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MANUFACTURING PLANT LOCATION: DOES STATE POLLUTION REGULATION MATTER?

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ABSTRACT

This paper tests whether differences across states in pollution regulation affect the location of manufacturing activity in the U.S. Plant-level data from the Census Bureau's Longitudinal Research Database is used to identify new plant births in each state over the 1963-1987 period. This is combined with several measures of state regulatory intensity, including business pollution abatement spending, regulatory enforcement activity, congressional pro-environment voting, and an index of state environmental laws. A significant connection is found: states with more stringent environmental regulation have fewer new manufacturing plants. These results persist across a variety of econometric specifications, and the strongest regulatory coefficients are similar in magnitude to those on other factors expected to influence location, such as unionization rates. However, a subsample of high-pollution industries, which might have been expected to show much larger impacts, gets similar coefficients. This raises the possibility that differences between states other than environmental regulation might be influencing the results.

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1. Introduction

Since the 1960s there has been a substantial increase in the environmental regulations faced by U.S. business. These regulations are primarily defined at the national level, but much of the implementation and enforcement is done by state regulatory agencies. In addition, some states impose additional regulations of their own. To the extent that some states regulate pollution more stringently than others, businesses in one state may have a competitive advantage over those in another state. This could influence firms' decisions about where to open new plants.

On the international level, the concern is often raised that environmental regulation may reduce the competitiveness of U.S. firms, leading firms to move production to foreign plants. Jaffe, et. al. (1995) contains an extended discussion of the issue of competitiveness, and a survey of the existing studies in this area. The debate over the North American Free Trade Act has highlighted these concerns, with fears that heavily-polluting plants could choose to move their activities to Mexico to take advantage of lax enforcement of environmental laws there.

Past research in this area has not found that pollution regulation is of overriding concern in determining plant location, although it does play some role. One set of research conducts surveys asking businessmen to rate the importance of different factors, including environmental regulatory measures. These studies find that "favorable pollution laws" (Epping 1986), "state clean air legislation" (Lyne 1990), and "environmental concerns" (Stafford 1985) are of small to moderate importance when locating new plants.

Empirical studies have sometimes found effects of regulation on location, but generally small ones. Bartik (1988) examines the location of new manufacturing branch plants of Fortune 500 companies between 1972 and 1978. He finds no effect of state spending on pollution control regulations, manufacturing spending on pollution abatement, or particulate emission regulations. McConnell and Schwab (1990) examine the location of motor vehicle assembly plants between 1973 and 1982. They find only a small impact of an SMSA's attainment with federal ozone standards, and no impact of state regulation expenditures or manufacturing abatement expenditures. Levinson (1996) examines the location of new manufacturing plants between 1982 and 1987. He finds a small negative impact of manufacturing abatement expenditures and an index of state environmental laws on location, but only for a narrow subsample of the data: branch plants of large firms in high-pollution industries.

Two recent studies, Henderson (1996) and Kahn (1994) have looked at the impact of air quality on plant location. Federal regulations require states to develop plans to improve air quality in counties which fail to meet federal air quality guidelines (called 'non-attainment' counties). These state plans generally involve stricter regulation of emissions from both existing and new sources, and provide one way to measure possible differences in regulation across counties. Henderson finds a reduction in the presence of polluting industries, and Kahn finds slower growth in manufacturing employment, in non-attainment counties.

Other studies considering the impact of pollution regulations on business along other dimensions have found significant effects, which might be expected to influence new plant location. Duffy-Deno (1992) finds a negative (but small) impact of manufacturing abatement costs on SMSA earnings and employment growth. Bartel and Thomas (1987) find that OSHA and EPA regulation tend to reduce profits in heavily regulated industries. Deily and Gray (1991) find that steel plants facing greater air pollution enforcement activity are significantly more likely to close.

Many studies have examined the impact of regulation on productivity growth. Barbera and McConnell (1986) find that pollution abatement expenditures accounted for a significant portion of the productivity slowdown in several industries. Gollop and Roberts (1983) find that stringency of air pollution regulation has a large negative impact on productivity of electric power plants. I have also found significant effects of regulation on manufacturing productivity, using both industry-level (Gray 1987) and plant-level data (Gray and Shadbegian 1995).

