Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States

May 20, 2001

Wolfgang Keller
University of Texas
keller@eco.utexas.edu

Arik Levinson
Georgetown University
aml6@georgetown.edu

Abstract
This paper estimates the effect of changing environmental standards on patterns of international investment. The analysis advances the existing literature in three ways. First, we avoid comparing different *countries* by examining foreign direct investment (FDI) to the U.S. and differences in pollution abatement costs among U.S. *states*. Data on environmental costs in U.S. states are more comparable than that for different countries, and U.S. states are more similar in other difficult-to-measure dimensions. Second, we account for differences in states' industrial compositions, an acknowledged problem for earlier studies. Third, we employ an 18-year panel of relative abatement costs, allowing us to control for unobserved state characteristics. We find robust evidence that pollution costs have had moderate deterrent effects on foreign investment.

***JEL* keywords:** environmental regulations; location of foreign direct investment; pollution haven; pollution abatement costs.

***JEL* codes:** R38; F23; Q28.

Acknowledgments.
This paper has benefitted from funding provided by the National Science Foundation and the Wisconsin Alumni Research Foundation, and from invaluable research assistance by Joe Hendrickson. Wayne Gray, Kevin Hassett, Jim Hines, John List, Gib Metcalf, Domenico Siniscalco, Matt Slaughter, and numerous participants in seminars at the *International Seminar on International Trade* conference and the NBER and CEPR have provided especially constructive comments.

Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States

I. Introduction.

In recent years, a variety of interest groups have called for addenda to international trade agreements to harmonize domestic environmental regulations. Industry representatives in the U.S. worry that stricter standards will put U.S. manufacturers at a competitive disadvantage. Environmentalists fear that linked trade agreements will prevent countries from setting their desired levels of environmental regulation. Free trade advocates worry that countries may be able to circumvent international agreement on tariffs by choosing strategic levels of domestic regulation (Ederington, 1999; Copeland, 1990). And, some economists have worried that governments may seek to attract foreign direct investment (FDI) by competitively undercutting each other's environmental standards.[1] All these fears are based on the presumption that domestic regulations affect the location of FDI in quantitatively important ways. This paper tests that presumption by asking whether FDI to U.S. states has responded significantly to relative changes in states' environmental compliance costs.

Despite numerous attempts in the economics literature, there is little robust or quantitatively significant evidence that environmental regulations affect the location of FDI. However, empirical papers on this topic typically suffer from at least one of three important drawbacks: (1) they have trouble quantifying international differences in environmental regulations, (2) they are cross-section analyses, and therefore cannot control for unobserved heterogeneity among regions, or (3) they use cost-based measures of environmental standard

[1]See Bhagwati and Srinivasan (1995) for a discussion of these concerns.

stringency that fail to control for regions' industrial composition. This paper addresses each of these three problems by examining inward foreign direct investment to U.S. states, using a panel of pollution abatement cost indices that controls for states' industrial compositions.

We have focused our analysis on FDI, as opposed to domestic investment, for two reasons. First, much of the current debate is about the *international* effects of domestic regulations in the context of the World Trade Organization and various regional trade agreements. By studying FDI, we contribute more directly to that debate, though an equivalent analysis of domestic investment might be equally compelling. However, a second reason to focus on FDI is that foreign manufacturers may be more geographically footloose than domestic manufacturers. Particularly in the second half of the paper, when we examine planned new foreign plants, we hope that we capture some of the most cost-sensitive subsets of investment -- plants that have yet to be built and have no sunk costs linking them to particular states.

In general, we find robust evidence that abatement costs have small deterrent effects on foreign investment. Along the way, we demonstrate the biases associated with cross-sectional analyses typical of this literature, and the bias associated with failure to account for states' industrial compositions.

II. Measuring the Effects of Regulations on FDI.

Most papers in this literature note the difficulties inherent in quantifying the stringency of national environmental standards. Even if one could accurately measure stringency, countries differ on so many other grounds that it is hard to attribute any differences in international trade or investment to environmental regulations. Until recently, most analysts have thus resorted to comparing investment in developing countries to that in industrialized countries, assuming that industrialized countries have more stringent standards (Low, 1992; Leonard, 1988; Kahn, 2000). While this assumption seems realistic, the fact that industrialized countries are nevertheless the largest exporters of polluting goods suggests that differences in economic activity are not caused by environmental policy alone. World trading patterns are in part determined by factors and technologies that are not readily observable, and therefore difficult to control for statistically, and the same is likely true for FDI patterns.

We overcome the difficulties of comparing different countries by looking at the flow of investment from foreign countries into various U.S. states as a function of manufacturer's pollution abatement costs in those states. Though variation in state environmental stringency is almost certainly smaller than variation across countries, using state variation gives us two advantages: there are much better data on state environmental costs than on international costs, and different states are more comparable than different countries on non-environmental grounds. The states hold a large and increasing fraction of the responsibility for setting environmental standards in the U.S., and even those standards that are set federally impose different costs depending on the characteristics of the affected states.

We examine two types of FDI data. The first is data on the value of gross property, plant and equipment belonging to foreign-owned manufacturers, and manufacturing employees working for foreign-owned firms, from the series *Foreign Direct Investment in the United States* of the Bureau of Economic Analysis (BEA). Though comprehensive, these data have two disadvantages for our purposes. First, they include both new and existing facilities. Since most state environmental regulations impose stricter standards on new facilities, states with more new investment will have *higher* average compliance costs, which might induce a bias in our study against finding a deterrent effect of environmental regulations. The second disadvantage of the BEA data is that they include mergers and acquisitions. If the regulatory differences among states are capitalized into purchase prices (foreign investors receive a discount when buying manufacturers in stringent states), then we would expect there to be no deterrent effect of strict regulations on mergers and acquisitions.

Therefore, to avoid bias caused by differential treatment of new investment or compliance cost capitalization, as a second approach we examine planned new foreign-owned factory openings using data from a different series, also titled *Foreign Direct Investment in the United States*, collected by the International Trade Administration (ITA). These ITA data have the drawback that relatively few new foreign-owned manufacturing plants are observed in any given state in any year. From 1977 to 1994, the data contain only 958 new plants. Nevertheless, the ITA and BEA data together provide a comprehensive picture of FDI to U.S. states. By comparing foreign direct investment to different states rather than to different countries, we believe that we increase enormously our chances of accurately measuring regulatory stringency and of sufficiently controlling for other characteristics that attract or deter investment.

The second problem with the existing literature on the effects of environmental regulations is that most papers rely on cross-sectional data.[2] This makes it impossible to account for unobservable state characteristics that may be correlated with both regulatory compliance costs and investment. For example, suppose that some state is endowed with a natural resource desirable to a polluting industry. As a consequence, that state will be likely to attract polluting

[2]See, for example, Friedman, *et al.* (1992), Kolstad and Xing (1997), or Co and List (2000).

investment, and may simultaneously be induced to regulate stringently the pollution emanating from the industry. Both investment and regulatory compliance costs will be *positively* correlated with the presence of the desirable resource, inducing a spurious positive correlation between FDI and environmental compliance costs. As another example, suppose that some states have a tendency to favor polluting industries, perhaps because those industries are particularly important to the states' economies, or because those industries have long histories in the states.[3] Manufacturers in such states may benefit from tax breaks or subsidies in addition to lax regulations. In this case, investment and regulatory compliance costs will be spuriously *negatively* correlated. If the estimation does not account for the unobserved resource, or the unobserved protection of polluting industries, then it will impart an omitted variable bias on the predicted effect of regulatory compliance costs on investment.

By contrast, several recent studies of domestic investment use panel data and find reasonably sized and statistically significant negative effects of environmental stringency on economic activity. Henderson (1996), Greenstone (1998), and Kahn (1997) use data on whether or not each county in the U.S. is in compliance with national ambient air quality standards.[4] These standards are set uniformly at the federal level, and are thus unrelated to particular county characteristics, whether observed or otherwise. States are required to enforce more stringent pollution standards in counties declared out of compliance, and all three studies find that such counties subsequently experience fewer new plant births or less manufacturing employment growth. However, it is difficult to interpret the general magnitude of the effect of this zero-one

[3]See, for example, Congleton (1992).

