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Environmental regulations and manufacturers' location choices: Evidence from the Census of Manufactures

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Abstract

This paper uses establishment-level data from the Census of Manufactures and the Survey of Pollution Abatement Costs and Expenditures to examine the effect of differences in the stringency of state environmental regulations on establishment location choice. Unlike previous work in this area, which has focused on particular industries or sets of plants and on one or two measures of environmental regulatory stringency, this study explores the relationship between site choice and environmental regulations using a broad range of industries and measures of stringency. It uses a conditional logit model of plant location choice to show that interstate differences in environmental regulations do not systematically affect the location choices of most manufacturing plants.

Keywords: Industry location; Environmental regulations; Interjurisdictional competition

JEL classification: H73; R38; Q28

1. Introduction

The question of whether manufacturers' choices of locations are responsive to environmental standards has an intuitive answer. Profit-maximizing producers should take into account the compliance costs of local regulations, along with local factor availability and prices, when deciding where to locate a new plant. This intuition is supported by the behavior of national and local

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legislators and industry representatives, and by anecdotal evidence from the popular press. While the intuition is clear, the few empirical studies of manufacturer sensitivity to environmental regulations have mostly concentrated on particular industries or sets of plants, focusing on one or two environmental standards or measures of stringency. In general, they have found weak or insignificant effects. This study examines manufacturer location choice across most manufacturing industries and employs a wide array of measures of environmental standard stringency in an attempt to explore systematically the gap between what intuition suggests and what economists have found.

The results reported here show that the locations of branch plants of large firms are more sensitive to state characteristics than are plants in general, and that these branch plants appear to be deterred by stringent environmental regulations, as measured by a variety of different proxies for state environmental stringency. However, only a few of the coefficients on the measures of environmental stringency are statistically significant and none is large. Furthermore, the degree of aversion to stringent states does not seem to increase for pollution-intensive industries, which suggests either that the stringency proxies used are capturing some other state characteristic, or that pollution intensity is inversely correlated with an omitted variable such as geographic footlooseness.

Previous studies of industrial location choice have taken several forms. Surveys of manufacturing executives involved in plant location decisions generally conclude that environmental regulations are not a major determinant of site choice,[1] but these results are difficult to interpret. Some surveys ask open-ended questions about factors potentially influencing location, while others ask respondents to rank a preselected list of factors. Even consistently conducted surveys may be of little value if the respondents, through intent or ignorance, misrepresent the true effects of environmental regulations on location choice.

Empirical studies using data on state characteristics are potentially more useful. However, because of the limited availability of establishment-level data on new plant locations, most such work has used aggregate data on economic activity such as employment growth and net investment. The conclusions drawn using aggregate data generally support the survey evidence: environmental regulations do not appear to influence industry growth, employment, foreign direct investment, or cross-border trade. Duerksen (1983) presents the results of a study examining changes in industrial employment among states during the 1970s. States that gained employment relative to the national average had more lax environmental

[1] See, for example, Epping (1986), Schmenner (1982), Duerksen (1983), Wintner (1982), Stafford (1985), and Lyne (1990).

standards than states that lost employment, though this difference was statistically insignificant.[2] Duffy-Deno (1992) regresses employment and earnings for all manufacturing industries on a set of regional characteristics, including total pollution abatement costs for 63 metropolitan areas from 1974 to 1982. He finds that the coefficient on total pollution abatement costs per dollar of value added has statistically and economically insignificant coefficients. Most recently, Crandall (1993) finds that environmental compliance costs, as measured by the Census Bureau, do not have a "measurable effect on the regional distribution of manufacturing employment."

Many of the studies of the aggregate effects of environmental regulations have focused on the discrepancy between US environmental regulations and those found overseas. After examining trends in US direct investment abroad and US imports from pollution-intensive industries, Leonard (1988) finds no evidence that establishments in robust domestic industries have moved abroad in order to avoid US pollution regulations. Similarly, Grossman and Krueger (1991) conclude that differences between the US and Mexico's environmental regulations "play at most a minor role in guiding intersectoral resource allocations" (p. 36). Low and Yeats (1992) show that developing countries have gained a greater share of total world exports of pollution-intensive products, but that industrialized countries continue to be by far the largest exporters of these goods. They judge that the observed changes are "unlikely to be adequately explained by environmental policy" alone. Only Tobey (1990) attempts to control for other national characteristics and to include a quantitative measure of national environmental stringency. He uses a 1976 UN study that rates the environmental policies of about 40 countries on a scale from 1 (strict) to 7 (tolerant), and finds that this index does not have a statistically significant effect on net exports.

A problem faced by all domestic and international studies is that they use aggregate data, which cannot distinguish among changes caused by births of new plants, expansions of existing plants, contractions of existing plants, and plant closures, each of which will be affected differently by state characteristics. Many state environmental regulations, for example, consist of 'new source performance standards' that are more stringent for new firms. These standards effectively raise barriers to entry that protect existing older, often more labor-intensive plants. Using data that include all employment in a study of the consequences of regulations may conceal effects that work in opposite directions. Consequently, to isolate the effects of regulation on location it is necessary to use establishment-level data.

The primary obstacle to studying plant location decisions has been the inaccessibility of establishment-level data. Crandall (1993) uses data from

[2] Oddly, the difference was even smaller for pollution-intensive industries.

Dun and Bradstreet[3] to disaggregate employment changes due to plant openings, expansions, contractions, and closings. As a measure of regulatory stringency, Crandall uses total state-wide pollution abatement operating costs, divided by gross state manufacturing output. He finds that plant openings and closings are unresponsive to this measure of compliance costs, but warns against the conclusion that environmental policy does not affect plant openings because compliance costs from plants that are deterred from opening are by definition zero. In other words, Crandall is concerned about the nature of his proxy for environmental stringency: states may have low pollution abatement costs because they have stringent regulations and polluting industries choose to locate elsewhere.