In this study I examine changes in the location of manufacturing activity from 1963 to 1987, based on the Census Bureau's plant-level Longitudinal Research Database (LRD). I calculate the birth rate of new plants for each state at five-year intervals, and then test for an influence of state-level environmental regulation. I control for factors traditionally expected to affect plant location (taxes, factor prices, and labor force characteristics). A wide variety of measures of state-level environmental regulation are considered, including expenditures (state regulatory spending and business pollution abatement spending), political support (membership in conservation organizations, Congressional voting patterns and an index of state laws), and regulatory stringency (air pollution enforcement activity). This model is estimated separately for all manufacturing and for a subset of the most pollution-intensive industries, using several different econometric specifications.

I find a significant negative connection between plant birth rates and some of the regulatory measures. The results give some support for the idea that new plants tend to locate in areas with less strict regulation, using the political and regulatory stringency measures, although the expenditure measures are less often significant. The strongest regulatory coefficients are similar in magnitude to those on other control variables, such as unionization. Panel data estimation methods give similar results, as do analyses which focus on the number of new plants in the state (such as poisson or conditional logit models), although the relative impacts of different variables differ across the models.

The results also present a few puzzles, which may indicate that they are measuring some phenomenon other than a simple impact of regulation on plant location. The most important of these is that the observed connection between regulation and location is not noticeably stronger for plants in highly pollution-intensive industries than it is for all manufacturing plants. This suggests that some other state characteristics, correlated with the measures of state environmental regulation, might be influencing the analysis.

A brief sketch of the theoretical model underlying the plant location decision is presented in Section 2, along with a discussion of the econometric modelling which is used. Section 3 contains a discussion of the data sources used in the analysis. The basic empirical results are presented in section 4, followed in section 5 by the conclusions (and areas for further investigation).

2. Modelling Plant Location: Theory and Econometrics

There is a substantial theoretical literature on the incentives for governments to compete with each other by lowering taxes to attract businesses. In general, this 'undercutting' behavior leads to lower-than-optimal tax rates. Similar theoretical results for environmental regulation are found by Cumberland (1981) and Oates and Schwab (1986): the competition to attract business will reduce environmental quality below optimal levels. Markusen et. al. (1993) consider the case of two governments trying to influence the plant location decision of a single firm (with increasing returns to scale). They include the negative externality from pollution (assumed to be local), and find that if the pollution is bad enough, each government will try to drive the firm to locate in the other jurisdiction with regulations that are too strict, rather than too lax (the famous 'Not In My Back Yard' scenario). In cases with less serious pollution, the usual 'undercutting' result applies.

The decision for a manufacturing firm about where to locate its activities can be made along several dimensions for a multi-plant firm. Production could be reallocated among existing plants, some plants could be closed down, and new plants could be opened. This study concentrates on the movement of plants through new plant openings, because this offers a discrete event, with the notion of the firm comparing the profitability of current and potential locations when deciding location, although I also examine 'net birth rates' (incorporating both openings and closings).

Once a firm has decided to open a new plant, it bases its location decision on the expected profitability of the different possible sites. Profitability depends on several sets of characteristics of the location. Factor prices differ across the country, as prices for labor, energy, land, and materials show substantial variation (the price of capital is likely to show less variation across states, since the interest rate is generally set in the national market for credit - though variation in the supply of used capital goods might lead to some variation). Factor quality and availability (especially a suitable labor force, and suppliers of essential intermediate goods) is another important determinant. Differences across states in product market conditions could also affect profitability (size of market, number of competitors, and of course the market price), but this would be less important for goods with national markets (such as most manufactured goods). States may also differ in their taxing or regulating of business, including environmental regulations.

Following Bartik (1985) and others in the area, I assume that the expected profits for a new plant of firm i in site j can be written as:

(1) $$\pi_{ij} = B'X_{ij} + e_{ij} .$$

The firm naturally chooses the location with maximum profits, so that states with less desirable attributes are less likely to be chosen, as are states which contain fewer sites. The number of sites, or 'scale' of a state, as measured by area or population, is often the most powerful explanatory variable in the estimation. Several econometric methods have been used for these analyses, depending on what aspect of the data is considered most important.