[4]See also List, *et al.* (2001).

measure of regulatory stringency without knowing how much more costly are the environmental regulations in non-compliant counties.

We address this second problem, omitted variable bias, by examining investment and environmental regulatory costs over an 18-year period, from 1977 to 1994, which allows us to control for unobserved time-invariant state characteristics in the estimations. Rather than use a zero-one measure of regulatory stringency, such as counties' compliance status, we use a continuous, time-varying measure of the pollution abatement costs in each state, based on data from the Pollution Abatement Costs and Expenditures (PACE) survey, conducted by the U.S. Census Bureau as part of the Annual Survey of Manufactures.

The third shortcoming of much of the existing literature on investment responses to environmental regulations is that quantitative measures of regulatory costs typically fail to account for regions' industrial compositions. Friedman, *et al*. (1992), Crandall (1993), and Co and List (2000), for example, measure environmental stringency using total statewide pollution abatement costs from the PACE survey, and conclude that investment is largely unaffected by environmental regulations. As they note, however, the problem with their measure of costs is that states that attract polluting industries will have higher abatement expenditures than states that have cleaner industrial compositions even if the regulatory stringency faced by individual firms is the same for all states.[5] If lax regulations do attract polluting industries, pollution abatement spending may in fact be negatively correlated with the stringency of state regulations.

[5]Co and List (2000) also examine inward FDI's cross-sectional correlation with state environmental agencies' budgets, and with ambient pollution readings in each state, with similar outcomes: coefficients are small, often statistically insignificant, and are not larger in magnitude for more pollution-intensive industries.

We address this third problem by measuring state pollution abatement costs from the PACE data, adjusted using each state's industrial composition. Ideally, one would study this issue industry-by-industry, using separate measures of pollution abatement costs for each industry to assess regulatory compliance costs. While abatement costs by state and industry are published annually by the Census Bureau, so many of the observations are censored to prevent disclosure of confidential information that the data are not comparable year-to-year or state-to-state. Furthermore, the Census Bureau has not maintained the historical disaggregated data. Therefore, we propose an alternative index.[6]

The index compares the *actual* pollution abatement costs in each state, unadjusted for industrial composition, to the *predicted* abatement costs in each state, where the predictions are based solely on nationwide abatement expenditures by industry and each state's industrial composition.[7] Let the actual costs per dollar of gross state product (GSP) be denoted

$$S_{st} = \frac{P_{st}}{Y_{st}} \qquad \textbf{(1)}$$

---

[6]More details about this index, and a comparison of it with other indices of state environmental standard stringency can be found in Levinson (2001). Gray (1998) and Levinson (1996) construct similar indices using the confidential plant-level Census data. The advantage of the index used here is that it is available publicly and yields information similar to that from the unpublished Census data.

[7]For two reasons, we use pollution abatement *operating expenses* (as opposed to *capital expenses*) in the index. First, operating expenses for pollution abatement equipment are easier for PACE survey respondents to identify separately. Abatement capital expenses may be difficult to disentangle from investments in production process changes that have little to do with pollution abatement. Second, abatement capital expenditures are highest when new investment takes place. So states that have thriving economies and are generating manufacturing investment tend to have high levels of abatement capital expenses, regardless of the stringency of those states' environmental laws.

where P_{st} is pollution abatement costs in state *s* in year *t*, and Y_{st} is the manufacturing sector's contribution to the GSP of state *s* in year *t*. S_{st} is the type of unadjusted measure of regulatory compliance costs commonly used, and it overstates the costs in states with more pollution-intensive industries and understates the costs in states with relatively clean industries.

To adjust for states' industrial compositions, compare **(1)** to the *predicted* abatement costs per dollar of GSP in state *s*:

$$\hat{S}_{st} = \frac{1}{Y_{st}} \sum_{i=20}^{39} \frac{Y_{sit} P_{it}}{Y_{it}} \quad , \qquad \textbf{(2)}$$

where industries are indexed from 20 through 39 according to their 2-digit manufacturing SIC codes,[8] Y_{sit} is industry *i*'s contribution to the GSP of state *s* at time *t*, Y_{it} is the nationwide contribution of industry *i* to national gross domestic product, and P_{it} is the nationwide pollution abatement operating costs of industry *i*. In other words, $\hat{S}_{st}$ is the weighted average of national pollution abatement costs in each 2-digit industry, where the weights are the shares of each industry in state *s* at time *t*.

The industry-adjusted index of relative state stringency, S_{st}*, is simply the ratio of actual expenditures in **(1)** to the predicted expenditures in **(2)**[9]

[8]SIC code 23 (apparel) is omitted because it is relatively pollution-free, and as a result no data for that industry are collected by the PACE survey.

[9]The state's GSP is in both the numerator and the denominator of **(3)**, so equation **(3)** can be expressed as $S_{st}^* = P_{st} \; / \; \hat{P}_{st}$, where $\hat{P}_{st}$ is the summation term in **(2)**.

$$S_{st}^{*} = \frac{S_{st}}{\hat{S}_{st}} \quad . \tag{3}$$

When S_{st}* is greater than 1, industries in state *s* at time *t* spent more on pollution abatement than those same industries in other states. By implication, states with large values of S_{st}* have relatively more stringent regulations.[10]

In section III.2 below we use the BEA's continuous measures of FDI to estimate models of three different types: a pooled ordinary least squares specification as a benchmark, a fixed-effects least-squares (within groups) estimator, and a dynamic panel data model that includes the lagged dependent variable as a regressor. In section III.3, we employ the ITA's data on new factory openings to estimate count data models. Before that, however, we begin with simple descriptive statistics.

III. The Evidence.

III.1 Descriptive Statistics.

Table 1 presents summary statistics of *S**, *S*, and FDI by state. The first column contains the average industry-adjusted index *S**, from 1977 to 1994, as described by equation **(3)**. The second column contains the unadjusted index, *S*, as described by equation **(1)**.[11] The correlation

---

[10]Support for the inference that relatively high abatement costs indicate relatively stringent regulations can be found in Berman and Bui (1999), which regresses pollution abatement costs at the 4-digit SIC-code level on detailed industry-specific regulations, and finds strong positive associations.

[11]Because no PACE data were collected in 1987, Table 1 and all subsequent tables omit that year.

between the two is about 0.7. A number of states that appear to have relatively high costs according to the unadjusted index have much lower ranking after accounting for their industrial compositions. New Jersey, for example, falls from the 20th most costly state, in column (2) to the 34th in column (1). Other states' apparent stringency improves after controlling for their industries. Florida rises from 25th to 13th. Using the unadjusted measure of compliance costs in column (2), pollution abatement expenditures as a share of gross state product from manufacturing, would give a misleading picture of Florida's and New Jersey's relative stringency.

Many readers will notice that even the industry-adjusted index, *S**, does not conform to conventional wisdom about the true rankings of states' environmental stringency, though it is typically closer to the mark than the unadjusted index. There may be several reasons for the remaining peculiarities of the index. The PACE data may be an inaccurate record of true compliance costs. States that have stringent rules for new plants but lax rules for existing plants may have tough reputations but low costs. And, there may be considerable variation in states' industrial compositions *within* two-digit SIC codes. Still, we believe the index *S** is the best available continuous time-varying measure of relative state environmental costs.

Columns (3) and (4) of Table 1 present the average value of gross property, plant and equipment (PP&E) of foreign-owned affiliates from 1977 to 1994, for all manufacturers and for the chemical industry, respectively.[12] At the bottom of Table 1 are these same averages for the states with the 5 lowest and 5 highest adjusted pollution abatement indices, *S**, and for the 20 lowest and highest. On average, the five states with the lowest cost indices have *lower* values of

[12]We use SIC 28, chemicals and allied products, as an example of a pollution-intensive industry. Of the relatively polluting industries, SIC 28 has the most consistently reported uncensored data in the BEA publications.

PP&E for foreign-owned affiliates than the five states with the highest indices, and the 20 states with the lowest indices have about the same value of PP&E as the 20 states with the highest costs. Even looking at SIC code 28, "chemicals and allied products," the five states with the lowest cost indices have *lower* values of PP&E than the five states with the highest indices, and a similar pattern is observable for the 20 lowest and 20 highest states. For many reasons, we would not expect to find a deterrent effect of environmental compliance costs on FDI as measured by the value of PP&E in these cross-section comparisons. Those states that do not attract a lot of polluting manufacturing probably do not enact stringent regulations -- there is simply less need to worry about industrial pollution in states with less industrial activity, and those states that *do* attract polluting manufacturing may respond by enacting more stringent regulations.