Bartik (1988) and McConnell and Schwab (1990) use subsets of the Dun and Bradstreet data and an empirical specification following McFadden's (1974) conditional logit model. Bartik examines the locations chosen by branch plants of Fortune 500 companies between 1972 and 1978. The results lead him to support "the prevailing wisdom that environmental variables have only small effects on business locations." McConnell and Schwab examine data from the 1970s on SIC code 3711, vehicle assembly. These plants, in the process of painting cars and trucks, emit volatile organic compounds that contribute to urban ozone (smog). As a measure of regional environmental stringency, McConnell and Schwab use a series of dummy variables for whether or not the county chosen is in compliance with federal ambient ozone standards.[4] They find significant coefficients only for those counties that were extremely far out of compliance (Houston, Los Angeles, and Milwaukee).[5] Friedman et al. (1992) use the conditional logit model and establishment-level data on the planned locations of foreign firms within the United States. In one specification they include a variable similar to that used by Crandall (1993), i.e. total state-wide pollution abatement capital expenditures per dollar of gross state product from manufacturing. The resulting coefficient is statistically insignificant, though this may be due to the fact that the abatement expenditures variable measures statutory incidence, includes only direct capital expenditures, and does not control for the states' industrial compositions.

[3] There are many acknowledged problems with these data. Both Schmenner (1982) and McConnell and Schwab (1990) cross-checked their extracts of the Dun and Bradstreet data carefully, and found problems with many of the observations. Crandall (1993) notes that the Dun and Bradstreet data have difficulty distinguishing plant births and deaths from sales and acquisitions.

[4] Their interpretation of this regulatory stringency variable is that out-of-compliance counties will enforce stricter standards in an effort to comply. It is possible, of course, that the effect works in the other direction, i.e. that cities with lax regulations exceed federal ambient air quality standards.

[5] McConnell and Schwab note in their conclusion that these results may not reveal much about location choice in general if vehicle assembly plants are not geographically footloose.

All three studies (Bartik, 1988; McConnell and Schwab, 1990; and Friedman et al., 1992) use McFadden's conditional logit model and establishment-level data to study the effect of environmental regulations on plant site choice. However, they are not directly comparable, because they use different samples of new plants, different measures of environmental stringency, and different sets of other independent variables. This paper attempts to examine this issue systematically by testing different subsets of plants from different industries, and by testing a wide variety of measures of state environmental standard stringency.

2. The data

I use the establishment-level Census of Manufactures data to examine the effect of environmental regulations on the number of new plants that locate in each state.[6] 'Establishments' constitute the unit of observation for the Census, and are defined as single physical locations engaged in one of the manufacturing industry categories of the SIC.[7] Manufacturing establishments that appeared in the 1987 quinquennial Census but were not in the 1982 Census are designated as 'new plants' here and constitute the dependent variables in the models that follow. There are several arguments in favor of using new plant openings, rather than plant closings, as a measure of sensitivity to variations in state environmental standard stringency. The first, and most obvious, involves the fixed cost of building a manufacturing facility. If the facility is a viable economic enterprise, but because of high local environmental compliance costs is incurring losses or would be more profitable elsewhere, then the facility should shut down and move to another location only if the savings in environmental compliance costs exceed the cost of the move. The locations of existing plants will thus appear insensitive to all but large differences in state regulations. This apparently inertial behavior in the face of compliance cost differentials is avoided by examining the location decisions of new plants. New plants with no fixed costs can, in theory, make location decisions on the basis of even tiny differences in compliance costs, all else being equal.

Other reasons for studying the locations of new plants involve the

[6] Previous work has emphasized that establishment-level microeconomic data are necessary to study location choice. In particular, Schmenner (1982), Bartik (1988), and Crandall (1993) have noted the suitability of the Census of Manufactures, but were prevented from using it by confidentiality restrictions. For this study, I have gained access to the Census data through the Census Bureau's Center for Economic Studies, which has available both the Census of Manufactures and the Pollution Abatement Costs and Expenditures (PACE) Survey.

[7] I have excluded plants with fewer than 20 employees because data for many of these small plants are imputed by the Census Bureau. They accounted for only 2.2% of the total value added in 1987.

structure of existing regulations. Many environmental regulations, both state and federal, apply only to new plants, or are more stringent for new plants than for old plants. By protecting existing plants, these 'grandfather' regulations provide a reason to expect plant births to be more sensitive to environmental regulations than plant deaths. Finally, state versions of the federal Superfund law, and the federal law itself, impose stringent cleanup and liability costs on manufacturers that dismantle and sell industrial sites. To avoid these costs, many manufacturers claim that they maintain existing sites with skeletal work crews, without manufacturing any product, merely to avoid the regulatory costs of shutting down (Lyne, 1985). On the books these facilities appear as open factories, while in practice they have closed. To avoid the complications posed by these liability regulations and grandfather regulations, and to avoid inertial behavior driven by moving costs, this study focuses solely on the locations of new manufacturing plants.

A critical problem faced by all studies that examine the economic effects of environmental regulations has been quantifying those regulations in a meaningful way. Attempts have taken three broad directions: qualitative indices of regulatory stringency, quantitative measures of enforcement effort on the part of states, and measures of compliance costs incurred by plants. In the empirical results that follow, I explore six environmental regulatory measures drawn from these categories. The descriptive statistics for these measures and the other independent variables used are presented in Table 1.