If the focus is on the comparison across states, and if e_{ij} follows a Weibull distribution, the choice can be described using the conditional logit model (McFadden 1973). In the usual case, only characteristics of the site are considered, since little is typically known about the company making the decision. The probability of firm i choosing site s is:

(2) $$\Pr(is) = \exp(B'X_s) / \Sigma_j \exp(B'X_j).$$

The relative probability of any two sites (s and q) attracting a new plant is just given by the differences in their X variables:

(3) $$\Pr(is) / P(iq) = \exp(B'(X_s - X_q)).$$

This is an advantage computationally, but it does require the assumption that each site's error term is uncorrelated with the others, which may be unlikely in this case. A potential conceptual disadvantage of this model is the assumption that the total number of new plants has already been determined, and does not depend on the explanatory variables (for example, more stringent regulation in a state would not reduce the total number of new plants opened, but simply reallocate them to other states).

An alternative procedure, based on a Poisson model, focusses on the possibility that a state's characteristics may directly affect the total number of new plants opened. The number of new plants in state s, N_s, is generated by a Poisson distribution with mean λ_s, which depends on state characteristics X_s:

(4) $$\lambda_s = \exp(B'X_s).$$

The log-likelihood for the sample is given by:

(5) $$L(B) = \Sigma_s \{-\log(N_s!) - \exp(B'X_s) + N_s B'X_s\}.$$

This could be interpreted as allowing for there being a certain number of 'potential' new plants, some of which will open and some will not. Policies that encourage plants to open will result in more of the potential plants opening.

A key difference between the Poisson model and the conditional logit model lies in the treatment of a country-wide change in one of the X variables. Suppose that regulatory stringency increases in all states. The conditional logit model assumes the total number of new plant openings will remain unchanged, which presumably understates the impact of overall increases in regulation.

On the other hand, the Poisson model predicts that all states would attract fewer new plants, even if some states increased their stringency more than others.[1] Which model is preferable depends on which aspect of regulatory variation is more important.

In this paper I consider both the Poisson and conditional logit models, but begin by focussing on a less sophisticated linear regression model. I calculate the birth rate of new plants in a state (B_s), measured as the number of plants born during the period divided by the total plants present at the start of the period, and explain variations in birth rates with a simple linear regression,

(6) $$\log(B_s) = B'X_s + u_s.$$

This analysis relies on the birth rate calculation (dividing by the number of existing plants) to control for differences in scale across states, so measures of state size (area, population, or number of plants) are likely to be less important. The assumption here is that, all else equal, the number of new plants should be roughly proportional to the number of existing plants. I also do some panel data analyses, looking at both fixed-effects and random-effects models. This allows us to control for the influences of other, unmeasured characteristics of states which might influence the plant location decisions. The regression-based analyses may be more robust, at the cost of some loss in efficiency since they don't take into account the specialized nature of the dependent variable and the choice process.[2]

Some possible econometric issues are determined by the nature of the data in the sample. Since my plant opening data comes from the Census of Manufactures, taken at 5 year intervals, I can only observe the average number of new plants opened over several years. This makes it more difficult to capture any issues of timing (for example, whether an increase in a state's wages this year

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[1] A Poisson analysis might pick up common shifts in state regulation with time dummy controls.

[2] The main advantage of the Poisson, dealing with cases of zero or small integer numbers of births, is not especially relevant here because many new manufacturing plants open in even the smallest state over a five-year period. It may even prove a disadvantage, if the Poisson is overly sensitive to the very large numbers of plants opened in some states.

affects new plant openings immediately, or with a two- or three-year lag). In the absence of any more specific information on the timing of the plant location decision, I will use the explanatory variables at the start of the period to explain plant openings during the period. For example, the number of plants opened in Ohio between 1982 and 1987 depends on Ohio's characteristics in 1982.

This has the added benefit of reducing concerns about possible endogeneity of the explanatory variables. For example, the opening of new plants tends to reduce unemployment, so regressing plant openings on concurrent unemployment could give a misleading negative coefficient. There could still be some endogeneity bias, but it would have to depend on autocorrelation of errors over time (which should reduce its importance).[3]

Another feature of the data with econometric implications is the nature of the regulatory measures. Most of these are strictly cross-section measures (one value per state), so there is no way to look at the impact of changes in regulation over time. Even those measures which nominally include some time series variation do not extend back into the 1960s at any level of detail, and nearly all of their variation occurs across states rather than over time. This limits the use of fixed-effects estimation to control for unobserved state-specific characteristics, since all of the cross-state variation in regulation is absorbed by the fixed-effects. Random-effects models may also have their own problems, since they depend on the assumption that the state-specific effects are uncorrelated with the other explanatory variables.