Columns (5) and (6) report similar statistics for employees of foreign-owned affiliates. Here, for all manufacturing and for chemical manufacturing alone, those states with lower pollution abatement costs tend to have more employees. Finally, columns (7) and (8) display the number of planned new foreign-owned plants, from the ITA data. The states with the five lowest cost indices, and those with the 20 lowest indices, have more annual planned new plant births than the 5 and 20 most costly, respectively, and this holds true for all manufacturing plants and for the 7 most pollution-intensive 2-digit SIC codes.[13] Again, however, we do not expect these cross-section comparisons to be particularly informative.

---

[13]The SIC codes included in column (8) are 26 (pulp and paper), 28 (chemicals), 29 (petroleum), 32 (stone clay and glass), 33 (primary metals), and 34 (fabricated metals). These are the industries studied in Co and List (2000).

The primary advantage of these data over most previous attempts to assess responsiveness to regulatory stringency is their intertemporal variation. Table 2 begins to take advantage of the panel nature of these data by examining *changes* in pollution abatement costs and FDI. It compares the average pollution abatement costs and FDI for the first 5 years of the data (1977-1981) to the averages for the last 5 years (1990-1994). The five states whose average costs fell most during this time period saw their industry-adjusted index of abatement costs fall by 0.597, their average annual value of PP&E grow by $2.5 billion, their average employment in foreign-owned manufacturers grow by 16,698, and their average annual number of new plants grow by 0.32. On the other hand, the five states whose costs increased the most over the 18 years saw their average index increase by 0.446, their average PP&E grow by only $0.8 billion, their average employment grow by 3,658, and their average number of new plants remain unchanged. While this comparison suggests that states that became more costly received less FDI, the 5 lowest and 5 highest states tend to be the smallest, and much of their variance may be due to noise in the data.

To account for this, the middle two lines of Table 2 examine the 10 states whose relative costs declined most to the 10 states whose costs increased most. With the exception of employment in the chemical industry, every measure of FDI increased more to those states whose relative pollution abatement costs declined. The bottom two rows of Table 2 conduct the same exercise for the lowest 20 states and highest 20 states. In general, similar patterns appear, especially for the dirtier industries, though they are muted somewhat by the fact that comparisons among 40 of the 48 continental states necessarily blurs the contrast between states with increasing and decreasing index values.

Table 2 is remarkable, in that it appears to present strong evidence of a deterrent effect of environmental regulations, especially with regard to new plant births in the last two columns. However, the table is based on comparisons that do not control for other observable state characteristics that may have been changing during the same time period. In the next section, we control for other such state characteristics.

III.2 Estimates using continuous data.

To control for other characteristics of states, we estimate variants of

$$\ln(FDI_{st}) = \beta \ln(S^{*}_{st}) + \gamma \ln(X_{st}) + \delta_t + d_s + \epsilon_{st}, \quad \textbf{(4)}$$

where FDI_{st} is a measure of foreign direct investment in state s during year t, S^*_{st} is as defined by equation **(3)**, X_{st} is a set of other state characteristics that may affect investment -- market proximity, taxes, energy costs, land prices, wages, unionization, etc. -- δ_t is a set of year dummies, d_s is a set of state dummies, and ϵ_{st} is an error term. Equation **(4)** is in logs because we expect the effect of changes in state characteristics to be larger for large states, and smaller for small states. The state fixed effects, d_s, will account for unobserved state characteristics that would otherwise impart an omitted variable bias.

Table 3 presents the first such estimations. The first column presents means and standard deviations of the regressors. Market proximity is a distance-weighted average of all other states' GSPs. Along with population, this measures the size of the domestic market that may be served by the FDI. Unemployment rates are included to capture labor market characteristics, although of course FDI may affect unemployment simultaneously. Unionization rates measure labor activism, and may also serve as a regional indicator, since union membership is so much lower in the South. Average state-wide production worker wages are included as a regressor, though we have not controlled for workers' productivity. Total road mileage is included as a measure of public infrastructure, and land prices and energy prices are included to capture factor costs, though they too may be simultaneously determined. Tax effort is an index, calculated as actual tax revenues divided by those that would be collected by a model tax code, as calculated by the Advisory Commission on Intergovernmental Relations (ACIR).

As a benchmark against which to compare the fixed-effects estimates, columns (2) and (3) contain pooled, OLS regressions of PP&E in the manufacturing sector and the chemical industry, respectively, on the industry-adjusted index of abatement costs and other covariates, without including state fixed effects (d_s). Controlling for other state characteristics, PP&E appears to be positively correlated with abatement costs (0.261), though the coefficient is insignificant for the chemical industry (0.091). However, columns (2) and (3) likely omit state characteristics correlated with both FDI and environmental regulations. Drawing conclusions based on columns (2) and (3) would be similar to doing so based on the bottom rows of Table 1: costly states have more investment.

This type of result pervades the empirical literature on investment and environmental regulations. It suggests no industry relocation response to environmental regulations, no pollution haven effect, and no need to worry about a race to the bottom in environmental standards. In fact, it suggests that pollution-intensive industries are *attracted* to states with high compliance costs. The only sensible interpretation of these positive coefficients, however, is that they are due to the endogeneity of pollution regulations and compliance costs. States attracting polluting manufacturers respond by enacting costly regulations.

Once we include state fixed effects, in columns (4) and (5) the abatement cost coefficient becomes negative and significant for all manufacturing investment (−0.079) and for chemicals (−0.198). Because Table 3 is estimated in logs, we can interpret these coefficients as elasticities. A 10 percent increase in relative pollution abatement costs is associated with a 0.79 percent drop in manufacturing FDI, and a 1.98 percent drop in chemical industry FDI. For reference, average manufacturing PP&E during this time period was about $2.8 billion, while the average chemical industry PP&E was $1.0 billion. The standard deviation of this index (in levels) within states over time ranges from 0.04 for Wisconsin to 0.56 for Colorado, and averages 0.18. So a one-standard-deviation increase in the index, for the average state, is associated with a decline in foreign-owned manufacturing PP&E of $40 million, and a decline in chemical PP&E of $36 million. This amounts to less than 1.5 percent of average manufacturing PP&E, and about 3.6 percent of average chemical industry PP&E.

Table 4 runs some robustness checks on the results described in Table 3. In the first row we run identical specifications to those in Table 3, but with employment as the dependent variable rather than PP&E. The effect of adding fixed effects is similar. The pooled manufacturing coefficient, in column (1), is positive and significant. When fixed effects are added, in column (3), the coefficient on S^* becomes negative, though not significant. The pooled chemical industry coefficient, in column (2), is negative and statistically significant. But adding the fixed effects in column (4) nearly doubles the measured effect of pollution abatement costs on chemical industry employment. If we take literally the coefficient for the chemical industry, it suggests that a one-standard-deviation increase in a state's pollution abatement cost index (+0.18) is associated with 550 fewer jobs in that industry, a fall of about 7 percent relative to the average of 7692 employees in foreign-owned chemical plants per state.

In the second row of Table 4 we estimate the same set of regressions from Table 3 using the unadjusted index *S*, from equation **(1)**. This is the index that has often been used by the literature without controlling for states' industrial compositions. The pooled coefficients are much larger, and more statistically significant, than those in Table 3 for the industry-adjusted index. However, after controlling for fixed effects in columns (3) and (4) of Table 4, the coefficients on the unadjusted index (−0.091 and −0.280) are not significantly different from those for the adjusted index in Table 3 (−0.079 and −0.198). This suggests that adding the fixed effects does a reasonable job of controlling for states' industrial composition, even in the absence of the index adjustment.

The same similarity holds true for the employment regressions, in rows (1) and (3) of Table 4. The fixed effects coefficients for the industry-adjusted pollution abatement cost index, for all manufacturing and chemicals (−0.013 and −0.397), are similar to those for the unadjusted index (−0.057 and −0.384).

