassuring (1991, 1994). However, this project focuses on only one aspect of the TRI, the off-site disposal of toxic waste. Compared to intentional and accidental releases to water or air, off-site disposal is far more easily monitored by manufacturers and governments, and thus these data may be more reliable.

Finally, this paper uses measures of economic activity from the U.S. Census Bureau's County Business Patterns, which annually reports county-level employment by SIC code. Other data on state and county characteristics, including population density, income, percent of earnings from manufacturing, and land prices, come from the U.S.A. Counties data published by the Census Bureau.

III. Hazardous Waste Disposal Taxes are Large and Varied Across States

Table I depicts how hazardous waste disposal taxes have increased in the United States in recent years, and their variation across states. Currently these tax rates range from zero in many states, to over $100 per ton in a few states. From 1987 to 1992, the average per-ton disposal fee rose by 80 percent in real terms before falling somewhat in 1993.[10] In part this change is due to increases in tax rates among states that imposed taxes in 1987, and in part it is due to an increase in the number of states imposing such taxes. Figure 1 depicts those states that increased their hazardous waste disposal taxes during the period. Column (4) of Table I presents the weighted average distance waste is shipped, by county, from 1989 through 1993. Although the year-to-year differences are not statistically significant, the mean shipping distance follows a pattern similar to the tax rates, growing steadily until 1992 before falling off. While it is tempting to infer that the increases in taxes and shipping distances are related, that relationship is not obvious. Figure 2 presents the states whose shipping distances increased, and there is no apparent connection to the map in Figure 1. Nevertheless, Table I does address several of the important criticisms of the existing empirical literature on environmental regulations and economic growth: it presents a panel of quantifiable data on environmental stringency and demonstrates that the standards vary significantly among states.

The next step in addressing the criticisms is to show that hazardous waste generators incur substantial costs as a result of these taxes. One way to show that would be to demonstrate that firms in jurisdictions with high hazardous waste disposal taxes are more likely to ship waste out-of-state, and are more likely to ship waste farther, than firms in jurisdictions with low hazardous waste disposal taxes.[11] To investigate the magnitude of the tax incentives to export waste from the state in which it was generated, I estimate a model in which the dependent variable is the natural log of the percent of waste shipped out of state, and the unit of observation is the county. Assume that firms choose disposal sites by minimizing disposal

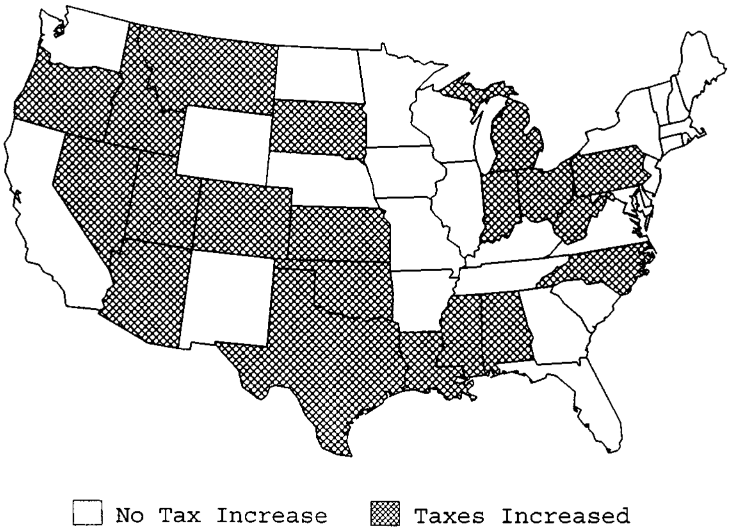

Figure 1. States with increased HW disposal taxes 1987–1993.

Table I. Hazardous waste taxes and shipping distances.

Year	States with hazard waste disposal taxes	Average State disposal tax		Average shipping distance by county	
		$ Nominal	$1993	Miles	St. dev.
	(1)	(2)	(3)	(4)	(5)
1987	21	7.77	9.88	*n.a.*	*n.a.*
1988	21	9.03	11.02	*n.a.*	*n.a.*
1989	25	10.36	12.07	244	152
1990	27	13.39	14.80	255	182
1991	28	16.26	17.25	313	229
1992	30	17.20	17.71	353	241
1993	31	14.88	14.88	314	220

Sources:
Col. (1) Commerce Clearing House, various years.
Col. (2) Toxics Release Inventory, various years.
Notes:
Averages over 48 states.
Shipping distances are weighted by quantity shipped.

costs. An increase in the origin state disposal tax will increase the proportion of waste in each county that is shipped interstate for disposal, and an increase in destination disposal taxes will decrease that proportion. However, the choice of regressor for the destination disposal tax is not obvious. There are at least two complications. First, the minimum interstate transport and disposal costs faced by firms that elect to keep waste in-state are unobserved. I proxy for this by using the

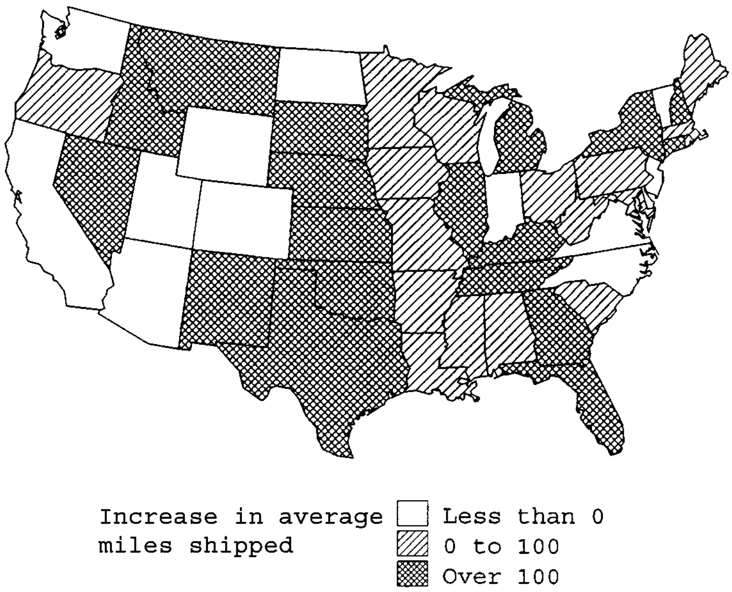

Figure 2. Change in mean HW shipping distance 1989–1993.