The Conservation Foundation Index. In 1983 the Conservation Foundation constructed a qualitative index to attempt to measure each state's "effort to provide a quality environment for its citizens" (Duerksen, 1983). The 23 components of this index include environmental and land-use characteristics such as the League of Conservation Voters' assessment of the congressional delegation's voting record, the existence of state environmental impact statement processes, and the existence of language specifically protecting the environment in state land-use statutes. These were assigned point values on the basis of their importance, as judged by the Conservation Foundation staff, and aggregated into an index ranging from 0 to 63. For this study the components containing the dollar amount of state spending on various environmental programs were dropped, leaving a total of 19 components.[8]

The FREE Index. The Fund for Renewable Energy and the Environment

[8] The qualitative indices of regulatory stringency are negatively correlated with the quantitative measure of regulatory effort (given by Monitoring Employment). The unmodified Conservation Foundation Index thus contains offsetting components from different types of these stringency proxies. To separate clearly the different stringency measures, I removed the dollar spending by regulatory agencies from the rest of the Conservation Foundation Index.

Table 1
Descriptive statistics

Variable	Mean	Median	Minimum	Maximum	Standard deviation	Source
Conservation Foundation	23.6	22.0	9	39	7.3	Duerksen (1983)
FREE Index	30.3	29.5	14	49	9.5	FREE (1987)
Green Index	10.1	10.0	3	18	3.4	Hall and Kerr (1991)
Monitoring Employment	0.06	0.04	0.01	0.20	0.04	NGA (1982)
Aggregate Abatement Cost	0.77	0.54	0.12	3.56	0.73	PACE Survey and Census of Manufactures
Industry Abatement Cost	−0.12	−0.11	−0.57	0.27	0.18	Author's calculations from merged PACE and Census data (Table 2)
Business Tax	0.067	0.062	0.031	0.126	0.024	Wheaton (1983)
Wages	8.55	8.61	6.54	11.47	1.21	1982 Census of Manufactures
Unionization	0.21	0.18	0.04	0.52	0.13	Troy and Sheflin (1985)
Roads	3.20	2.90	1.00	8.71	1.55	Statistical Abstract of the United States
Energy Cost	4.92	4.68	2.77	8.40	1.35	Alexander Grant & Co. (1985)

(FREE, 1987) published as index of the strength of state environmental programs. The components of the index include state laws regarding air quality, hazardous waste, and groundwater pollution for the early 1980s.

The Green Index. Hall and Kerr (1991) compiled the widely cited 'Green Index' of state environmental standards by simply adding up the number of statutes each state had from a list of 50 common environmental laws. For this paper I have excluded statutes pertaining to consumer recycling programs, agriculture, and transportation that appear unlikely to affect manufacturing costs. The remaining 21 statutes include state superfund laws, air toxics programs, air emissions fees, and water permit programs.

Monitoring Employment. The above three qualitative indices attempt to capture state regulatory stringency as reflected by the states' statutes. To measure the states' effort and ability to enforce these statutes, I use the number of employees at state environmental agencies in 1982, divided by the number of existing manufacturing plants (National Governors' Association, 1982).

Aggregate Abatement Cost. This is the first of two compliance cost measures used in the empirical work that follows. It is essentially the variable used by Crandall (1993) and Friedman et al. (1992). I use the gross aggregate pollution abatement operating costs (across all plants in all industries) from the published PACE data, divided by the number of production workers in the state in 1982.[9] A major problem with this variable is that it aggregates abatement costs across industries that self-select into states for many unobservable reasons. A state that attracts polluting industries will naturally have high abatement costs, regardless of that state's environmental standards.

Industry Abatement Cost. This last variable attempts to eliminate the industry aggregation problem from the previous measure of compliance costs. The goal of this variable is to estimate how much manufacturers are required to pay for pollution abatement in each state, holding constant the characteristics of the manufacturer, including its industry. Using the raw, establishment-level PACE data, I regressed the log of gross pollution abatement operating costs on the log of the book value of capital, the log of

[9] An immediate question arises: How do we normalize gross abatement costs by the size of each state? Dividing by the number of production workers implies that such costs vary linearly with plant size, whereas dividing by the number of plants would imply that these costs are fixed and that there are large returns to scale in pollution abatement. (Crandall, 1993, and Friedman et al., 1992, normalize abatement costs by gross state manufacturing output.) To address this issue I ran a simple test using raw data from the PACE survey. I regressed establishment-level gross abatement costs on the number of production workers, and that number squared. The squared term has a negative and significant but tiny coefficient, indicating that abatement costs over the relevant range of plant sizes is most closely approximated by a linear function of the number of production workers.

the number of production workers, the log of value added, a dummy for new plants, dummies for four-digit SIC codes, and individual state dummies.[10] The results are reported in Table 2. A high point estimate for a state dummy coefficient indicates that, all else equal, plants in that state spend more on pollution abatement operating costs. The omitted state, New York, appears to have high environmental costs by this measure, and as a result all of the statistically significant coefficients are negative, indicating that plants in most states incur lower compliance costs than similar plants in New York. These state dummy coefficients are interpreted as measures of state stringency, and are included as independent variables in the location choice models that follow.[11]

There are several remaining problems with this final measure of state-specific compliance costs. First, respondents to the PACE survey presumably provide direct dollar amounts spent on pollution abatement. It would be impossible for them to assess the true economic costs of pollution abatement, including inefficiencies resulting from input substitution or altered production processes. Thus the plant-specific abatement operating costs may overstate or understate true compliance costs. Second, the coefficient on the state dummy variable measures how much more a plant would have to spend on pollution abatement if it located in that state rather than in the omitted state, holding constant capital, labor, value added, and industry. But it is unlikely that plants locating in two different states would hold all of those other factors constant. Given that manufacturers can respond to regulations in ways aside from spending more on pollution abatement, this measure may overstate true compliance cost differences.