In row (4) of Table 4 we estimate specifications based on averages of the data over three time periods: 1977-81, 1982-86, and 1988-94. We do so for two reasons. First, averaging over multi-year periods addresses concerns that year-to-year noise in the data mask long-run trends. Second, it measures FDI reactions to changes in environmental costs over longer periods, which may be more realistic. The 48 states, and three time periods, yield 144 observations. The pattern of coefficients is largely similar to those using the annual data, though the negative coefficients in the fixed effects specifications are less precisely estimated.

So far, the evidence presented has all been based on a static model of investment in which annual measures of FDI are regressed on concurrent state characteristics. However, one might object that investment is by nature a dynamic process. FDI may, for example, be a function of expected future state characteristics. In addition, FDI to existing facilities may be a function of past investments to those facilities. In either case, the usual orthogonality conditions may not hold across time. To explore this issue in a dynamic context, suppose that a reduced form relationship for FDI can be characterized by the following equation:[14]

$$FDI_{st} \;=\; \rho FDI_{s,t-1} \;+\; \beta S^{*}_{st} \;+\; \gamma X_{st} \;+\; \delta_t \;+\; d_s \;+\; \epsilon_{st} \quad . \qquad \textbf{(5)}$$

Equation **(5)** states that *FDI* is a function of current state characteristics and lagged values of *FDI*. Both FDI_{st} and $FDI_{s,t-1}$ are functions of d_s, a part of the unobserved error term, and therefore OLS fixed-effects estimates of **(5)** will be biased because $FDI_{s,t-1}$, a regressor, is correlated with the error term (Amemiya, 1985).

Arellano and Bond (1991) suggest a GMM estimation of **(5)** that uses lagged values of $FDI_{s,t-1}$ as instruments for $FDI_{s,t-1}$, and first differences to eliminate the fixed state effects d_s:

$$\Delta FDI_{st} \;=\; \rho \Delta FDI_{s,t-1} \;+\; \beta \Delta S^{*}_{st} \;+\; \gamma \Delta X_{st} \;+\; \delta_t \;+\; \Delta\epsilon_{st} \qquad \textbf{(6)}$$

where Δ symbolizes first differences. Since $FDI_{s,t-2}$ is correlated with $\Delta FDI_{s,t-1}$, but not correlated with ΔFDI_{st}, it is a valid instrument. In fact, all past values $FDI_{s,t-3}$, $FDI_{s,t-4}$, and so on, as well as values of the exogenous variables $S*$ and X, are valid instruments for $\Delta FDI_{s,t-1}$.

Row (5) of Table 4 presents the coefficient β from GMM estimates of **(6)** using the Arellano and Bond estimator. When equation **(6)** is estimated using all manufacturing FDI, in

---

[14]This discussion is based on Baltagi (1995) and Arellano and Bond (1991).

column (3), the coefficient (2.4) is tiny and statistically insignificant, though still positive. Turning to the chemical industry, in column (4), the coefficient (−0.115) is negative, about 40 percent smaller than the base specification in Table 3, and statistically insignificant.

In row (6) we address some readers' concern that wage and land prices are themselves affected by environmental regulations. If these factors bear the incidence of the environmental regulations, then their prices will drop, offsetting the increased compliance costs to firms. To test for this, we estimate the base specification as in Table 3 without wages and land prices, and report the coefficient on the environment index. The same pattern of coefficients emerges, with a positive bias in the pooled estimates, and significant negative results with the fixed effects. In fact, the measured effect of the regulations is about 25 percent larger when these factor prices are omitted. However, we do not wish to exaggerate the importance of this finding, for wages and land prices may be correlated with environmental regulations for many reasons unrelated to factor price equalization, in which case row (6) merely demonstrates omitted variable bias.

Finally, in row (7), we estimate the base specification weighted by the GSP of each state. We do this out of concern that the results so far may be driven by a few small states. However, the weighted results are essentially indistinguishable from the unweighted results.

In sum, using continuous data on investment and employment by foreign-owned manufacturers in U.S. states, we find broad evidence that pollution abatement costs reduce manufacturing FDI by a small amount, and that they may reduce FDI by especially polluting industries by a slightly larger amount. Though we generally estimate statistically significant coefficients, their implied magnitudes are small economically. These results are obtained from an analysis that has addressed three important problems that pervade much of the previous literature: it examines inflows of FDI to U.S. states; it uses a panel of data to account for unobserved heterogeneity among states; and it uses a quantitative measure of stringency based on pollution abatement costs, adjusting for states' industrial compositions.

Despite these strengths, the measure of FDI used thus far is not without weaknesses. One important problem is that changes in observed FDI can result from new plants being constructed, old plants being closed, or from expansions and contractions of existing plants. Each of these four types of changes may respond quite differently to changes in environmental regulations, depending on how the regulations are written. Many state environmental regulations consist of "new source performance standards" that are more stringent for new plants than for existing plants. These standards effectively raise barriers to entry that protect existing older plants. These measures of gross FDI may conceal effects that work in opposite directions. A second problem with the BEA data is that they include FDI in the form of mergers and acquisitions. If future environmental compliance costs are fully capitalized into the prices paid for acquisitions, then cost differences among states will be offset by price differences and will have no effect on FDI. Consequently, in order to isolate the effects of regulations on the location of FDI, without the offsetting effect of grandfather regulations or cost capitalization for existing investment, in the next section we use establishment-level data to focus on new plants only.

III.3 Estimates using establishment-level count data.

To examine FDI in new plants only, we turn to the International Trade Administration (ITA) data. Though the ITA data include acquisitions, mergers, joint ventures, real estate transactions, equity increases, plant expansions and new plants, we focus only on the new plants.

Because the ITA data do not come from a mandatory survey, they may miss some foreign investment. However, the ITA's claim that its data cover "the vast majority of significant foreign direct investment transactions" is confirmed by BEA officials.[15]

We begin by estimating the effect of environmental regulations on FDI using a negative binomial specification. This is a common count-data specification that relaxes the Poisson mean-variance assumption.[16] In particular, we assume that n_{st}, the number of new plants in state s in year t, is distributed Poisson, with mean and variance λ_{st}. The negative binomial assumption is that $\log\lambda_{st} = X_{st}\beta + \text{offset}_{st} + \epsilon_{st}$, with the offset being unmeasured, and ϵ_{st} an unobserved parameter with a gamma distribution.

Table 5 contains estimates of β. When the data are pooled, the coefficient on the industry-adjusted index of abatement costs (−0.147) is negative but not significant. The polluting industries in column (2) have a nearly identical coefficient.

However, the pooled specifications in columns (1) and (2) make no use of the panel of data, and are almost certainly misspecified, since the error terms ϵ_{st} are likely to be correlated within states. Therefore, in columns (3) and (4) we include fixed effects for each of the eight U.S. Census regions. We did not include individual state dummies, as in Tables 3 and 4, because too many states have either no new foreign plants in any year, or very few, and individual state dummies perfectly predict outcomes. For all manufacturing industries, in column (3), the

---

[15]Personal correspondence. The ITA data come from newspapers, magazines, and business and trade journals, as well as from public files of Federal regulatory agencies such as the Securities and Exchange Commission, the Federal Trade Commission, and the Federal Reserve Board.

[16]See Cameron and Trivedi (1998), or Hausman, Hall and Griliches (1984).

environmental cost index coefficient (−0.467) is negative and statistically significant. The incidence ratio (in square brackets) suggests that a one-unit increase in a state's environmental index is associated with a 37 percent fall in the probability of a new plant locating in that state. Interpolating roughly, a one-standard-deviation increase in the index (+0.18), would be associated with a 7 percent decline in the location probability. This is approximately the same magnitude as the employment regressions in the top row of Table 4.

In column (4) of Table 5 we estimate the fixed-effects count-data model for seven polluting industries. Here, the coefficient is still large and negative, but it is smaller than for all manufacturing, and it is not statistically significant. A one standard deviation increase in the index is associated with about a 5 percent drop in the location probability.