county-wide average tax faced by firms that *do* ship interstate, weighted by pounds shipped.[12]

A second problem arises because total shipping costs include a component due to distance, which is omitted from the county-wide average destination tax variable used. States that are large or remote may be more likely to have disposal facilities of their own and to keep waste in-state. Furthermore, firms in such states will be willing to ship waste interstate only when destination taxes faced are low, to compensate for the large distances involved. The combination of these two effects could generate a spurious positive correlation between weighted average interstate tax paid and the likelihood of shipping waste interstate. In other words, any regression that fails to include total shipping costs contains an omitted variable bias that will make counties appear more likely to ship waste interstate when average interstate taxes are higher. To account for this, I rely on the time series variation in taxes and use a fixed-effects model with dummies for origin state. Because interstate tax rates vary year-to-year, and interstate distances do not, the state dummies will capture the component of interstate costs that would otherwise be omitted, as well as other time-invariant characteristics.

Table II regresses the log of out-of-state shipments for disposal purposes on a collection of county characteristics. Because the log of county-wide off-site transfers is included, the dependent variable can be thought of as the log of the percent of off-site waste that is exported. As expected, the local disposal tax increases the propensity to export waste for disposal, and destination taxes decrease that propensity.[13] A $1 increase in local disposal taxes increases the proportion of

Table II. The effect of taxes on interstate shipments: County-level regressions using TRI data and fixed origin-state dummies. (1988–93).

Dependent variable: log(out-of-state shipments for disposal).	Coefficient	Std. error
State disposal tax	0.0527*	(0.0055)
Weighted average tax on interstate shipments	−0.0062*	(0.0016)
Log (Total county-wide off-site transfers)	0.7510*	(0.0169)
County population density (1000/sq. mile)	0.2758*	(0.0334)
County median income ($1000s)	0.0737*	(0.0148)
County% earnings from mfctring	1.0575*	(0.2941)
County land price ($1000s)	−0.0377*	(0.0133)
Year = 1990	−0.1023	(0.1104)
Year = 1991	−0.0996	(0.1065)
Year = 1992	−0.1998†	(0.1044)
Year = 1993	−0.2892*	(0.0994)
Observations	4150	
R^2	0.49	

Weighted least squares by tons of waste. Origin-state fixed effects not reported.
Standard errors in parentheses.
† Statistically significant at 10 percent.
* Statistically significant at 5 percent.

waste that is shipped interstate by 5 percent, while a $1 increase in destination disposal taxes decreases the proportion shipped interstate by 0.6 percent. Given the magnitude of recent tax increases, these estimates suggest that the competition between jurisdictions to prevent hazardous waste imports has significantly shifted the pattern of interstate hazardous waste transport from what it otherwise would have been. For example, among states with taxes, the average state tax rates rose about $6, from $17 to $23. Extrapolating from the coefficient in Table II, this suggests that the percent of hazardous waste generated in those states that is disposed of in other states rose by over 30 percentage points. By itself, I believe that Table II provides solid evidence that these taxes have had an empirically significant effect on a costly aspect of manufacturers' behavior, and thus addresses yet another of the criticisms of the current literature, that the regulations being studied are not costly enough to matter to economic activity.[14]

One could argue, however, that hazardous waste disposal taxes are merely one part of the regulations faced by firms that generate hazardous waste. In particular, the most important unobserved cost is that which is charged by the disposal facility. These disposal fees are unobserved because they typically involve long-term private contracts, and in many cases the disposal facility and the trucking company are owned by the same entity. In response to this concern, I use an

Table III. The effect of taxes on shipping distances.

Dependent variable: hazardous waste disposal shipping distance, measured from state centroids.	Coefficient	Std. error
Origin state disposal tax	0.746*	(0.252)
Log (Total plant off-site transfers)	6.73*	(0.40)
Origin county median income ($1000s)	61.49*	(0.50)
Origin county area (1000 sq. miles)	−97.89*	(11.70)
Origin county population (1000s)	−0.010*	(0.001)
Origin county % earnings from mfctring	48.38*	(11.95)
Origin county land price ($1000/acre)	0.834*	(0.347)
Destination county median income ($1000s)	−20.24*	(0.44)
Destination county area (1000 sq. miles)	15.75*	(0.90)
Destination county population (1000s)	−0.019*	(0.001)
Destination county % earnings from mfctring	−211.2*	(11.7)
Destination county land price ($1000/acre)	−1.044*	(0.430)
Year = 1990	−0.958	(3.44)
Year = 1991	−9.38*	(3.54)
Year = 1992	−16.28*	(3.57)
Year = 1993	−13.79*	(3.53)
Observations	34494	
R^2	0.14	

Includes 48 origin-state dummy variables.
Standard errors in parentheses.
* Statistically significant at 5 percent.

alternative measure of disposal costs faced by manufacturers in each county: the county-wide weighted-average distance hazardous waste is shipped.

In support of using distance as a measure of disposal costs, in Table III I regress this average shipping distance on a set of county characteristics similar to those used in Table II. The county-wide weighted average toxic waste shipping distance is calculated from the TRI, from 1989 to 1993.[15] A $1 increase in local hazardous waste disposal taxes is associated with a 0.75 mile increase in shipping distances. At the average values of these variables in Table I, this represents an elasticity of approximately 0.04. Though the elasticity may be small, recent tax changes have been large, again suggesting that significant costs have been imposed on hazardous waste generators.