In some analyses I allow for differences in the impact of regulation on location over time, by interacting time dummies with the regulatory measures. It is not clear what the time pattern of coefficients ought to be. Nearly all of the regulatory data comes from the end of the period, so if states' regulatory intensity varies over time, the earlier coefficients should be more affected by

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[3] The presence of a state-level business cycle may help explain the positive connection I find between new plant openings and unemployment rates (states with a high unemployment rate in one census may be especially likely to grow over the next five years).

measurement error, and be biassed towards zero. On the other hand, one reason given for federal environmental legislation has been to reduce regulatory differences across states, so there might be a bigger impact early in the period (when most regulation was state-based). If states which have been successful in attracting business in the past face less pressure to relax standards in the future, there might be a positive connection between late stringency and early birth rates - regulatory stringency would be endogenous, possibly with a long lag.

3. Data Description and Limitations

The basic data on new plant openings comes from the Longitudinal Research Database (LRD) maintained at the Center for Economic Studies of the Census Bureau.[4] This contains information from the Census of Manufactures, done every five years since 1963 on all manufacturing plants in the country (around 300,000 plants in each census).[5] The data is linked together over time, so for each census I can categorize each plant as opening (absent in the prior census), continuing (present in both this and the prior census), or closing (present in the prior census but absent in this census). I aggregate together the data for each state to get the total number of opening, closing, and continuing plants at five year intervals. I then divide the number of openings by the total plants from the previous census (continuing plus closings) to get a birth rate for each state, along with a net birth rate (openings minus closings). These two birth rates are both included as measures of the state's attractiveness to new businesses.

[4] The LRD data is confidential, but there are enough new plants in each state that the plant opening data could be aggregated at the Census Bureau into "non-confidential" totals, and then analyzed outside the Census Bureau.

[5] The timing of the Census was changed early in the period, so the actual Census dates are 1963, 1967, 1972, 1977, 1982, and 1987. The 1963-1967 birth rate was adjusted to reflect the shorter interval between the first two Censuses.

I also identify a subset of manufacturing industries that are 'high pollution' as a consistency check on the results: if regulation matters for plant location, it should matter more for plants in high-pollution industries. I calculate the average pollution abatement operating costs for each industry, based on the Census' Pollution Abatement Costs and Expenditures survey. Roughly 20 percent of the industries, those whose pollution abatement operating costs exceeded 3% of their total shipments, are included in the high-pollution sample. Similar birth rates are calculated for this subsample.[6]

The regulatory data comes from a variety of sources. The Green Index publication (Hall and Kerr 1991) contains rankings of all the states on a large number of environmental-related variables. A measure of regulatory stringency is the 'Green Policies' (ENVPOLICY) index, designed to measure the stringency of state environmental regulations based on a set of 77 specific indicators, such as the presence of state laws on specific topics such as recycling. A measure of environmental problems in each state is the 'Green Conditions' (DIRTY) index, which indicates the state's combined ranking on over 100 measures of the quality of the state's environment, including air and water pollution information.[7]

These indices were created by aggregating the state's rankings on individual measures, so the interpretation of a regression coefficient is somewhat problematic (it is not clear what a 'one unit' change in the index represents). They were designed to capture a general tendency towards more stringent regulation, or better environmental conditions. In general, ENVPOLICY should be negatively related to plant openings (more stringent regulations reducing profitability leading to fewer

[6] A few states had one or two census years with too few plant openings in the high-pollution industries for the data to be released publicly. These state-years were deleted from the high-pollution dataset before taking it from the Census Bureau. I used the average rates of plant opening for that state in its 'publicly releasable' years to impute the missing values, in order to maintain a balanced panel.

[7] The original rankings were designed so that low scores reflected stricter regulation and a cleaner environment. Since all other stringency measures use higher values to indicate stricter regulation, I multiplied the Green Policies index by -1 to improve comparability.

new plants). DIRTY might be positively or negatively related to plant openings (a cleaner environment might be more desirable, but might also be associated with a tendency toward more stringent regulations, or a general opposition to new industry not picked up by the policy variables).