In Table 6 we present some alternative count-data models. In the first row, we address the concern that the regressions in Table 5 are biased because so many of the states had zero plant births in any given year. Of the 768 state-year observations, 412 experienced zero plant births during the 16 years, and 519 experience zero births in the polluting industries. Consequently, in row (1) of Table 6 we estimate a "zero-inflated negative binomial" (also called a "hurdle model") version of the basic pooled specifications (Greene, 2000). These assume that the number of new plants in a state, n_{st}, is governed by the following process:

$$\begin{aligned} prob(n_{st} = 0) &= e^{-\theta} \\ prob(n_{st} = n) &= \frac{(1 - e^{-\theta}) e^{-\lambda} \lambda^{n}}{n!(1 - e^{-\lambda})} \end{aligned} \qquad \textbf{(7)}$$

The specifications in row (1) use a logit model to estimate the top equation, with state populations, market proximity, unionization rates, and road mileage as regressors. The results are similar to those from the basic regression in Table 5, though the negative coefficients in columns (3) and (4) are smaller and less statistically significant.

As a second means of examining the excess of zeros, and also of addressing concerns that year-to-year noise masks substantive changes, in row (2) of Table 6 we present estimates based on the multi-year averages of the data.[17] The pooled specifications in columns (1) and (2) yield negative, statistically insignificant coefficients, while the regional fixed-effects models in columns (3) and (4) have larger negative coefficients that are statistically significant. The coefficient on all manufacturing (−0.852) suggests that a one-standard-deviation increase in the environmental cost index is associated with a 10 percent fall in new foreign plant births over 5 to 7 years.

Because the Poisson regressions may be more standard in the count-data literature, despite the mean/variance restriction, in row (3) of Table 6 we estimate a Poisson version of Table 5, with similar results. The regional fixed effects render the cost index coefficient more negative, and more statistically significant.

Finally, in row (4) of Table 6, we revisit the issue of whether wage and land prices should be omitted, because these factor prices are themselves determined by regulations, and themselves determine FDI. As row (4) demonstrates, omitting those variables has negligible effects on the pollution cost index coefficient.

In sum, the results from the ITA data on new plants generally appear to support the results using the BEA data on PP&E and employees, with one caveat. The major systematic difference

[17] Of the 144 observations in row (2), (3 periods times 48 states), 35 had zero new manufacturing plants, and 52 had zero new polluting plants.

between the continuous measures of investment and employment, and the discrete number of new plants, is that polluting new plant births (column (4) Tables 5 and 6) appear less sensitive to environmental cost than manufacturing as a whole (column (3)). By contrast, in Tables 3 and 4, chemical industry investment, which includes acquisitions and investment in existing plants, appears more sensitive to environmental costs than manufacturing as a whole.

There are a number of potential explanations for this discrepancy. First, because of data limitations we use examples of polluting industries that are not directly comparable. For the count data, we have pooled seven 2-digit industries, including many that may be geographically tied to local product or factor markets. The pulp and paper, petroleum, stone clay and glass, and primary metals industries simply may not be geographically mobile enough to relocate in response to environmental regulations. By contrast, for the continuous BEA data, we use the chemical industry, which may be more footloose.

In addition, the difference between the BEA and ITA results may involve the mismeasurement of compliance costs due to the presence of grandfathered regulations (new source performance standards), and the fact that our pollution cost data come only from existing sources of pollution. It may be that in really stringent states, with retrofitting requirements in addition to new source standards, investors in polluting, geographically immobile industries choose to build new plants rather than retrofit aging plants, whereas in lax states with no retrofitting requirements, investors extend the lives of existing polluting plants. As a consequence, we could be seeing the deterrent effect of stringent retrofitting standards on investment in existing facilities in Tables 3 and 4, but the results in Tables 5 and 6 may be tempered by the fact that those retrofitting standards encourage some firms to build new plants earlier than they would otherwise.

Either way, broad similarities between the two sets of results outweigh the differences. In both sets of results, pooled estimates, driven largely by cross-section variation in state characteristics, generate spurious positive or insignificant estimates of the effects of environmental costs on FDI. In both data sets, however, once we account for unobserved heteroskedasticity with fixed state or regional effects, environmental costs have a statistically significant deterrent effect on FDI. And, in both data sets, the measured effect is economically small. Doubling of the environmental cost index is associated with FDI decreases of less than 10 percent.

IV. Discussion and Implications.

Before drawing conclusions based on these results, we must acknowledge several important caveats. First, our industry-adjusted index of environmental abatement costs, *S**, controls for states' industrial compositions at the level of 2-digit SIC codes. While this surely accounts for a lot of the differences among states, there is equally certain to be heterogeneity among states *within* 2-digit classifications. For example, industry code 26, pulp and paper, contains paper mills, which are among the most pollution-intensive manufacturers, along with envelope assemblers, which emit very little pollution. To the extent that some states contain relatively more pulp mills and others merely assemble envelopes, high abatement costs in the former will not necessarily reflect more stringent environmental regulations. Consequently, the 2-digit industry adjustment in equation **(3)** may still mask considerable heterogeneity, and states that find themselves attracting relatively polluting industries -- *within* any given 2-digit SIC code -- may respond by enacting strict regulations. However, we have found that including state fixed effects achieves much the same result as controlling for industry composition at the 2-digit level. If this is true in general, then the industry composition bias beyond the 2-digit level may also be substantially mitigated by the fixed effects.

A second caveat involves the efforts that states make to attract and retain certain industries. These efforts are largely unmeasured in the current estimations. However, one can easily imagine that changes in state efforts to promote investment in particularly polluting industries may be correlated with environmental regulations affecting those industries. It may be that states enacting stringent environmental regulations enact compensatory tax breaks or infrastructure subsidies. Or, it may be that states enacting weak pollution regulations are also inclined to pass generous investment subsidies. Under the former circumstances, we are likely to have underestimated the deterrent effect of regulations, absent the development incentives. Under the latter scenario, we may be overstating the effect of environmental regulations by falsely attributing some of the effects of unobserved development incentives to correlated observed low environmental costs. Again, analysis of the political economies of state pollution regulations lies outside our agenda for this paper.

Third, our industry-adjusted index makes no attempt to control for the relative *age* of different states' manufacturers. This is important because many state environmental standards are more strict for new sources of pollution than for existing sources. Consequently, states such as Florida, that have relatively new manufacturing bases, have relatively high compliance costs, even after controlling for their industrial compositions. Conversely, states such as Connecticut that have relatively old manufacturers will experience lower compliance costs. There is, therefore, a potential positive correlation between the amount of new investment and our industry-adjusted index of abatement costs. Furthermore, this bias will not be entirely eliminated by the state or regional fixed effects if the relative ages of states' manufacturing bases have changed over time. If Florida's manufacturers have become relatively newer, as Connecticut's have aged, then Florida's environmental costs will have risen *because* it has attracted new investment. There is, however, some evidence that correlations between pollution costs and manufacturers' capital vintage are insignificant (Levinson, 1996).

In studying the effect of differences in environmental compliance costs on the location of inward FDI to U.S. states, our approach has two distinctive features. First, our measure of abatement costs controls for the industrial composition of states. The results indicate that this is important: both the least-squares and the count data regressions yield stronger and more positive association between environmental regulations and FDI with the unadjusted, compared to the adjusted abatement cost index. This suggests that a high unadjusted abatement cost index primarily reflects a high share of industrial activity in polluting industries. Therefore, results from studies that do not take this composition effect into account allow only very limited inferences.

Second, our panel approach controls for unobserved heterogeneity through the inclusion of fixed effects. Though it is not clear *a priori* which way the omitted-variable bias goes, the coefficients on the environmental variables *fall* when state fixed effects are added to the model.

Finally, while the motivation for this research is to draw inferences about the sensitivity of FDI to *international* differences in environmental stringency, we recognize that the stringency of environmental legislation differs much more across countries than across U.S. states. However, the variation in other characteristics such as factor costs, market access, transportation costs, and exchange rate risks also varies more across countries than across states. Thus, our analysis does not necessarily underestimate the sensitivity of FDI location with respect to environmental legislation at the international level.

In sum, the results here address three important obstacles in the existing literature. By looking at FDI inflows to U.S. states we examine comparable jurisdictions with comparable environmental compliance cost data. By accounting for those states' industrial compositions, we eliminate bias caused by the uneven distribution of industries among states. And by examining FDI and pollution abatement costs using a 17-year panel, we control for potential unobserved heterogeneity among states and regions that may be correlated with both the amount of FDI and the stringency of regulations. Consequently, we are able to document moderate effects of pollution abatement costs on capital and employees at foreign-owned manufacturers, particularly in pollution-intensive industries, and on the number of planned new foreign-owned manufacturing facilities.