For states with disposal taxes, average tax rates rose from $17 to $27 per ton between 1987 and 1992. This $10 increase is associated with a 7.5 mile increase in average shipping distances. One study estimated the cost of transporting hazardous waste to be 23¢ per ton per mile (ICF 1988). This implies that waste generators should be willing to ship waste as far as 43 miles in order to avoid a $10 tax increase. The fact that the average response (7.5 miles) is significantly smaller is likely due to the fact that some generators can avoid increased local taxes with smaller adjustments, and that some adjustments involve altering long-term contracts. In other words, Table III estimates a short-run elastic response, whereas any response to distances among states in necessarily a long-run response. (Taxes change frequently; interstate distances do not.) In sum, Tables II and III suggest that hazardous waste taxes may be a useful tool for studying the economic effect of environmental regulations because they address the four concerns outlined in the introduction to this paper. Hazardous waste taxes (1) are readily quantified, (2) are large enough and (3) varied enough across states to have affected the pattern of hazardous waste disposal, and (4) are varied enough across time to create a panel data set that can be used to capture unobserved heterogeneity among states.

IV. The Effect of Disposal Taxes on Employment Growth by Hazardous Waste Generators

The previous section demonstrated that hazardous waste disposal taxes have important effects on the economics of interjurisdictional hazardous waste transport for disposal purposes. The next question to ask is whether these taxes affect employment in industries that generate hazardous waste. Table IV presents some summary statistics for the employment and tax data being examined. The first row contains data for the 48 contiguous states, according to whether the state experienced a tax increase between 1988 and 1993. On average, all states lost manufacturing employment during this period. States experiencing tax increases lost fewer jobs, though the difference is statistically insignificant. A similar pattern holds for the 3077 counties that had manufacturing employment, presented in the second row of Table IV. On average, all counties lost manufacturing employment, and those counties in states with tax increases lost slightly less employment. On an annual basis, a similar pattern holds, as presented in the third and fourth rows of Table IV. Here however, the average jurisdiction experiencing a tax increase in a given year also experienced an increase in manufacturing employment. All of these comparisons contradict the conventional wisdom that would suggest that increased environmental costs decrease employment.

Figure 3 depicts those states that lost manufacturing employment from 1988 to 1993, those that gained up to 10000 jobs, and those that gained over 10000 jobs. While on average states lost 22000 manufacturing jobs during this period, half of the states gained employment, and one-quarter gained more than 10000 jobs apiece. Again, however, no obvious link connects the employment changes in Figure 3 with the tax and distance changes depicted in Figures 1 and 2. At a minimum, Table IV and Figure 3 suggest that the effect of taxes on employment will be difficult to study without taking account of the heterogeneous character of the jurisdictions.

Table IV. Hazardous waste taxes and employment changes.

	No increase in HW tax			HW disposal tax increased			All jurisdictions and years		
	No. of juris-dictions (1)	Employment change (mean) (2)	Tax change (mean) (3)	No of juris-dictions (4)	Employment change (mean) (5)	Tax change (mean) (6)	No. of juris-dictions (7)	Employment change (mean) (8)	Tax change (mean) (9)
States, 1988–93	29	−34496	−1.62	19	−4045	+14.00	48	−22443	+4.56
(48 states)		(72368)	(6.69)		(36204)	(16.71)		(62036)	(13.90)
Counties, 1988–93	1719	−551	−1.50	1358	−109	+12.66	3077	−358	+4.75
(3077 counties)		(5886)	(6.44)		(2314)	(14.80)		(4684)	(13.01)
States, annual	198	−6120	−0.44	42	+3201	+7.31	240	−4489	+0.91
(240 state-years)		(20102)	(3.05)		(7005)	(8.63)		(18818)	(5.40)
Counties, annual	12705	−99	−0.38	2900	+46	+6.71	15605	−72	+0.93
(15605 county-years)		(1592)	(2.75)		(719)	(7.17)		(1471)	(4.83)

Sources: Author’s calculations from Commerce Clearing House publications (tax data) and County Business Patterns data (employment data).

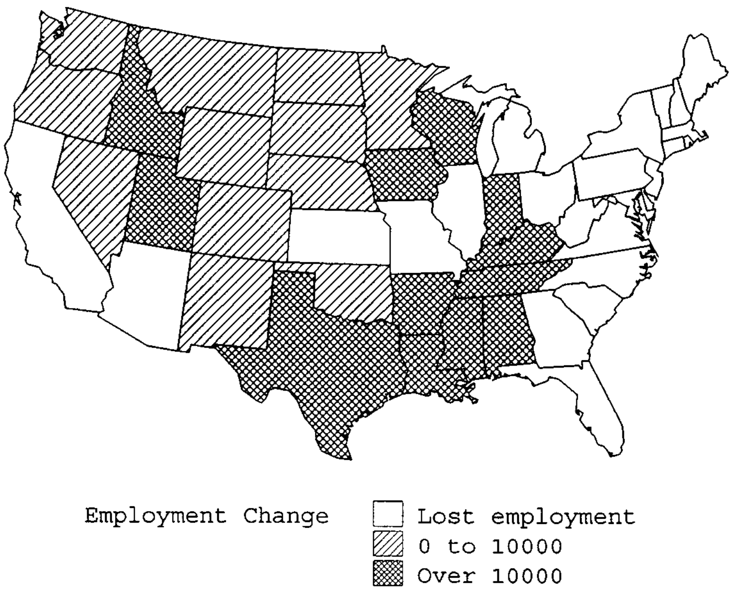

Figure 3. Change in manufacturing employment 1988–1993.

To do that, I refer to the now extensive literature on the effect of business taxes on employment. As Newman and Sullivan (1988) point out, several econometric approaches have been taken to measure the process by which local government characteristics affect employment. First, one could imagine that the world is in a steady-state, and use a single cross-section of data on location characteristics to estimate the equilibrium tradeoffs people and industries have made between wages, factor costs, and location characteristics. This approach will have the most difficulty sorting out the simultaneity of jurisdictional characteristics and outcomes (do strong environmental regulations create healthy economies or vice versa?). Alternatively, one could use a single cross-section of changes in jurisdiction characteristics and economic variables and estimate the comparative static response of the latter to the former. Finally, one could (with sufficient data) use a panel of cross-section and time-series data to examine differences in economic growth across jurisdictions as a function of changes in jurisdiction characteristics. This last approach is followed by Helms (1985) and Crandall (1993) in the context of tax competition. I follow it loosely here in the context of hazardous waste regulations.