Table 3 presents the correlations among the six variables. The three qualitative variables (the Conservation Foundation, FREE, and Green indices) are strongly positively correlated with each other, suggesting that the three may measure the same phenomenon. The measure of state regulatory effort (Monitoring Employment) is positively correlated with aggregate abatement costs, but negatively correlated with the qualitative variables. Finally, my measure of industry-specific abatement costs from the first-stage regression of abatement costs on state dummies (Industry Abatement Cost) is positively correlated with all of the other environment variables except state Monitoring Employment. It is positively, but not

[10] Implicit in this specification is a Cobb–Douglas production function in which output (value added) is estimated as a function of capital (K), labor (L), and pollution (P), with dummy variables for new plants, industries, and states: $Y = A \cdot K^{\beta_1} \cdot L^{\beta_2} \cdot P^{\beta_3}$. The model estimated here substitutes pollution abatement, which is observable, for pollution, takes the logarithm of both sides, and inverts the function to estimate abatement as a function of the other variables.

[11] Note that the asterisks in Table 2 reflect only the fact that the relevant coefficients are statistically different from zero. More important is the fact that many coefficients are statistically different from each other.

Table 2
First-stage regression for industry-specific compliance costs
Dependent variable: ln(gross pollution abatement operating costs)

Variable	Coefficient	Std. error
ln(capital)	0.545*	0.016
ln(production workers)	0.439*	0.022
ln(value added)	0.084*	0.016
New plant dummy	0.060	0.061
AL	−0.035	0.094
AR	−0.072	0.103
AZ	−0.232	0.155
CA	−0.150*	0.064
CO	−0.384*	0.140
CT	−0.001	0.097
DE	0.273	0.194
FL	0.022	0.095
GA	−0.194*	0.084
IA	−0.034	0.104
ID	−0.004	0.190
IL	0.055	0.067
IN	0.013	0.078
KS	−0.330*	0.115
KY	0.065	0.101
LA	−0.102	0.107
MA	−0.109	0.086
MD	0.148	0.108
ME	−0.041	0.163
MI	0.084	0.076
MN	−0.209*	0.091
MO	−0.195*	0.091
MS	−0.255*	0.123
MT	0.110	0.273
NC	−0.144	0.080
ND	−0.566	0.384
NE	−0.196	0.144
NH	−0.276	0.178
NJ	0.117	0.077
NM	−0.500	0.322
NV	−0.239	0.348
NY	na	na
OH	0.056	0.067
OK	−0.396*	0.120
OR	0.122	0.110
PA	0.022	0.067
RI	−0.247	0.148
SC	−0.184	0.096
SD	−0.020	0.264
TN	−0.078	0.088

Table 2 (*continued*)

Variable	Coefficient	Std. error
TX	−0.151*	0.071
UT	−0.494*	0.177
VA	−0.097	0.093
VT	−0.111	0.220
WA	−0.182	0.107
WI	−0.186*	0.078
WV	−0.115	0.143
WY	−0.412	0.365

$n = 11\,034$, d.f. $= 10\,565$, $R^2 = 0.74$.

* Statistically significantly at 5%.

Uses PACE data without sample weights.

Includes dummy variables for four-digit SIC codes.

perfectly, correlated with Aggregate Abatement Costs. There are two possible conclusions from the pattern of correlations in Table 3. If environmental stringency is a one-dimensional phenomenon, then it would seem that these cannot all be correctly measuring stringency, and that studies of the economic effects of environmental regulations that examine only one or two proxies for the strength of such regulations run the risk of mismeasuring stringency. Alternatively, if environmental stringency has several dimensions, such as the strength of the laws, the strength of states' enforcement, and compliance costs, then these variables may simply be measuring those different dimensions.

Other variables included in the models that follow are typical of those found in other studies of industrial location: measures of, or proxies for, business taxes, labor market conditions, market size and accessibility, and energy costs. The measure of business taxes used is taken from Wheaton (1983), and was also used by McConnell and Schwab. A problem common to all of these studies has been defining the pertinent average effective tax rate. Wheaton's business tax rates are among the most carefully developed, although they use data from 1977, several years before the time period studied here.[12] Labor costs are captured by the average production worker wage in the state, as calculated from the 1982 Census of Manufactures. The models also control for the percentage of the work force that was unionized in 1984 (Troy and Sheflin, 1985). The proxy for infrastructure used here is the number of highway miles per 1000 acres of non-federal land in each state. Energy costs are the average cost of energy for manufacturers per million BTUs as reported by Alexander Grant & Co. (1985).

[12] I developed a similar tax rate using 1988 data from the Advisory Commission on Intergovernmental Relations (ACIR), and the results below do not depend on which set of rates are used. The reported results use the Wheaton rates.

Table 3
Correlation of environmental stringency measures across states

$N = 48$ states	Conservation Foundation	FREE Index	Green Index	Monitoring Employment	Aggregate Abatement Cost	Industry Abatement Cost
Conservation Foundation	1.00					
FREE Index	0.68	1.00				
Green Index	0.66	0.71	1.00			
Monitoring Employment	−0.22	−0.45	−0.28	1.00		
Aggregate Abatement Cost	−0.09	−0.30	−0.21	0.48	1.00	
Industry Abatement Cost	0.39	0.38	0.30	−0.01	0.32	1.00

Finally, I include data on the number of existing plants in each state (by industry for the disaggregate specifications). This variable has three interpretations. It measures the size of each state, as larger states will naturally have greater numbers of new plants. Second, it may proxy for location (or 'agglomeration') economies present in concentrations of industry. Finally, the number of existing plants will capture some of the otherwise unobserved characteristics of the states that make them more or less attractive to industry.