A direct measure of enforcement activity for air pollution regulation is taken from the EPA's Compliance Data System. This database reports all air pollution enforcement actions, identifying the affected plant by industry and location. The total number of inspections of manufacturing plants between 1984 and 1987, divided by the number of manufacturing plants in 1982, was calculated for each state (INSPECT). Greater enforcement activity is expected to put more pressure on plants in the state to come into compliance with air pollution regulations, raising costs and reducing profitability. In Deily and Gray (1991) higher enforcement was found to increase the probability of steel plant closings.

Other measures of state-level regulation are based on expenditures. The Council of State Governments (1991) calculated the total spending on each state's programs for environmental and natural resources in 1988. In the empirical analysis, these are represented as dollars per capita (REGSPEND).[8] State spending on environmental regulations could be linked to more stringent enforcement (imposing additional costs on business), expected to discourage plant openings.

The Census Bureau's Pollution Abatement Costs and Expenditures (PACE) survey reports the dollars spent for pollution abatement by manufacturing firms, giving totals for all industries in each state and for all plants nationwide in each industry. I divide pollution abatement operating costs by total manufacturing shipments to measure pollution abatement intensity (for each state and each industry). I then calculate a predicted abatement intensity for each state, multiplying each industry's abatement intensity by its share in total state employment (from the Census of Manufactures). The

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[8] Expressing the expenditure as a percentage of total state government spending gives similar results in the empirical analysis.

residual abatement intensity (actual minus predicted), is used in the regressions (PASPEND). The survey was first done in 1973, and the 1973 values are used for all years of data before 1973. This is equivalent to assuming that the relative rankings of the states were unchanged before 1973 and allowing the year dummies in the regressions to control for a general tendency towards lower expenditures before 1973.

Two measures of the state's political support for environmental regulation are examined. CONSERVE is the number of members of three 'conservation' groups (Sierra Club, Greenpeace, and National Wildlife Federation - taken from Hall and Kerr (1991)) - per 1000 in the state population. Conservation-minded voters might be more inclined to support state policies for stringent environmental protection. I also measure environmental support by the state's politicians. The League of Conservation Voters calculates a scorecard for each member of Congress on environmental issues, with data available back to the early 1970s. I use the average score for House of Representative members from the state (LCVOTE) in my analysis.[9]

In addition to the regulatory variables, a number of other variables are used to control for differences across states that might influence the number of new plant openings (all dollar values are converted to 1982 values using the GDP deflator). Factor price measures include ENERGY (dollars per million BTU, from the Energy Information Administration), LANDPR (value per acre of agricultural land and buildings, from the City and County Databook), and WAGE (average hourly wage in manufacturing, taken from the Statistical Abstract). Labor market indicators include UNION (percent of non-agricultural workforce unionized, from Bureau of Labor Statistics), UNEMP (civilian unemployment rate), and INCOME (income per capita). Labor quality is measured by the fraction of

[9] The earliest year available in the League of Conservation Voters data is 1970. I tried calculating comparable measures for 1963 and 1967, using congressional voting data, but there were few obvious environmental votes during these years. The resulting voting measures are also not very strongly correlated with plant openings during the 1960s. Therefore I use the 1970 values of the LCV voting data for the earlier periods in the analysis.

the over-25 population with college degrees (EDUCAT). State taxes are measured by property taxes per capita (PROPTAX). ELECDM is the percentage of votes for Democratic candidates in the U.S. House of Representatives for the state. Population density (POPDEN) controls for differences in the size of the local product market and possibly also for 'agglomeration effects' (the tendency to locate where existing businesses are already located). AREA controls for the different number of possible sites available in different states. Since I examine birth rates, rather than number of new plants, these 'scale' effects (POPDEN and AREA) need not have positive signs (and in fact I find that birth rates over this period are generally higher in large but lightly populated states).

4. Results

The means and standard deviations of the variables used in the analysis are presented in Table 1. This table also presents the fraction of the variation in each variable which is explained by fixed cross-state differences (C.S.). This is important for understanding where the explanatory power of the analyses comes from. For most variables (especially the regulatory ones) the majority of variation comes from differences across states. In fact, many of the regulatory variables are based on a single cross-section of data (giving them a C.S. value of 1.0).