Assume that L_{jt} is the employment in jurisdiction j at time t and that $(1 - \delta)$ is the fraction of the previous period's employment that is due to time-invariant characteristics of jurisdiction j. Therefore

$$L^*_{jt} = L_{jt} - (1 - \delta)L_{j,t-1} \tag{1}$$

where L^*_{jt} is the part of employment due to changes in economic conditions since last period. Equation (1) can be rewritten in logs as

$$\ln L_{jt} = \ln L_{j,t-1} + \ln\left[1 + \delta\left(\frac{L^*_{jt}/\delta - L_{j,t-1}}{L_{j,t-1}}\right)\right]. \tag{2}$$

A first order approximation to equation (2) is

$$\ln L_{jt} = \ln L_{j,t-1} + \delta \ln\left(\frac{L^*_{jt}/\delta}{L_{j,t-1}}\right). \tag{3}$$

The component of employment that is due to changes in economic conditions, L^*_{jt}, is then assumed to be a log-linear function of jurisdiction characteristics

$$\ln L^*_{jt} = \alpha + X'_{jt}\mathrm{B} + J(j) + T(t) + \varepsilon_{jt} \tag{4}$$

where $J(j)$ is a vector of jurisdiction dummy variables, and $T(t)$ is a vector of time dummies. Substituting (4) into (3) generates the equation to be estimated:

$$\begin{aligned}\ln L_{jt} \;=\; & \delta(\alpha - \ln\delta) + (1-\delta)\ln L_{j,t-1} + \delta X'_{jt}\mathrm{B} + \delta J(j) + \\ & \delta T(t) + \delta\varepsilon_{jt}.\end{aligned} \tag{5}$$

In what follows, I focus on changes in hazardous waste disposal costs (taxes or shipping distances) and hold constant invariant characteristics of jurisdictions with fixed-effects dummy variables.

ECONOMETRIC ISSUES

Before estimating equation (5), it is important to discuss two econometric issues: the endogeneity of lagged dependent variables in fixed-effects models, and the potential simultaneity of environmental policy and economic growth. First note that in equations such as (5), where the number of observations is large but the number of time periods is small, fixed effects estimators with lagged dependent variables will be biased.[16] Unfortunately, the typical fixes for this bias involve using two and three-period lags to instrument for the one-period lags, and in this short panel that would eliminate almost all of the time series variation in the tax rates or shipping distances. Hence, for this paper I present the admittedly biased results of estimating equation (5) in conjunction with similar estimations without the fixed effects included.

The second issue, the possibly simultaneous determination of public policies and economic growth, appears to confuse much of the popular media. While members of industry have been quick to forecast disastrous economic consequences of environmental regulations,[17] some analysts have claimed just the opposite. A widely cited recent study surveyed all 50 U.S. states and concluded that “The states that do the most to protect their natural resources also wind up with the strongest economies and the best jobs for their citizens.”[18]

From an economist's perspective, the view that jurisdictions with tough environmental regulations have healthier economies appears to be confused by an endogenous policy. The more likely explanation is that jurisdictions with strong economies can afford tough regulations. Put differently, environmental quality is a normal good, wealthy jurisdictions demand more of it and impose tough standards on industry. In cross-section data, strong economies and tough regulations are positively correlated, leading to the false inference that tough regulations cause economic growth, rather than the other way around.

Equation (5) has the potential to make the same mistake. Employment is regressed on lagged employment and current hazardous waste taxes, implying that taxes affect employment, not the opposite. I assume that regulatory changes take more than one year to enact, so that current employment cannot affect current taxes.[19] If valid, that assumption guarantees that there are no directly endogenous right-hand-side variables in equation (5) – current employment L_{jt} cannot cause either last year's employment $L_{j,t-1}$ or this year's tax rate. However, if equation (5) omits important information about jurisdictions that is correlated with both taxes and employment growth, the simultaneity of environmental policy and economic growth has the potential to affect the results through omitted variable bias resulting from the unobserved heterogeneity among jurisdictions. This is the principal reason to use the time series of hazardous waste taxes and a fixed-effects model to control for the jurisdictions' heterogeneity.

RESULTS

Table V examines the effect of hazardous waste taxes on employment growth at the county level. In order to demonstrate the importance of controlling for industry composition and unobserved heterogeneity, column (1) serves as a benchmark by controlling for neither. The dependent variable is the log of the county's manufacturing employment. The only independent variables in column (1) are the counties' previous year's employment ($\ln L_{j,t-1}$), a year dummy, and the state hazardous waste tax. The coefficient on tax (0.00017) is positive and insignificant, for at least two reasons. First, it aggregates across industries, many of which are not likely to be affected by (or may even benefit from) hazardous waste taxes. Second, the specification contains no other information about the jurisdiction. If that missing information (unobserved heterogeneity) is positively correlated with both taxes and employment, then the tax coefficient may have a positive bias. One omitted variable that might be positively correlated with both taxes and employment is the attractiveness of the state to industries that generate hazardous waste. This attractiveness may be related to the availability of resources, the costs of other factors of production, transportation infrastructure, or access to product markets.

To account for the first problem, industry aggregation, column (2) runs the pooled 1988–93 data on lagged employment, a year dummy, and the state tax rate interacted with dummy variables for two-digit SIC code dummy variables.

Table V. County employment growth and hazardous waste taxes, 1988–1993.
Dependent variable = log(employment).