3. A model of new plant births

Following Bartik (1988) and McConnell and Schwab (1990) I assume that each new plant has a latent (unobserved) profit function that is dependent on the characteristics of the state in which it locates

$$\hat{\pi}_{ij} = F(w_j, x_j, e_j) , \tag{1}$$

where $\hat{\pi}_{ij}$ are the latent profits that could be earned by plant i in state j, w_j is a vector of state-specific factor prices, x_j is a vector of state-specific fixed factors, and e_j is a measure of the stringency of state j's environmental regulations. If profit-maximizing plant managers consider a number of sites and choose the site at which the plant's profits would be highest, then increases in a state's factor prices or regulatory stringency, or decreases in the amount of infrastructure available, will lower these latent profits and decrease the likelihood of a plant choosing that state. In other words, $\partial\pi_{ij}/\partial w_j < 0$, $\partial\pi_{ij}/\partial x_j > 0$, and $\partial\pi_{ij}/\partial e_j < 0$. McFadden's (1974) conditional logit model can then be used to represent plant location choice econometrically.

To use the conditional logit model, I assume that Eq. (1) can be estimated in log form with a disturbance term following a Weibull distribution, where the profits of firm i, if the firm were to locate in state j, are equal to

$$\pi_{ij} = \beta' z_j + \epsilon_{ij} , \tag{2}$$

and where $z_j = (w_j, x_j, e_j)$ is a vector of state characteristics. The probability that state k maximizes profits for plant i is then

$$P(ik) = \frac{e^{\beta' z_k}}{\sum_{j=1}^{J} e^{\beta' z_j}} , \tag{3}$$

where J represents the total number of possible states. Eq. (3) forms the basis for the conditional logit model. In the empirical work that follows, the parameter β is estimated using maximum likelihood.

The strong assumption that the error terms in Eq. (2) are independently and identically distributed Weibull, while convenient analytically, imposes the unfortunate 'independence of irrelevant alternatives' (IIA) restriction on the predicted probabilities. With 48 choices (the contiguous United States), this property could be problematic. There is no reason, for example, to think that a firm's decision not to locate a plant in Oregon is independent of its decision to reject Washington or Idaho. To mitigate this problem, regional dummy variables are included for the four Census regions.[13] To the extent that the error terms are correlated only within regions and not across regions, the regional dummies should reflect this correlation and reduce the IIA problem. However, if the error terms are correlated across states that do not lie in the same region, the model may be misspecified. In the next section I discuss results from the conditional logit model for single-firm plants and for the branch plants of the largest 500 multi-plant manufacturing firms.

4. Empirical results

As a first look at mobility and state characteristics, I used Alexander Grant & Co.'s (1985) index of general manufacturing climates, with the environmental regulatory variable removed.[14] I separated from the census of new manufacturing plants the new branch plants of the largest 500 multi-plant manufacturing firms (ranked by value added). Results from the conditional logit models for all new plants and for new branch plants of large firms are presented in Table 4. The manufacturing climate coefficient is larger and more statistically significant for the branch plants of large firms than for all new plants in general, indicating that the branch plants of large

[13] An alternative correction for the IIA assumption that preserves the convenience of the logistic distribution is the 'nested' multinomial logit model. A nested model here would assume that plants first choose a region of the country, and then a state within that region. However, it is difficult to conceive of regional characteristics that affect location choice in ways different from the state characteristics already included. Instead, I follow Bartik (1988) and McConnell and Schwab (1990) and include dummy variables for Census regions.

[14] Alexander Grant & Co. is a consulting firm specializing in manufacturer location decisions. Its 1985 index of general manufacturing climates consists of 22 variables, normalized and then weighted according to responses to a survey of 37 state manufacturers' associations. Their environmental index is aggregate state-wide capital and operating costs of pollution abatement equipment, divided by the dollar value of industrial shipments. Of all the environmental variables explored by this paper, theirs is the only one having a positive relationship with the number of plant births. The problem, I suspect, lies with their inclusion of capital costs. States with many new plant births have high aggregate capital costs for pollution abatement equipment.

Table 4
Conditional logit model of location sensitivity to 'manufacturing climate'

	All new plants[a]	Branch plants of large firms
Manufacturing climate variable	0.0047*	0.0160*
	(0.0010)	(0.0014)
Existing plants	1.04*	0.94*
	(0.02)	(0.02)
Pseudo R^2	0.13	0.11
Log-likelihood	13 008	7120
n	3880	2060

* Statistically significant at 5%.
[a] Random sample.
Standard errors in parentheses.

firms are more sensitive to states' manufacturing climates.[15] It could be that large multi-plant firms have economies of scale in location searches. They have experience with operating in many states and know first-hand the attributes of those states. It may therefore be easier for the branch plants of multi-plant firms to be sensitive to states' business climates. Alternatively, branch plants could simply be more geographically flexible. One might imagine that an entrepreneur opening a single unaffiliated plant would be more likely to do so where he or she resides, while a large multi-plant firm would hire managers to run that plant and would be more flexible in its choice of location. As a consequence, the discussion that follows will focus on the branch plants of large firms, the sample that appears more likely to demonstrate sensitivity to environmental regulations.[16]

Table 5 presents results from the conditional logit model with a full set of state characteristics and using the branch plants of the largest 500 firms.[17] The tax variable is never significant at 5%, although in all but one of the

[15] For computational reasons, for the all-plant specification I took a random sample of plants, stratified by state so that the proportion of new plants appearing in each state would remain true to the total (subject to rounding errors necessary to maintain integer quantities of new plants).