References

Advisory Commission on Intergovernmental Relations (ACIR). 1988. State Fiscal Capacity and Effort. Washington DC, ACIR.

Amemiya, Takeshi. 1985. Advanced Econometrics. Cambridge, MA. Harvard University Press.

Arellano, Manuel, and Bond, Stephen R. 1991. "Some test of specification for panel data: Monte Carlo evidence and an application to employment equations" Review of Economic Studies 58, 277-297.

Baltagi, Badi H. 1995. Econometric Analysis of Panel Data. New York: John Wiley & Sons.

Becker, Randy and Vernon Henderson. 1997. "Effects of Air Quality Regulation on Decisions of Firms in Polluting Industries," NBER working paper #6160, September.

Berman, Eli and Linda Bui. 1999. "Environmental Regulation and Productivity: Evidence from Oil Refineries," mimeo, Boston University.

Bhagwati, Jagdish N., and T.N. Srinivasan. 1995. "Trade and the Environment: Does Environmental Diversity Detract from the Case for Free Trade?" Economic Growth Center Working Paper No.721, Yale University.

Bureau of Economic Analysis (BEA). 1999. Foreign Direct Investment in the United States, annual series, various years, U.S. Department of Commerce, Washington, D.C.

Bureau of Economic Analysis (BEA). 1997. "U.S. Intra-firm Trade in Goods," Survey of Current Business, Bureau of Economic Analysis, February.

Cameron, Colin and Pravin K. Trivedi. 1998. Regression Analysis of Count Data. Cambridge University Press.

Co, Catherine and John List. 2000. "The Effects of Environmental Regulations on Foreign Direct Investment," Journal of Environmental Economics and Management, 40(1) 1-20.

Congleton, Roger D. 1992. "Political Institutions and Pollution Control," Review of Economics and Statistics, 74(3) August.

Copeland, Brian R. 1990. "Strategic Interaction Among Nations: Negotiable and Non-negotiable Trade Barriers," Canadian Journal of Economics, 23: 64-108.

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

Ederington, Josh, 1999, "International Coordination of Trade and Domestic Policies," mimeo, University of Miami.

Friedman, Joseph, Daniel A. Gerlowski and Jonathan Silberman. 1992. "What Attracts Foreign Multinational Corporations? Evidence From Branch Plant Location in the United States," Journal of Regional Science Vol. 32, No. 4, pp.403-418.

Gray, Wayne B. 1997. "Manufacturing plant location: Does state pollution regulation matter?" NBER Working Paper #5880.

Greene, William H. 2000. Econometric Analysis. Fourth Edition. Prentice Hall: New Jersey.

Greenstone, Michael. 1998. "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures," mimeo, University of California at Berkeley.

Hausman, Jerry, Bronwyn H. Hall, and Zvi Griliches. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship," Econometrica 52(4) 909-938.

Henderson, J. Vernon. 1996. "Effects of Air Quality Regulation," American Economic Review 86(4), September, 789-813.

International Trade Administration (ITA). Foreign Direct Investment in the United States (various years). United States Department of Commerce. Office of Trade and Economic Analysis.

Kahn, Matthew. 1997. "Particulate Pollution Trends in the U.S." Regional Science and Urban Economics, 27: 87-107.

Kahn, Matthew. 2000. "United States Pollution Intensive Trade Trends from 1972 to 1992," Columbia University mimeo.

Kolstad, Charles, and Y. Xing. 1997. "Do Lax Environmental Regulations Attract Foreign Investment?" UC Santa Barbara Working Paper #6-95R, February.

Leonard, H. Jeffrey. 1988. Pollution and the Struggle for the World Product, Cambridge: Cambridge University Press.

Levinson, Arik. 1996. "Environmental Regulations and Manufacturers' Location Choices: Evidence from the Census of Manufactures," Journal of Public Economics, 61(1).

Levinson, Arik. 2001. "An Industry-Adjusted Index of State Environmental Compliance Costs," in Metcalf, Gilbert. and Carlo Carraro, C., eds., *Behavioral and Distributional Effects of Environmental Policy*. University of Chicago Press.

List, John A., Daniel Milliment, and W. Warren McHone. 2001. "Effects of Air Quality Regulation on the Destination Choice of Relocating Firms," mimeo, Southern Methodist University.

Low, Patrick, and Alexander Yeats. 1992. "Do 'Dirty' Industries Migrate?" In Patrick Low, ed., International Trade and the Environment. Washington, DC: World Bank.

Low, Patrick, ed. 1992. International Trade and the Environment, Washington, DC: The World Bank.

Data Appendix

Gross Value of Property, Plant and Equipment (PP&E) of Foreign-Owned Manufacturers

Bureau of Economic Analysis (BEA), U.S. Department of Commerce, *Foreign Direct Investment in the United States.*

Employment of Foreign-Owned Affiliates

Bureau of Economic Analysis (BEA), U.S. Department of Commerce, series *Foreign Direct Investment in the United States.*

New Foreign-owned manufacturing plants

International Trade Administration (ITA), Department of Commerce. These data were culled from generally available public sources, transaction participants, and a variety of knowledgeable contacts. The major portion of the data were derived from public secondary sources such as newspapers, magazines, and business and trade journals, as well as from the public files of Federal regulatory agencies.

The data contain the country of origin of the investment, the name of the business enterprise, the 4-digit SIC code of the business enterprise, the reported value of the investment, the state in which the investment was made, the year, and the investment type. Types of foreign direct investment include acquisitions and mergers, joint ventures, real estate transactions, new plants, plant expansions, and equity increases. Any other transaction classified as foreign direct investment is collected under the heading of "other." The Office of Trade and Economic Analysis maintains that the monitoring program identifies the vast majority of significant foreign direct investment transactions in the United States.

New Plant Data: Data on new plants include the state in which the plant was built, the country of origination, the year, the amount of the investment, and the SIC code. We focus on the Manufacturing sector.

Pollution Abatement Costs and Expenditures (PACE) Data

All PACE data were manually entered from tables published by the US Department of Commerce, Bureau of the Census. The variable of interest from this source was the Pollution Abatement Gross Annual Cost (GAC) total across all media types. These data are published in Current Industrial Reports: Pollution Abatement Costs and Expenditures, MA-200, various years. The 1977 data are only for establishments with 20 or more employees. Although survey data was collected from all establishments for the years 1973-1979, in order to lessen the administrative burden on small businesses, they were dropped from the survey, starting in 1980. The PACE Survey was not collected in 1987.

Note: There were some censored observations for the state totals.

Gross State Product data:

All gross state product data were acquired via the Regional Economic Information System CD, 1969-1994 published by the US Department of Commerce, Bureau of Economic Analysis, Regional Economic Measurement Division.

Population

Source: Current Population Survey: www.census.gov/population/estimates. Files st9097t1.txt, st8090ts.txt, st7080tx.txt.

Market proximity

This is a measure of how near each state is to potential markets in other states. It is a distance-weighted measure of Gross State Product:

$$M_{it} = \sum_{j \neq i} \frac{Y_{jt}}{d_{ij}}$$

where Y_{jt} is the GSP of state j at time t, and d_ij is the distance from state i to state j (miles between populations-weighted state centroids). Source: BEA. Distances are approximated as a straight line along a great-circle route.

Unionization Rates

Union Membership as Percent of Civilian Labor Force. The Bureau of National Affairs, Inc., "Union Membership and Earnings Data Book: Compilations from the Current Population Survey." Notes: BNA's series begins in 1983. All of the data were obtained through the Statistical Abstracts, except for 1985, 1988, 1990, and 1993, which were obtained directly from BNA. Unionization rates prior to 1983 have been extrapolated from the 1983-1994 trend.

Unemployment

Total Unemployed as Percent of Civilian Labor Force. Source: US Bureau of Labor Statistics, "Geographic Profile of Employment and Unemployment," annual.