	All industries (1)		Pooled by industry (2)		By industry with county fixed effects[a] (3)	
$\log(\text{employment})_{t-1}$	0.981*	(0.003)	0.914*	(0.001)	0.873*	(0.001)
Year = 1990	−0.025	(0.009)	0.023*	(0.006)	0.024*	(0.006)
Year = 1991	−0.077*	(0.009)	−0.054*	(0.006)	−0.053*	(0.006)
Year = 1992	−0.007	(0.010)	0.015*	(0.007)	0.015*	(0.007)
Year = 1993	−0.015†	(0.009)	0.005*	(0.006)	0.006	(0.006)
Local HW disposal tax	0.00017	(0.00021)				
Tax∗SIC20 (food)			0.0020*	(0.0004)	0.0041*	(0.0006)
Tax∗SIC21 (tobacco)			−0.0054†	(0.0029)	−0.0101*	(0.0030)
Tax∗SIC22 (textiles)			−0.0005	(0.0008)	−0.0028*	(0.0009)
Tax∗SIC23 (apparel)			0.0011*	(0.0005)	−0.0019*	(0.0006)
Tax∗SIC24 (lumber)			0.0019*	(0.0003)	0.0040*	(0.0005)
Tax∗SIC25 (furniture)			−0.0013*	(0.0007)	−0.0024*	(0.0008)
Tax∗SIC26 (paper)			0.0020*	(0.0007)	0.0007	(0.0008)
Tax∗SIC27 (printing)			0.0005*	(0.0003)	0.0032	(0.0005)
Tax∗SIC28 (chemicals)			0.0013*	(0.0005)	0.0011	(0.0007)
Tax∗SIC29 (petroleum & coal)			−0.0032*	(0.0008)	−0.0062*	(0.0009)
Tax∗SIC30 (rubber & plastics)			0.0020*	(0.0005)	0.0022*	(0.0007)
Tax∗SIC31 (leather)			−0.0024*	(0.0009)	−0.0061*	(0.0010)
Tax∗SIC32 (stone/clay/glass)			−0.0012*	(0.0004)	0.0000	(0.0005)
Tax∗SIC33 (primary metals)			0.0005	(0.0007)	−0.0007	(0.0009)
Tax∗SIC34 (fabricated metals)			0.0011*	(0.0005)	0.0025*	(0.0006)
Tax∗SIC35 (machinery)			0.0009*	(0.0004)	0.0033*	(0.0006)
Tax∗SIC36 (electronics)			0.0020*	(0.0006)	0.0021*	(0.0007)
Tax∗SIC37 (transportation)			0.0010	(0.0006)	0.0012†	(0.0007)
Tax∗SIC38 (instruments)			0.0014*	(0.0007)	0.0000	(0.0008)
Tax∗SIC39 (miscellaneous)			0.0014*	(0.0006)	−0.0020*	(0.0007)
Constant	0.167*	(0.022)	0.365*	(0.006)	0.525*	(0.008)
R-squared	0.97		0.86		0.86	
Observations	15605		186605		186605	

Heteroskedastic-consistent standard errors in parentheses.
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
[a] County dummies not reported. Constant reported is average fixed effect.

The dependent variable is the counties' employment in each 2-digit SIC code. In this case, the tax appears to have a positive and statistically significant effect on employment in 12 industries, and a negative and statistically significant effect on employment in 5 others. But recall that column (2) retains the problem that many omitted variables may be correlated with both employment and tax rates.

To account for omitted variables that vary across counties but are fixed over time, column (3) runs a fixed-effects model, in which county dummies are calculated but not reported. In this specification, 6 of the statistically significant tax-industry interaction coefficients are positive while 7 are negative. This change in the signs of the tax coefficients provides weak evidence that increases in hazardous waste disposal taxes may have had a measurable detrimental effect on employment growth in some industries. However, several issues weaken even further the case for a measurable employment effect of these environmental taxes. These issues include omitted cost variables, the magnitudes of the tax-industry interaction coefficients, and the pattern of these coefficients across industries. They are discussed in order.

First, among the omitted variables that may change over time is the pre-tax cost of hazardous waste disposal. If pre-tax disposal cost increases are positively correlated with state taxes across counties, then the tax-industry coefficients in column (3) of Table V are probably biased upwards. If they are negatively correlated, the tax-industry coefficients are likely spuriously small. Because these pre-tax disposal costs are unobserved, I use as a proxy the county-wide average shipping distance for hazardous waste disposal, calculated from the TRI. Hazardous waste generators in counties with high local disposal costs will be likely to ship waste farther, all else equal. (Table III demonstrated this for taxes; presumably the same is true for all disposal costs.)

Table VI presents the same set of regressions as Table V, except that county-wide weighted-average shipping distances are used as a measure of disposal costs, rather than state taxes. A similar pattern of coefficients appears, though the reversal of signs is less distinctive. In column (1), the benchmark minimal specification, the distance coefficient (0.0008) is positive but statistically insignificant. In column (2) when distance-industry interactions are substituted for the simple distance variable, they are positive and significant for 6 industries, negative and significant for 6 others. In the fixed-effects model in column (3), 6 of the distance-industry interactions remain positive and 7 are negative.

The distance specification in column (3) of Table VI yields point elasticities that are highly correlated with those of the tax specification in column (3) of Table V. (The correlation coefficient for the tax-industry and distance-industry coefficients between the two models is 0.97.) However, the addition of interacted industry-distance variables and the fixed-effects jurisdictions dummies does not result in as sharp a distinction as found with the tax specifications in Table V. One reason for this may have to do with the nature of the distance variable. While distance shipped serves as a broad proxy for hazardous waste disposal costs, and while it is certainly correlated with hazardous waste taxes (as seen in Table III), one can imagine situ-

Table VI. County employment growth and hazardous waste shipping distances, 1989–1991. Dependent variable = log(employment).