Note that the numbers of new plants are primarily cross-section in variation (C.S. above .95). This means that a traditional analysis using numbers of new plants, either in regression or Poisson form, will be heavily driven by differences in the scale of states, and the particular scaling factor chosen may substantially influence the results. There is much more within-state variability in the birth rates (C.S. below .7, and below .5 for net birth rates). This tends to reduce the importance of fixed state characteristics. It could possibly lead us to understate the impact of regulatory variables, to the extent that stringent regulation over a long time period reduces both the numerator and the denominator of the birth rate.

The basic model of birth rates, using ordinary regression, is presented in Table 2, both for all manufacturing industries and for high-pollution industries. In general, most of the control variables are consistent across the models. The scale-related variables (AREA and POPDEN), indicate that large states with low population density tend to have larger birth rates over the study period. Higher unionization is consistently negative, but wages and land prices do little and energy prices are unexpectedly positive. Higher property taxes are usually negative but not always significant, while voting for Democratic candidates is positive. States with a more educated workforce or higher income tend to attract more new plants. Unemployment has a positive coefficient, which may reflect a rebound from a depressed state economy (since the UNEMP measure comes from the starting year of the birth rate calculation). Finally, the negative coefficient on DIRTY shows that states with dirtier environments have lower birth rates (although they also have lower death rates, as no impact is found on net birth rates).[10]

Three measures of regulatory stringency are included in these tables: ENVPOLICY, LCVOTE and PASPEND. These include the only two regulatory variables with any time-series variation. LCVOTE and ENVPOLICY have the expected sign and are significant in most regressions, although not all. Using the ENVPOLICY measure, a one standard deviation increase (.67) in stringency is associated with a reduction in a state's annual birth rate (first column, Table 2) of about .5 percentage points (about .25 standard deviations). A similar increase in LCVOTE is associated with about half that reduction in the birth rate. These impacts are similar in magnitude to those of other significant explanatory variables: a one standard deviation increase in UNION is associated with a birth rate reduction of about .4 percentage points. On the other hand, the

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[10] These control variables are omitted from the following tables, as the results are similar. The complete tables of results are available from the author on request.

coefficient on PASPEND, while negative, is never significant.

Table 3 explores the impact on plant location of a variety of measures of regulatory stringency. Each measure is considered separately, so that each coefficient in the table comes from a different regression which includes all of the basic control variables from Table 2. The measures of regulatory stringency (ENVPOLICY and INSPECT) and political support (LCVOTE and CONSERVE) are negatively related to new plant birth rates, as is industry pollution abatement spending (PASPEND), although not always significantly. By contrast, state regulatory spending (REGSPEND) is positively connected with birth rates, though not significantly. This might reflect endogeneity: government agencies in growing states could have more resources to spend.

One puzzle in the results, true in virtually all of the models tested, is that high-pollution industries do not seem to be especially sensitive to the regulatory measures. In both Table 2 and 3, the regulation coefficients are the same or smaller for the high-pollution industries. The means and standard deviations for both sets of dependent variables are similar, so the coefficient magnitudes may be directly compared.

Another issue is how to deal with several regulatory variables that might affect plant location in different ways. Table 4 shows the correlations among the environmental measures. All of the regulatory measures (except for PASPEND) show the expected correlations with DIRTY: higher stringency, state spending, and political support are associated with higher environmental quality. Of the different regulatory measures, the only pair which seems to give strongly opposing pictures are INSPECT and ENVPOLICY, where states which do more inspections have less strict policies. The spending measures are not very strongly correlated with the other regulatory measures. I tested using factor analysis to combine the six regulatory measures into three factors. The results (available on request) are similar to those shown here: states with more stringent regulation have fewer births, but the factor including government regulatory spending sometimes has the opposite sign.

As discussed in Section 2, several other specifications might be used to model plant location decisions. Table 5 considers some analyses which take advantage of the panel nature of the dataset, presenting fixed-effect and random-effect models corresponding to the birth rate models from Tables 2. Taken as a whole, the results are similar to those obtained earlier. LCVOTE remains significantly negative for the all-industry sample (and has similar coefficient magnitudes), but has substantially smaller coefficients for the high-pollution sample. PASPEND remains insignificant, while ENVPOLICY is little changed in the random-effects analysis (since ENVPOLICY comes from a single cross-section, it drops out of the fixed-effects analysis).