Wages

Production Workers in Manufacturing Industries – Average Hourly Earnings by State. Source: US Bureau of Labor Statistics, "Employment and Earnings," monthly. Notes: missing production workers average hourly wages for 1981, and for years prior to 1980. These numbers are interpolated and extrapolated in the data.

Road Mileage

This is the sum of Urban Highway Mileage and Rural Highway Mileage. Sources: Federal Highway Administration, U.S. Department of Transportation. www.fhwa.dot.gov/ohim/summary95/section5.html, file hm210.xlw.

Energy Prices

Prices of Fuel and Electricity for Industrial Sector. Source: State Energy Price and Expenditure Report, U.S. Energy Information Administration, www.eia.doe.gov/emeu/sep/, file allprice.csv.

Land Prices

Land Value per Acre. US Department of Agriculture, Economic Research Service, www.econ.ag.gov/Prodsrvs/dp-lwc.htm#prices.

Tax effort

Advisory Commission on Intergovernmental Relations, 1988, State Fiscal Capacity and Effort. This variable measures the extent to which a state utilizes its available tax bases. It is a state's actual revenues divided by its estimated capacity to raise revenues based on a model tax code, multiplied by 100. The national average is 100.

Table 1: Summary Statistics
Averages 1977-1994

State	Abatement cost index S* (1)	Unadjusted index S (2)	Property, Plant & Equipment of foreign-owned affiliates ($millions): Manufacturing (3)	Property, Plant & Equipment of foreign-owned affiliates ($millions): Chemicals (4)	Employees of foreign-owned affiliates: Manufacturing (5)	Employees of foreign-owned affiliates: Chemicals (6)	Annual number of new foreign-owned plants: Manufacturing (7)	Annual number of new foreign-owned plants: Polluting industries[e] (8)
Alabama	1.19	0.0219	2876	803	22747	4502	0.94	0.65
Arizona	1.39	0.0148	1430	206	11927	2588	0.35	0.18
Arkansas	1.17	0.0168	826	131	14152	2034	0.18	0.12
California	0.90	0.0121	10397	2026	150365	33285	5.24	2.06
Colorado	1.01	0.0113	926	320	13612	3085	0.35	0.12
Connecticut	0.67	0.0079	1565	335	29448	4825	0.88	0.35
Delaware	1.30	0.0344	2786	2724	25304	32300	0.65	0.59
Florida	1.21	0.0138	2940	749	43306	6878	0.76	0.24
Georgia	0.91	0.0127	4729	861	54975	8947	3.82	1.00
Idaho	1.66	0.0181	210	24	3138	434	0.00	0.00
Illinois	0.91	0.0132	6389	1331	86496	14230	2.29	1.06
Indiana	1.14	0.0196	5088	765	53453	8609	2.18	1.41
Iowa	0.96	0.0106	1245	262	15482	3406	0.53	0.24
Kansas	0.76	0.0115	705	182	10828	2420	0.24	0.06
Kentucky	0.99	0.0146	2923	561	25185	4289	1.76	1.00
Louisiana	1.51	0.0538	5094	2835	18421	6974	0.47	0.41
Maine	1.55	0.0237	1093	42	8713	449	0.12	0.06
Maryland	1.17	0.0185	1799	408	26491	5484	1.00	0.24
Massachusetts	0.67	0.0067	2126	506	39880	8212	1.00	0.35
Michigan	1.01	0.0121	4129	631	55779	7827	2.12	1.18
Minnesota	0.66	0.0092	1720	168	24294	3522	0.18	0.12
Mississippi	1.47	0.0213	990	518	10585	1651	0.29	0.18
Missouri	0.79	0.0104	2404	664	27731	7312	0.71	0.53
Montana	1.49	0.0341	528	566	1496	554	0.00	0.00

(continued)

Table 1 (continued)

State	Abatement cost index S* (1)	Unadjusted index S (2)	Property, Plant & Equipment of foreign-owned affiliates ($millions)		Employees of foreign-owned affiliates		Annual number of new foreign-owned plants	
			Manufacturing (3)	Chemicals (4)	Manufacturing (5)	Chemicals (6)	Manufacturing (7)	Polluting industries[e] (8)
Nebraska	0.83	0.0088	257	72	5226	1502	0.06	0.00
Nevada	0.63	0.0072	270	38	2944	650	0.29	0.18
New Hampshire	0.75	0.0072	492	35	9999	505	0.00	0.00
New Jersey	0.82	0.0158	6972	3810	88583	43431	2.47	1.65
New Mexico	1.64	0.0306	679		2701	607	0.12	0.00
New York	0.77	0.0087	5055	1084	91944	17760	4.59	1.65
N. Carolina	0.82	0.0088	6485	2467	76700	22005	4.12	2.12
N. Dakota	0.77	0.0105	189		1448	417	0.00	0.00
Ohio	0.82	0.0139	6177	1044	83174	11386	2.82	2.29
Oklahoma	0.58	0.0103	1614	1296	13929	5106	0.24	0.18
Oregon	1.22	0.0139	871	88	9559	1491	1.00	0.47
Pennsylvania	0.91	0.0169	5891	1450	92059	17095	1.94	1.18
Rhode Island	0.72	0.0075	506	151	7577	1401	0.18	0.00
S. Carolina	0.99	0.0160	4913	2056	44540	13793	1.71	0.82
S. Dakota	0.68	0.0056	62	4	1601	113	0.00	0.00
Tennessee	1.10	0.0165	4554	1480	52981	12125	2.41	0.94
Texas	1.39	0.0311	14632	7970	89008	25756	3.82	2.88
Utah	0.93	0.0164	480	120	7117	1077	0.12	0.00
Vermont	0.66	0.0065	215	9	2729	131	0.35	0.18
Virginia	0.96	0.0118	3295	1637	36171	11360	2.53	1.00
Washington	1.37	0.0196	2197	153	18107	2874	0.88	0.18
W. Virginia	1.58	0.0433	3024	2229	16123	8772	0.18	0.18
Wisconsin	0.89	0.0110	2161	154	38627	4142	0.47	0.24
Wyoming	0.72	0.0259	838	992	1225	1005	0.00	0.00
Avg. for lowest 5[a]	0.64	0.0082	1077	293	14669	2931	0.39	0.20
Avg. for highest 5[b]	1.59	0.0339	2020	1314	9819	3261	0.18	0.13
Avg. for lowest 20[c]	0.75	0.0103	2525	803	35413	8987	1.19	0.60
Avg. for highest 20[d]	1.33	0.0235	2841	1229	24874	5609	0.89	0.50

Omits AK, HI, and 1987. Columns (4) and (6) omit 1992-94, and columns (7) and (8) omit 1989.

[a]OK, NV, MN, CT, MA.

[b]NM, ID, WV, ME, MT.

[c]Add to (a) VT, SD, RI, NH, KS, NY, ND, MO, NJ, NC, WY, OH, NE, WI, GA.

[d]Add to (b) LA, MS, TX, AZ, WA, DE, OR, FL, AL, MD, AR, IN, TN, MI, CO.

[e]SIC codes 26, 28, 29, 32, 33, 34, 37. (See footnote 13.)

Table 2
Changes in Average Pollution Abatement Costs and FDI (1977-1981) to (1990-1994)

	Change in industry-adjusted index of abatement costs (*S**) (1)	Property, plant & equipment change: total manufacturing (2)	Property, plant & equipment change: chemical industry (3)	Employment change: total manufacturing (4)	Employment change: chemical industry (5)	Total new plants: total manufacturing (6)	Total new plants: polluting industries[g] (7)
5 largest declines[a]	-0.597	2,495	1,311	16,698	1,306	0.32	0.00
5 largest increases[b]	0.446	801	209	3,658	451	0.00	-0.04
10 largest declines[c]	-0.370	3660	982	20,949	2206	0.58	0.28
10 largest increases[d]	0.310	3007	720	19,567	2972	-0.44	-0.20
20 largest declines[e]	-0.230	4,508	1,757	26,183	5,796	0.43	0.13
20 largest increases[f]	0.190	5,282	1,551	31,577	4,385	-0.13	0.00

[a] AZ, NM, ID, DE, FL.
[b] WY, ND, RI, CO, SD.
[c] Add to (a) IN, AL, IA, WA, OK.
[d] Add to (b) ME, CT, MA, IL, GA.
[e] Add to (c) NJ, WV, MS, OR, MI, PA, MT, MD, VA, NC.
[f] Add to (d) MN, CA, TX, SC, UT, OH, WI, NY, NH, KY.
[g] SIC codes 26, 28, 29, 32, 33, 34, 37. (See footnote 13.)