	All industries (1)	Pooled by industry (2)	By industry with county fixed effects[a] (3)
$\log(\text{employment})_{t-1}$	0.986* (0.001)	0.918* (0.001)	0.888* (0.002)
Year = 1990	−0.017* (0.005)	0.023* (0.006)	0.024* (0.006)
Year = 1991	−0.062* (0.005)	−0.060* (0.006)	−0.056* (0.006)
Year = 1992	−0.011* (0.005)	0.006 (0.007)	0.010* (0.007)
Year = 1993	−0.005 (0.005)	0.001 (0.007)	0.006* (0.007)
Average HW shipping distance (1000s of miles)	0.0008 (0.0062)		
Distance∗SIC20 (food)		0.100* (0.021)	0.127* (0.022)
Distance∗SIC21 (tobacco)		−0.232† (0.129)	−0.462* (0.162)
Distance∗SIC22 (textiles)		−0.081* (0.036)	−0.207* (0.038)
Distance∗SIC23 (apparel)		0.001 (0.025)	−0.015 (0.025)
Distance∗SIC24 (lumber)		0.055* (0.020)	0.070* (0.021)
Distance∗SIC25 (furniture)		−0.063* (0.023)	−0.124* (0.025)
Distance∗SIC26 (paper)		0.057† (0.030)	−0.017 (0.030)
Distance∗SIC27 (printing)		0.071* (0.012)	0.103* (0.013)
Distance∗SIC28 (chemicals)		0.037† (0.023)	0.005 (0.024)
Distance∗SIC29 (petroleum & coal)		−0.192* (0.040)	−0.378* (0.043)
Distance∗SIC30 (rubber & plastics)		0.093* (0.029)	0.070* (0.029)
Distance∗SIC31 (leather)		−0.152* (0.045)	−0.325* (0.049)
Distance∗SIC32 (stone/clay/glass)		−0.055* (0.022)	−0.065* (0.022)
Distance∗SIC33 (primary metals)		0.008 (0.036)	−0.067† (0.036)
Distance∗SIC34 (fabricated metals)		0.054* (0.027)	0.072* (0.028)
Distance∗SIC35 (machinery)		0.117* (0.019)	0.151* (0.020)
Distance∗SIC36 (electronics)		0.055 (0.034)	0.034 (0.034)
Distance∗SIC37 (transportation)		0.039 (0.026)	0.017 (0.026)
Distance∗SIC38 (instruments)		0.021 (0.030)	0.056† (0.031)
Distance∗SIC39 (miscellaneous)		−0.068* (0.026)	−0.130* (0.027)
Constant	0.144* (0.013)	0.385* (0.008)	0.522* (0.009)
R-squared	0.99	0.87	0.87
Observations	9990	145965	145965

Heteroskedastic-consistent standard errors in parentheses.
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
[a] County dummies not reported. Constant reported is average fixed effect.

ations in which the distance shipped is *inversely* correlated with disposal costs. Suppose for example, that waste from one county is largely shipped to another state, which then raises its tax. Generators may choose to avoid the tax increase by keeping waste in-state, thus decreasing distance shipped. In this example, costs increase while shipping distance decreases. Cases such as this may explain why in cross section specifications such as that presented in Table III shipping distances are a predictable function of taxes, while in fixed-effects panel specifications such as in Table VI shipping distances have less consistent employment consequences than taxes.

A second issue involves the magnitudes of the tax-industry interactions, both in absolute value and relatively between Tables V and VI. The largest negative coefficient in column (3) of Table V is −0.0054 for SIC 21 (tobacco). It implies that a $1 increase in a state's hazardous waste disposal tax decreases employment in the tobacco manufacturing industry by 0.54 percent. At the average 1993 tax rate of $15 (including states with zero taxes) this implies an elasticity of employment with respect to taxes of −0.08. In Table VI, the largest negative coefficient in column (3) is −0.462 (also for SIC 21). It implies that a 100-mile increase in a county's average hazardous waste shipping distance reduces SIC 21 manufacturing employment in that county by 4.6 percent. At the pooled mean shipping distance of 212 miles, this implies an elasticity of −0.098. Both the tax and distance elasticities are thus quite small, suggesting that the recent increases in hazardous waste disposal taxes have not affected employment growth in substantial ways.

Figure 4 plots the tax and distance elasticities, scaled on the left axis, by two-digit SIC code and shows the two measures correspond remarkably well in their measured effect on employment ($\rho = 0.97$). Because the tax and distance variables are different measures of compliance costs, and are drawn from different data, I interpret their similar roles in these models as evidence of the robustness of these results.

Finally, a third issue involves the comparison across industries. If these effects, however small, are truly measuring responses to hazardous waste disposal costs, then we would expect larger effects from those industries that generate more hazardous waste, all else equal. Table VII ranks two-digit SIC codes according to the ratio of pounds of TRI off-site disposal shipments to employment. This waste/labor ratio can serve as an index of pollution intensity, and is reported in column (3) of Table VII. Figure 4 then plots this measure of pollution intensity against the tax and distance elasticities calculated from Tables V and VI.

As can be seen from Figure 4, there is no systematic increase in the measured employment response to distance or taxes as pollution intensity increases. At first glance, Figure 4 thus casts considerable doubt on the veracity of these coefficients as measures of employment responses. This doubt, however, must be mitigated by the concern that Figure 4 does not take into account that industries vary in their ability to avoid the economic incidence of these taxes. Industries facing inelastic local product demand may raise prices, maintaining profitability and