[16] To provide further evidence that branch plants of large firms are more sensitive to state characteristics, I ran the conditional logit models for a full set of state characteristics using all new plants (the 'all new plant' analog to Table 5 below). As in Table 4, branch plants of large firms appear to be more sensitive to a variety of state characteristics, especially infrastructure and unionization, than do all new plants.

[17] For computational reasons, I needed to take a random sample of 80% of the 2060 new large-firm branch plants.

Table 5
Industrial location and state characteristics
New branch plants of large firms, conditional logit model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Conservation Foundation	−0.006						
	(0.005)						
FREE Index		−0.016*					−0.009**
		(0.006)					(0.005)
Green Index			−0.014				
			(0.013)				
Monitoring Employment				−0.130			−0.099
				(0.080)			(0.073)
Aggregate Abatement Cost					−0.081		
					(0.079)		
Industry Abatement Cost						−0.599*	−0.501*
						(0.278)	(0.252)
1-Business tax	1.095	−0.207	1.151	1.191	2.405	2.132	0.797
	(1.812)	(1.841)	(1.825)	(1.772)	(1.808)	(1.740)	(1.699)
Wages	−0.085	−0.084	−0.211	−0.035	0.085	0.007	0.122
	(0.376)	(0.367)	(0.365)	(0.378)	(0.458)	(0.377)	(0.350)

Table 5 (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Unionization	[illegible]	−1.391*	−1.018*	−1.102*	−1.065*	−0.788*	−1.058*
	(0.3[illegible]7)	(0.398)	(0.381)	(0.385)	(0.382)	(0.399)	(0.377)
Roads	0.390*	0.[illegible]*	0.396*	[illegible].333*	0.345*	0.448*	0.364*
	(0.134)	(0.13[illegible])	(0.135)	(0.135)	(0.135)	(0.139)	(0.127)
Energy cost	−0.368	−0.192	−0.34[illegible]	−0.28[illegible]	−0.399	−0.236	−0.013
	(0.297)	(0.305)	(0.[illegible]98)	(0.3[illegible]2)	(0.297)	(0.305)	(0.281)
West	0.5[illegible]0*	0.[illegible]2*	0.599*	0.563*	0.527*	0.540*	0.547*
	(0.121)	(0.121)	(0.127)	(0.121)	(0.124)	(0.122)	(0.108)
Midwest	0.527*	0.661*	0.570*	0.535*	0.485*	0.535*	0.603*
	(0.100)	(0.1[illegible])	(0.105)	(0.100)	(0.111)	(0.100)	(0.097)
South	0.750*	0.768*	0.763*	0.841*	0.772*	0.838*	0.818*
	(0.116)	(0.116)	(0.116)	(0.128)	(0.117)	(0.123)	(0.120)
Existing plants	1.032*	1.098*	1.023*	0.965*	1.025*	1.013*	1.028*
	(0.042)	(0.048)	(0.039)	(0.049)	(0.041)	(0.039)	(0.052)
Log-likelihood	5673	5670	5674	567[illegible]	5674	5672	7071
Pseudo R^2	0.1107	0.1113	0.1107	0.1108	0.1107	0.1109	0.1132

$n = 1648$

Standard errors in parentheses.
* Statistically significant at 5%.
** Statistically significant at 10%.

regressions it has the expected positive sign.[18] The average wage of production workers is insignificant. One explanation for this result may be that there are unmeasured and therefore omitted productivity differences between states. If omitted productivity is positively correlated with both wages and states' attractiveness, then it imparts a positive bias on the wage coefficient. I have run these models with several productivity measures included (output per manufacturing worker and education levels) with unsatisfactory results. An alternative explanation for the statistical insignificance of average wages may be that any wage effect is being captured by the unionization variable, which is uniformly negative and significant. The robustness of this result confirms some of the previous work on location choice, for which unionization seems to play an important role (Bartik, 1991; Crandall, 1993). The proxy for infrastructure (road miles per 1000 acres) is consistently positive and significant, and the measure of energy costs is consistently negative and insignificant. The dummy variables for the census regions are all positive and significant, indicating that new plants are opening at markedly lower rates in the Northeast, even controlling for other characteristics of those states.

Finally, the environmental measures appear with uniformly negative coefficients in the conditional logit model. The coefficient on the FREE index is statistically significant at 5%, Monitoring Employment is close to significance at 10%, and Industry Abatement Cost also appears to be significant, although its standard errors are likely to be underestimated.[19] Given the pattern of correlation among these measures of stringency (Table 2), it seems possible that they measure different characteristics of state environmental regulatory regimes that manufacturers care about when making location decisions. To address this possibility, I ran a similar set of regressions including three measures of stringency simultaneously: one qualitative index of state laws, the FREE index; a quantitative measure of enforcement, Monitoring Employment; and one measure of compliance costs, Industry Abatement Cost. The results with all three measures of stringency are presented in column (7) of Table 5. Included together, the FREE Index is negative and significant at 10%, Monitoring Employment is negative but insignificant, and Industry Abatement Cost appears to be significant, with the same caveat regarding its standard errors.

To draw conclusions about these variables beyond their statistical signifi-

[18] If business taxes are interpreted as a profits tax, then the left-hand side of Eq. (2) is $\ln(\pi(1-t))$. I thus include $\ln(1-t)$ as an independent variable, and its expected coefficient is positive.