Table 3
FDI and Abatement Costs
1977 -1994

Dependent variable: ln(property plant and equipment FDI)	Mean (in levels) (1)	Pooled Manufacturing (2)	Pooled Chemicals[a] (3)	State Fixed Effects Manufacturing (4)	State Fixed Effects Chemicals[a] (5)
ln(Industry-adjusted index of abatement costs (*S**))	1.0 (0.3)	0.261* (0.074)	0.091 (0.139)	-0.079† (0.046)	-0.198* (0.092)
ln(Market proximity)	6268 (7277)	0.762* (0.073)	1.64* (0.15)	0.150 (0.210)	1.60* (0.47)
ln(Population)	4940 (5134)	0.592* (0.090)	0.281 (0.192)	0.473 (0.300)	-0.673 (0.603)
Unemployment rate	6.61 (2.09)	0.077* (0.013)	0.166* (0.024)	-0.003 (0.010)	0.036† (0.019)
Unionization rate	16.6 (6.7)	-0.020* (0.006)	-0.074* (0.010)	-0.024* (0.008)	-0.113* (0.014)
ln(Wages)	8.81 (1.21)	0.307 (0.219)	-0.164 (0.432)	-0.743* (0.346)	-1.13 (0.72)
ln(Road mileage)	80.5 (48.4)	-0.561* (0.054)	-0.846* (0.102)	-0.102 (0.205)	-0.768† (0.423)
ln(Land prices)	865 (686)	-0.237* (0.045)	-0.282† (0.087)	-0.144† (0.078)	-0.422* (0.141)
ln(Energy prices)	5.38 (1.46)	-0.975* (0.095)	-2.29* (0.22)	0.160 (0.105)	-0.0003 (0.2116)
ln(Tax effort)	96.1 (16.1)	-0.564* (0.134)	-1.09* (0.24)	-0.353* (0.170)	-0.114 (0.341)
Fixed effects		year dummies	year dummies	year and state dummies	year and state dummies
Observations	816	811	563	811	563
Censored		5	109	5	109
R^2		0.85	0.79		

Standard errors in parentheses. Monetary values are real 1982 dollars.
1987 is dropped because no PACE data were collected that year.
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
[a] The chemical industry investment data is only for 1977-1991.

Table 4
Alternative specifications

	Coefficients on Index of Abatement Costs	Pooled: Manufacturing (1)	Pooled: Chemicals[a] (2)	State Fixed Effects: Manufacturing (3)	State Fixed Effects: Chemicals[a] (4)
(1)	Adjusted index (*S**), with employment as the dependent variable.	0.121[†]	-0.218*	-0.013	-0.397*
		(0.067)	(0.101)	(0.041)	(0.072)
(2)	Unadjusted Index (*S*), with PP&E as the dependent variable.	0.579*	0.660*	-0.091*	-0.280*
		(0.047)	(0.119)	(0.046)	(0.093)
(3)	Unadjusted index (*S*), with employment as the dependent variable.	0.078[†]	0.122	-0.057	-0.384*
		(0.045)	(0.080)	(0.041)	(0.072)
(4)	Five-year averages, with PP&E and adjusted index (*S**).[b]	0.240	0.006	-0.166	-0.143
		(0.184)	(0.331)	(0.163)	(0.279)
(5)	Dynamic Panel Model (GMM), with PP&E and adjusted index (*S**).	--	--	0.029	-0.115
				(0.072)	(0.110)
(6)	Drop wages and land values.	0.260*	0.032	-0.105*	-0.267*
		(0.075)	(0.140)	(0.046)	(0.092)
(7)	Weight by Gross State Product (GSP)	0.259*	0.087	-0.075	-0.183*
		(0.073)	(0.136)	(0.053)	(0.089)

Standard errors in parentheses.
* Statistically significant at 5 percent.
[†] Statistically significant at 10 percent.
[a] The chemical industry investment data is only for 1977-1991.
[b] Row (4) averages all dependent and independent variables for 1977-1981, 1982-1986, and 1988-1994, and treats each period as one observation. There are thus 48 states and three periods, for 144 total observations. The last period, 1988-1994, takes a seven-year average for total manufacturing in columns (1) and (3), and a 4-year average for the chemical industry, in columns (2) and (4).

Table 5
Count Data Models
Of New Foreign-owned Plants
As a Function of Abatement Costs
1977 -1994

Dependent variable: number of planned new plants	Pooled Negative Binomial All Manufacturing (1)	Pooled Negative Binomial Polluting industries (2)	Regional Fixed-Effects Negative Binomial All manufacturing (3)	Regional Fixed-Effects Negative Binomial Polluting industries[a] (4)
Industry-adjusted index of abatement costs	-0.147 (0.194) [0.863]	-0.140 (0.237) [0.869]	-0.467* (0.206) [0.627]	-0.306 (0.266) [0.736]
Market proximity (millions)	0.050* (0.018)	0.060* (0.020)	0.0039 (0.0165)	0.0014 (0.0211)
Population (millions)	0.069* (0.025)	0.033* (0.028)	0.033* (0.023)	0.050 (0.032)
Unemployment rate	0.048 (0.038)	0.087† (0.046)	-0.098* (0.037)	-0.052 (0.046)
Unionization rate	-0.011 (0.016)	-0.013 (0.020)	0.019 (0.020)	0.011 (0.026)
Wages	-0.118 (0.073)	-0.023 (0.090)	0.073* (0.086)	0.147 (0.113)
Road mileage (millions)	2.70* (1.86)	5.04* (2.16)	11.3* (2.1)	9.55* (2.58)
Land prices ($1000 per acre)	0.131 (0.106)	0.218† (0.124)	0.071 (0.102)	0.078 (0.130)
Energy prices	0.044 (0.058)	0.023 (0.072)	0.103† (0.059)	0.066 (0.078)
Tax effort	0.0020* (0.0043)	0.0034 (0.0053)	0.0106* (0.0041)	0.0031 (0.0054)
Fixed effects	year dummies	year dummies	year and region dummies	year and region dummies
Observations	768	768	768	768
Pseudo R^2	0.12	0.13	0.20	0.19

Standard errors in parentheses (). Incidence rate ratios [e^{β}] in square brackets. Omits 1989.
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
[a] SIC codes 26, 28, 29, 32, 33, 34, 37. (See footnote 13.)

Table 6
Alternative Count Data Models
Of New Foreign-owned Plants
As a Function of Abatement Costs
1977 -1994

		Pooled		Regional Fixed-Effects	
	Stringency measures	All Manufacturing (1)	Polluting industries (2)	All manufacturing (3)	Polluting industries[a] (4)
(1)	Zero-inflated negative binomial model.	-0.173	-0.229	-0.359	-0.341
		(0.219)	(0.273)	(0.230)	(0.285)
		[0.841]	[0.795]	[0.699]	[0.711]
(2)	Five-year averages.[d]	-0.566	-0.608	-0.852*	-0.839†
		(0.423)	(0.452)	(0.364)	(0.456)
		[0.568]	[0.544]	[0.427]	[0.432]
(3)	Poisson.	-0.217†	-0.114	-0.612*	-0.360
		(0.128)	(0.178)	(0.166)	(0.224)
		[0.805]	[0.892]	[0.542]	[0.698]
(4)	Drop wages and land values.	-0.184	-0.148	-0.446*	-0.275
		(0.193)	(0.235)	(0.204)	(0.264)
		[0.832]	[0.862]	[0.640]	[0.759]

Standard errors in parentheses. Omits 1989, when no new plant data were collected.
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
a SIC codes 26, 28, 29, 32, 33, 34, 37. (See footnote 13.)
d Row (2) averages all dependent and independent variables for 1977-1981, 1982-1986, and 1988-1994, and treats each period as one observation. There are thus 48 states and three periods, for 144 total observations. The last period, 1988-1994, takes a six-year average, because there are no new-plant data for 1989.