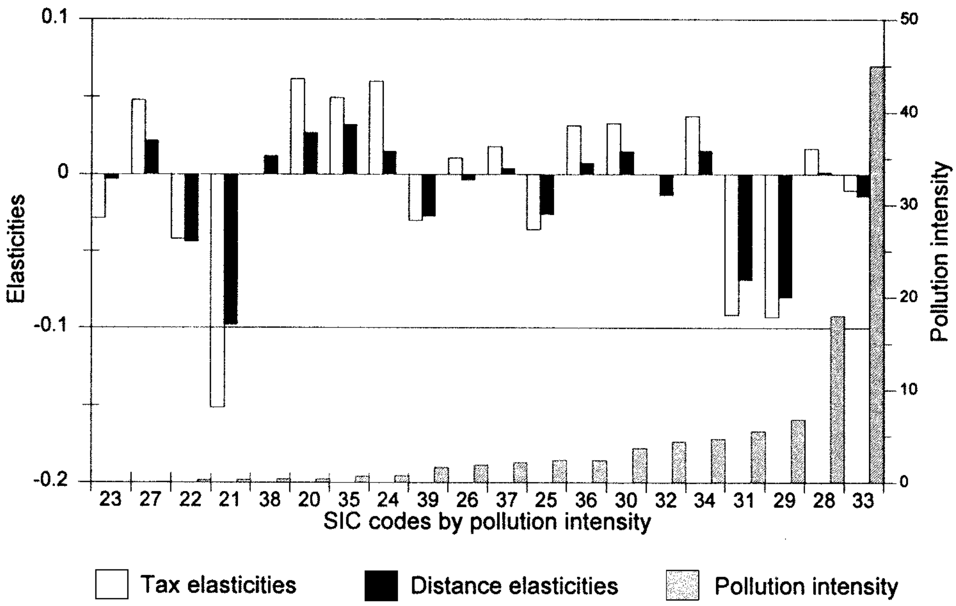

Figure 4. Pollution and employment effects by 2-digit SIC code.

employment. Industries facing inelastic local labor supply may lower wages, with similar consequences. Most importantly, geographically mobile industries may be able to relocate to jurisdictions with less stringent environmental standards. For example, SIC 33 (primary metals) has relatively small coefficients on taxes and distance and yet is quite pollution intensive. The small coefficients may be due to the fact that this industry cannot easily relocate to jurisdictions with less expensive disposal because it is bound to local raw materials markets. Conversely, SIC 22 (textiles) has higher than average employment responses and yet has among the lowest waste/labor ratios. This divergence may be due to the fact that this industry is relatively footloose in that it is not tied to local factor or skilled-labor markets.

What is needed to sort out the differences across industries in Table VII and Figure 4 is an index of "footlooseness." While this concept has intuitive appeal, there is no clear way to construct such an index. Industries may be bound to certain regions for three reasons: local factor markets, local product markets, and transport costs. None of these are measurable in the data constructed for this research, so any systematic investigation will necessarily be postponed. Nevertheless, the geographic mobility of industry is fundamental to employment responsiveness, and should eventually be incorporated into this line of research.

Table VII. Two-digit industries ranked by pollution intensity.

SIC code	Industry	TRI disposal shipments 1992 (lbs) (1)	March employment 1991 (2)	Pollution intensity [(2)/(1)] (3)
23	Apparel	47,112	3,063,350	0.02
27	Printing	166,094	4,598,077	0.04
22	Textiles	543,406	1,889,351	0.29
21	Tobacco	17,774	58,984	0.30
38	Instruments	993,730	2,828,420	0.35
20	Food	1,594,350	4,369,773	0.36
35	Machinery	3,841,677	5,752,154	0.67
24	Lumber	1,483,842	2,054,785	0.72
39	Miscellaneous	1,857,432	1,148,186	1.62
26	Paper	3,615,706	1,872,488	1.93
37	Transportation	11,437,553	5,226,065	2.19
25	Furniture	3,551,378	1,486,674	2.39
36	Electronics	11,191,096	4,624,199	2.42
30	Rubber & plastics	9,824,968	2,632,134	3.73
32	Stone, clay & glass	6,726,991	1,527,137	4.40
34	Fabricated metals	20,748,770	4,385,284	4.73
31	Leather	1,550,587	279,026	5.56
29	Petroleum & coal	2,178,141	319,036	6.83
28	Chemicals	46,551,327	2,583,463	18.02
33	Primary metals	96,569,713	2,148,738	44.94

Source: Author's calculations from County Business Patterns, 1991, and TRI, 1992.

V. Conclusions

Previous work investigating the employment consequences of interjurisdictional differences in environmental standard stringency is nearly unanimous in finding no economically or statistically significant effects. Explanations for the gap between these findings and the intuition that environmental regulations are detrimental to economic growth have claimed that environmental compliance costs are (1) difficult to quantify, (2) small, and (3) relatively homogeneous across jurisdictions, and (4) that the previous evidence relies mainly on cross-section data. This paper addresses these four concerns by constructing a database of quantifiable environmental compliance costs (state-level hazardous waste disposal taxes and average shipping distances for hazardous waste), showing that these costs have increased in recent years, and demonstrating that the increases have had measurable effects on at least one aspect of economic behavior (the decision to ship waste out of state). Though these measures of environmental compliance costs do appear to have statistically significant negative effects on employment growth in some industries, the effects are economically quite small and the relative size of the effects across industries does not correspond to the relative pollution-intensity of those industries.

Of course, the analysis here is limited by the fact that hazardous waste taxes are but one small part of overall environmental compliance costs, even for industries that generate the largest quantities of hazardous waste. Moreover, many other unmeasured characteristics of states and counties will affect firm location and employment growth: other taxes, public good provision, workers' wages and productivity, agglomeration economies, etc.

Ultimately, the contribution of this paper is to support the findings of previous literature that the jobs-environment tradeoff is inconsequentially small, but it does refute some existing explanations as to why that may be. Of the explanations we are left with, the most compelling may be that pollution-intensive industries are also those that are the least geographically footloose, in which case environmental authorities find themselves in the favorable position of being able to tax the most pollution-intensive industries at the highest rates without worrying about capital or labor flight to competing jurisdictions.

Acknowledgement

The author is grateful to the National Science Foundation and the Canadian Employment Research Forum for financial support, and to Charles Franklin, Denise Jarvinen, and John Karl Scholz for useful comments.