Table 6 examines an alternative approach, looking at the number of new plants opened, rather than the birth rate. For these analyses, I need to explicitly control for the differences in scale across states, so the number of existing plants in the prior period is also included as an explanatory variable. There are three models included: OLS (on the log of new plants), Poisson, and conditional logit. The results show a fair degree of consistency across the different models, but there is one notable change from the earlier results. The ENVPOLICY variable now shows a positive relationship with the number of new plants, where it had been negatively related to the birth rate of new plants. On the other hand, LCVOTE and PASPEND tend to be more consistently negative. As with the earlier analyses, the results for the high-pollution industries are not much different from those for all industries. The relatively small number of plants in the high-pollution industries leads to much lower significance levels (compared to the all-industry sample), since the effective unit of observation is now the number of new plants opened, rather than the number of states, for the Poisson and conditional logit estimates.

So far I have examined all of the years of data together, assuming that different state characteristics had similar impacts on plant openings during all five time periods. I test this in Table 7 by interacting the regulatory policy variables with year dummies. Here there is some evidence for differences in regulatory impacts across years, but the results differ across the variables. LCVOTE and PASPEND are negative for the base period, 1982-87, while ENVPOLICY is positive. LCVOTE shows no significant interactions, while PASPEND has positive interactions for 1972-77 and ENVPOLICY has negative interactions for 1972-77). These results suggest that stricter state-level regulations were more important in the earlier years of the period (before 1980), while higher pollution abatement costs were more important in the later years. This is not unexpected, since the gradually increasing stringency of federal regulations should reduce the impact of state-level differences. Still, the limited time-series components of the regulatory variables and the possible interactions between the three regulatory variables call for some caution when interpreting the results.

5. Conclusions

It is possible to show a connection between state-level environmental regulation and new plant birth rates. These impacts are not enormous, but are roughly comparable to other non-regulatory explanatory variables such as unionization. It appears that states with stricter regulations, stronger political support for pollution regulation, and greater abatement costs, tend to have lower birth rates of new plants over the period. There is also the suggestion of a diminishing impact of these state differences in the 1980s, consistent with increasingly strict federal regulations overshadowing state-level differences.

There are some notes of caution that should be raised concerning the interpretation of these results. First, most of the regulatory measures provide only cross-state variation: only two have any time-series variation, and even these don't extend before the early 1970s. Thus I am forced to assume that the cross-state differences are highly persistent over time. This may not be a bad assumption, since there is a high degree of persistence over the 1970s and 1980s in the two measures with time-series information, but I can't be certain that the other regulatory differences are similarly persistent. Second, econometric methods which focus on the number of new plants show somewhat different results for particular regulatory measures. Spending measures become more negative and political measures less negative or even positive, although the overall impression for both analyses is that stricter regulation is associated with fewer new plant openings.

More importantly, the results for high-pollution industries are not much stronger than the results for all manufacturing industries. If plants in high-pollution industries are the main target of state environmental regulations, the regulatory measures should have a larger impact on their location decisions. This raises the possibility that the regulatory measures are standing in for omitted differences in something, perhaps 'business climate' or other state regulations not completely controlled for by the panel analysis. One possible suggestion (offered by a seminar participant) is that the high-pollution industries face tough federal regulations wherever they go, so that state regulatory stringency is more likely to affect moderately-polluting industries. Testing this will require further work at the Census Bureau to examine birth rates for many industries with different levels of pollution abatement costs.

There are several directions for future research that I am planning to explore. First, I will be looking for alternative regulatory measures that might extend the data back into the 1960s. The more time-series variation in the regulatory measures, the easier it will be to control for other differences across states. I will look for measures of other differences across states (including 'business climate') to try to reduce concern with possible omitted variables. Finally, I will be exploring the use of the LRD data at greater levels of detail, looking at industry, county, and plant-level data, to obtain more variability in the regulatory data within each year. This will permit more precise measures of regulation's impact on location, and will allow me to test whether different industries respond differently to pollution regulation.