[19] Recall that the Industry Abatement Cost measures are the coefficients on state dummies from the first-stage regression of abatement costs on plant characteristics in Table 2. Therefore the standard errors on Industry Abatement Cost in the second stage, the conditional logit, are understated (Murphy and Topel, 1985).

cance, it is necessary to interpret their magnitudes. The predicted probability of a plant choosing a state under the conditional logit specification is as in Eq. (3). To interpret the size of the coefficient, note that

$$\frac{\partial \ln P(ij)}{\partial z_j} = \hat{\beta}[1 - P(ij)] . \tag{4}$$

Thus the interpretation of any coefficient depends on the characteristics of the state being analyzed. To place these coefficients in context, Table 6 presents the percentage change in the probability of any one plant locating in a state with average characteristics, resulting from an increase in each of the listed parameters by one standard deviation. For example, the second column suggests that increasing the value of the FREE Index from 30 to 40, while holding all of the other parameters at their averages, would result in a 1.73% drop in the probability that a plant chooses to open in the

Table 6
Interpreting the coefficients of Table 5
The predicted percentage change in the probability of locating in a state with average characteristics as a result of a standard deviation increase in each independent variable

	(1) (%)	(2) (%)	(3) (%)	(4) (%)	(5) (%)	(6) (%)	(7) (%)
Conservation Foundation	−0.56	–	–	–	–	–	–
FREE Index	–	−1.73*	–	–	–	–	−0.86**
Green Index	–	–	−0.59	–	–	–	–
Monitoring Employment	–	–	–	−1.12	–	–	−0.76
Aggregate Abatement Cost	–	–	–	–	−0.89	–	–
Industry Abatement Cost	–	–	–	–	–	−1.21*	−0.94*
I-Business tax	−0.34	0.06	−0.37	−0.36	−0.72	−0.62	−0.21
Wages	−0.14	−0.13	−0.37	−0.06	0.14	0.01	0.18
Unionization	−1.79*	−1.96*	−1.58*	−1.62*	−1.54*	−1.11*	−1.38*
Roads	2.31*	2.34*	2.42*	1.92*	1.96*	2.49*	1.87*
Energy Cost	−1.22	−0.59	−1.19	−0.91	−1.27	−0.73	−0.04
Existing Plants	16.36*	16.22*	16.71*	14.91*	15.64*	15.03*	14.14*

* Underlying coefficient (Table 5) is significant at 5%.
** Underlying coefficient (Table 5) is significant at 10%.

hypothetical average state. Similarly, a one standard deviation change in Industry Abatement Cost, roughly equivalent to a change from Massachusetts to Minnesota, would result in a 1.21% fall in the probability of a new plant opening.[20]

Whether these effects are economically significant is debatable. Given that the average new large-firm branch plant employed 152 production workers in 1987, and that the average state attracted 43 such plants from 1982 to 1987, a 1% decline in the number of new branch plant openings over a five-year period results in the loss of only 65 production jobs. Even if a 1% decline in plant openings applied to all new plants with at least 20 employees, this would would result in the loss of only 305 jobs from the average state over five years. If these are the only costs of increasing environmental standard stringency by one standard deviation, then they are clearly not high.

One explanation for the lack of statistical or economic significance of the environmental stringency coefficients may be that stringent environmental standards merely alter the industrial composition of states without affecting the probability of new plant locations. In other words, while pollution-intensive industries may be deterred from locating in stringent states, clean industries may be attracted to those states for a variety of reasons. Clean industry could be attracted to stringent states by depressed land values, or if labor supply is relatively immobile, by depressed wages. Or, if labor supply is relatively mobile and if workers receive compensating wages for locating in lax (dirty) states, then clean industries could be deterred from locating in those lax states and attracted to clean states. To test this, I ranked the 20 two-digit SIC codes according to total abatement capital expenditures per dollar of investment. These range from essentially zero, for SIC 23 (apparel and other textile products) to over 16% for SIC 29 (petroleum and coal products).[21] The conditional logit model developed above was then run separately for new branch plants of large firms in each SIC code. The coefficients on the environmental variables from those estimations are presented in Table 7.

Very few of the environmental variables in Table 7 have significant and negative coefficients. The nine that do tend to be at the bottom of the table, among the dirtier industries, supporting the industrial composition hypothesis. However two of the five positive and significant coefficients also tend to be among dirtier industries. Nevertheless, it would be wrong to conclude that significant negative signs on the environmental variables in Table 5 are

[20] These calculations use the point estimates of each of the coefficients, regardless of their significance.

[21] A similar pattern is obtained if industries are ranked by operating costs per production worker, which range from essentially zero to $26 000 for petroleum and coal.