Notes

1. H. Report 95-294 cited in Bartik (1988).
2. See, for example, "Hearings Before the Subcommittee on International Trade of the Committee on Finance," U.S. Senate, October 25, 1991; and "Hearings Before the Subcommittee on Foreign Commerce and Tourism of the Committee on Commerce, Science, and Transportation," U.S. Senate, February 3, 1994.
3. Cropper and Oates (1992) suggest similar explanations for the lack of measurable effects of environmental regulations on local economies.
4. Two recent exceptions are Henderson (1997) and Gray (1997). Henderson finds significant effects of local regulations, while Gray does not.
5. U.S. Council on Environmental Quality, *Environmental Quality*, Washington, DC: 1992.
6. U.S. Environmental Protection Agency, *Environmental Investments: The Cost of a Clean Environment*, Washington, DC: December 1990.
7. See Table I, which reports the average tax for all 48 states, including those without taxes.
8. In 1995 five states imposed taxes on the gross receipts of facilities, ranging from 2 percent in Missouri to 10 percent in Connecticut.
9. Although the exact proportion of Resource Conservation and Recovery Act (RCRA) hazardous waste that would be characterized as toxic is difficult to calculate from published documents, the least it could be is 37 percent and the most it could be is 79 percent (calculated from EPA 1995).

10. In 1992 the United States Supreme Court ruled that Alabama's two-part waste disposal tax ($40 per ton for in-state waste, $112 per ton for out-of-state waste) was unconstitutional because it interfered with interstate commerce. In response, many states with similar discriminatory taxes lowered their taxes on disposal of out-of-state waste.
11. Sigman (1996) demonstrates that taxes on hazardous waste generation and management have reduced the amount of chlorinated solvent waste being sent to landfills.
12. This average measure is likely to understate the tax rates faced by firms that elect not to ship waste interstate. The rate will be understated for every county, however, and there is no reason to believe that the degree to which it is understated varies systematically by county.
13. The one obvious counter-intuitive coefficient is that on county land prices, which suggest that low price counties export more waste. I suspect that this is due to the missing variable for the quantity of waste generated in the county. In other words, counties that host more waste generation have both lower land values and higher waste exports, all else equal.
14. See Levinson (forthcoming) for more detail on this point.
15. The TRI shipping distance data are reliable only after 1989, which is why the distance regressions have one fewer year than the tax regressions.
16. See, for example, Hsiao (1986, p. 72) or Holtz-Eakin et al. (1988).
17. A California business association claimed in 1991 that "one in four California manufacturers currently plans to relocate" because of the state's costly "business taxes and environmental restrictions." ("Raising Business Costs," *Journal of Commerce*, October 16, 1991.)
18. Hall, Bob, *Green and Gold*, Durham, NC: Institute for Southern Studies, 1994.
19. Regressing employment on lagged taxes yields results indistinguishable from those that follow.

References

Bartik, Timothy J. (1988), 'The Effects of Environmental Regulation on Business Location in the United States', *Growth and Change* **19**(3), 22–44.

Bartik, Timothy J. (1991), *Who Benefits From State and Local Economic Development Policies?* Kalamazoo, MI: Upjohn Institute.

Crandall, Robert W. (1993), *Manufacturing on the Move*. Washington, DC: Brookings Institution.

Cropper, Maureen L. and Wallace E. Oates (1992), 'Environmental Economics: A Survey', *Journal of Economic Literature* **30**, 675–740.

Environmental Protection Agency (EPA) (1993), *National Biennial RCRA Hazardous Waste Report (Based on 1989 Data)*. Washington, DC: EPA, February.

Environmental Protection Agency (EPA) (1995), *National Analysis: The Preliminary Biennial RCRA Hazardous Waste Report (Based on 1993 Data)*. Washington, DC: EPA, March.

General Accounting Office (GAO) (1991), *Toxic Chemicals: EPA's Toxics Release Inventory Is Useful But Can Be Improved* (GAO/RCED-91-121). Washington, DC: GAO, June.

General Accounting Office (GAO) (1994), *Toxic Substances: EPA Needs More Reliable Source Reduction Data and Progress Measures*. Washington, DC: GAO, September.

Gray, Wayne B. (1997), 'Plant Location: Do Different Industries Respond Differently to Environmental Regulation?', Clark University mimeo.

Hall, Robert (1994), *Gold and Green*. Durham, NC: Institute for Southern Studies.

Henderson, Vernon and Randy Becker (1997), *Effects of Air Quality Regulation on Decisions of Firms in Polluting Industries*. NBER Working Paper #6160.

Helms, L. Jay (1985), 'The Effect of State and Local Taxes on Economic Growth: A Time Series – Cross Section Approach', *Review of Economics and Statistics* **67**(4), 574–582.

Holtz-Eakin, Douglas, Whitney Newey and Harvey S. Rosen (1988), 'Estimating Vector Autoregressions with Panel Data', *Econometrica* **56**(6), 1371–1395.

Hsiao, Cheng (1986), *Analysis of Panel Data*. New York: Cambridge University Press.

ICF Incorporated (1988), *1986–87 Survey of Selected Firms in the Commercial Hazardous Waste Management Industry*. Prepared for the Office of Policy Analysis, U.S. Environmental Protection Agency, March 31.

Jaffe, Adam B., Steven R. Peterson, Paul R. Portney and Robert N. Stavins (1995), 'Environmental Regulations and the Competitiveness of U.S. Manufacturing: What does the Evidence Tell Us?', *Journal of Economic Literature* **33**(1), 132–163.

Jarvinen, Denise (1995), *The Impact of State Regulatory Structure on Hazardous Waste Destination*. Ph.D. dissertation, U.C. Berkeley.

Levinson, Arik (Forthcoming), 'NIMBY Taxes Matter: The Case of State Hazardous Waste Disposal Taxes', *Journal of Public Economics*.

Newman, Robert J. and Dennis H. Sullivan (1988), 'Econometric Analysis of Business Tax Impacts on Industrial Location: What Do We Know and How Do We Know It?', *Journal of Urban Economics* **23**, 215–234.

Pashigian, Peter (1985), 'Environmental Regulations: Whose Self Interests Are Being Protected?', *Economic Inquiry* (October), 551–584.

Sigman, Hilary (1996), 'The Effects of Hazardous Waste Taxes on Waste Generation and Disposal', *Journal of Environmental Economics and Management* **30**, 199–217.

U.S. Council on Environmental Quality (1992), *Environmental Quality*. Washington, DC.