Table 7
Environmental coefficients by SIC code: Using specification from Table 5

SIC	Pollution intensity (%)	n	Conservation Foundation		FREE Index		Green Index		Monitoring Employment		Aggregate Abatement Cost		Industry Abatement Cost	
			Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
23 Apparel		40	0.002	(0.035)	0.036	(0.033)	0.089	(0.088)	0.284	(0.516)	-0.815	(0.553)	-0.424	(2.041)
27 Printing/publishing	0.6	181	-0.018	(0.018)	-0.047*	(0.021)	0.065	(0.045)	0.064	(0.208)	-0.373	(0.229)	-0.759	(0.864)
35 Machinery	0.7	173	0.006	(0.017)	0.005	(0.018)	0.040	(0.040)	0.019	(0.275)	-0.272	(0.244)	-0.019	(0.275)
38 Instruments	0.8	133	0.041**	(0.020)	-0.003	(0.024)	0.143**	(0.049)	0.023	(0.288)	-0.148	(0.294)	-1.096	(1.134)
30 Rubber/plastics	1.2	152	-0.030	(0.017)	-0.030	(0.018)	-0.071	(0.047)	0.226	(0.263)	-0.086	(0.259)	-1.547	(0.984)
36 Electronics	1.4	181	0.015	(0.017)	0.029	(0.019)	0.029	(0.042)	-0.365	(0.245)	-0.064	(0.269)	-0.956	(0.955)
22 Textiles	1.6	40	-0.040	(0.049)	-0.059	(0.035)	0.085	(0.164)	-0.065	(0.649)	-0.139	(0.734)	-1.777	(2.961)
24 Lumber	2.0	95	0.051**	(0.022)	0.015	(0.019)	0.092	(0.055)	-0.264	(0.301)	-0.623	(0.336)	-0.875	(1.015)
20 Food	2.7	249	0.000	(0.013)	0.006	(0.015)	-0.006	(0.033)	-0.607*	(0.210)	-0.518*	(0.199)	0.189	(0.662)
25 Furniture/fixtures	2.7	33	-0.065	(0.043)	-0.019	(0.047)	-0.025	(0.108)	-0.443	(0.669)	-0.006	(0.775)	1.047	(2.554)
34 Fabricated metals	3.0	158	-0.004	(0.018)	-0.030	(0.018)	0.018	(0.051)	-0.510	(0.283)	0.483	(0.298)	0.432	(1.033)
32 Stone, clay & glass	3.6	97	0.005	(0.026)	-0.066*	(0.024)	0.056	(0.057)	-0.174	(0.360)	-0.851*	(0.318)	-3.274*	(1.155)
26 Paper	4.5	79	0.022	(0.026)	0.025	(0.024)	0.080	(0.067)	0.263	(0.365)	0.383	(0.422)	0.099	(1.471)
37 Transportation	4.8	149	-0.005	(0.017)	0.007	(0.018)	0.003	(0.045)	0.026	(0.293)	0.256	(0.300)	-0.800	(0.957)
33 Primary metals	7.1	52	-0.028	(0.025)	-0.012	(0.025)	0.006	(0.072)	0.150	(0.449)	-0.597	(0.397)	-1.088	(1.498)
28 Chemicals	7.9	200	-0.036*	(0.016	-0.033*	(0.017)	0.014	(0.039)	0.531**	(0.[illegible]94)	0.549**	(0.219)	0.623	(0.863)
29 Petroleum & coal	16.5	26	-0.034	(0.042)	0.049	(0.051)	-0.012	(0.110)	0.678	(0.545)	-1.012*	(0.507)	-3.399	(2.100)

'Pollution intensity' is pollution abatement capital expenditures as a percentage of total new capital expenditures, 1986.
* Significant and negative at 5%.
** Significant and positive at 5%.

spurious simply because the more pollution-intensive industries in Table 7 do not have larger or more significantly negative signs than the cleaner industries. The industries in Table 7 are ranked by pollution abatement costs, not geographic flexibility, and it is possible that some of the industries at the bottom of Table 7, such as primary metals (SIC 33), paper (26), and transportation products (37), which show no apparent sensitivity to environmental regulations, are simply not geographically footloose. It is also true that the relevant sample size for some of these industries (for the branch plants of large firms) is probably too small to make broad generalizations.[22]

5. Conclusion

This study makes a systematic attempt to measure the effect of state environmental regulations on new manufacturing plant locations. It uses establishment-level data on location choices and pollution abatement costs, and focuses on a potentially sensitive subset of manufacturers, i.e. new branch plants of large multi-plant firms. Despite this effort, there seems to be little evidence that stringent state environmental regulations deter new plants from opening. Given the conclusion that regulations do not affect plant openings, the natural follow-up question is: Why not? It seems unlikely that environmental compliance costs are too small to weigh into location decisions, especially for the more pollution-intensive industries. On average, the industries studied here spent about 4% of their investment dollars on pollution abatement equipment. Some industries spent more than 5%, and one (petroleum and coal) spent 16% (see Table 7). An alternative explanation is that firms manufacturing products in a variety of jurisdictions find it most cost effective to operate according to the most stringent regulations, eliminating the necessity of designing a different production process for each location. Some argue that even if environmental compliance costs currently differ across states, they are converging to a uniform level. Or, it may simply be that the more pollution-intensive industries also happen to be the least footloose. These explanations lie outside the scope of this paper, but may be fertile ground for future research.

Three general conclusions may be drawn from this project. The first is that the branch plants of large firms appear more sensitive to local conditions, including environmental regulations, than do all plants in

[22] In fact, leather products (SIC 31), tobacco manufacturers (21), and miscellaneous industries (39) have been dropped from Table 7 for exactly this reason: too few large-firm branch plants appeared in these industries between 1982 and 1987.

general. Although several proxies for environmental standard stringency appear to have negative effects on the new plant births, these coefficients are significant only for the branch plants of very large firms. Two theories might explain why large-firm branch plants are more sensitive to variations in local environmental stringency. Such firms may have economies of scale in conducting site searches, and such plants may be more footloose than those of independent manufacturers. Either way, the sensitive subset of plants appears to be small.

A second important conclusion comes from examining the location choice model industry by industry. Very few industries have negative and significant coefficients for the environmental stringency variables, and an offsetting few have positive and significant coefficients. While it is difficult to sort the industries that are footloose from those that are not, industries that spend more on pollution abatement do not appear systematically less likely to locate in states with stringent environmental standards. The lack of a sensible pattern across industries provides further evidence against environmental regulations having a deterrent effect on manufacturer locations.

Finally, a third lesson that can be learned here is that care must be taken when interpreting the results of industry-specific studies, or studies that use only one of several possible measures of environmental stringency. It would be easy, for example, to pick any one of a number of the industries in Table 7, such as food products (SIC 20), and perform a study showing that plants in that industry are less likely to locate in states with lots of environmental regulators, as measured by the Monitoring Employment variable. Without comparing that industry with others, and without comparing that measure of stringency with others, such an interpretation would be misleading. Examining plant-level location decisions for many industries and measures of environmental regulatory stringency, the predicted effects of tighter standards are statistically insignificant and economically small, and do not appear to vary sensibly with the pollution intensity of the industry.

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