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Table 1

Descriptive Statistics
(N=240, 48 states * 5 periods)

	Mean	Std Dev	C.S.[1]	Description
		Dependent Variables		
(all industries)				
OPEN	2574.7	3241.4	.950	# New Plants open, t-1 to t
LOGOPEN	7.309	1.071	.965	Log(OPEN)
NPLANT	6693.5	8172.8	.973	# Plants in t-1
LOGPLANT	8.225	1.123	.985	Log(NPLANT)
BIRTH	8.631	2.294	.657	OPEN/NPLANT (*100, per year)
NETBIRTH	1.194	2.001	.376	(OPEN-CLOSE)/NPLANT (*100, per year)
(high-pollution industries only)				
HIOPEN	34.183	41.779	.954	# New Plants open, t-1 to t
LOGHIOPEN	2.995	1.077	.959	Log(HIOPEN)
NHIPLANT	455.6	529.9	.971	# Plants in t-1
LOGHIPLANT	5.534	1.141	.982	Log(NHIPLANT)
HIBIRTH	8.206	2.417	.625	HIOPEN/NPLANT (*100, per year)
HINETBIRTH	1.564	2.176	.363	(HIOPEN-HICLOSE)/NHIPLANT (*100)
		Control Variables		
WAGE	6.125	1.112	.075	Average manufacturing wage (1982$)
ENERGY	0.217	0.145	.108	1982$ per millions BTU (*1000)
LANDPR	0.522	0.522	.444	1982$1000 value / acre
UNION	0.219	0.089	.885	Non-farm unionization rate
UNEMPL	5.710	2.556	.176	Civilian unemployment rate
EDUCAT	11.597	4.484	.225	Pct college graduates in population
PROPTAX	0.205	0.131	.397	1982$ property taxes per capita
ELECDM	0.497	0.132	.314	Pct voted for Democratic Congressmen
INCOME	5.621	3.155	.059	1982$1000 Income per capita
POPDEN	0.151	0.220	.996	Population per sq. mile (000)
AREA	0.062	0.046	1.0	Square miles (000,000)
DIRTY	4.512	0.638	1.0	Green Conditions Index
Regulatory Stringency				
ENVPOLICY	-2.182	0.667	1.0	Green Policies Index
INSPECT	0.091	0.103	1.0	Air pollution inspections per plant
Regulatory Spending				
REGSPEND	59.618	73.938	1.0	State environmental spending
PASPEND	0.031	1.184	.424	Manufacturing pollution abatement costs, adjusted for industry mix
Political Support				
CONSERVE	8.444	3.584	1.0	Membership in 3 conservation groups, per 1000 population
LCVOTE	0.438	0.221	.677	Congressional environmental votes (League of Conservation Voters)

[1]C.S. = cross-state fraction of total variation of variable
(1.0 = purely cross-sectional, 0 = purely time-series)

Table 2

Basic Regressions
(t-statistics in parentheses)

	All Industries		High-Pollution Industries	
	Birth Rate	Net Birth Rate	Birth Rate	Net Birth Rate
Regulatory variables:				
LCVOTE	-1.437 (-2.40)	-1.566 (-2.69)	-1.347 (-1.83)	-1.157 (-1.54)
PASPEND	-0.118 (-1.34)	-0.002 (-0.03)	-0.113 (-1.05)	-0.024 (-0.22)
ENVPOLICY	-0.782 (-3.52)	-0.539 (-2.49)	-0.628 (-2.30)	-0.276 (-0.99)
Control variables:				
INTERCEPT	-2.240 (-0.82)	-9.707 (-3.66)	3.445 (1.03)	-5.455 (-1.60)
AREA	13.551 (4.96)	6.099 (2.30)	14.202 (4.24)	4.302 (1.26)
POPDEN	-2.249 (-2.87)	-1.519 (-1.99)	-2.313 (-2.41)	-2.664 (-2.72)
WAGE	-0.188 (-0.96)	0.102 (0.54)	-0.222 (-0.93)	-0.104 (-0.42)
UNION	-0.050 (-2.54)	-0.040 (-2.09)	-0.052 (-2.14)	-0.031 (-1.24)
LANDPR	-0.305 (-0.67)	-0.107 (-0.24)	-0.223 (-0.40)	-0.001 (-0.00)
ENERGY	2.149 (0.93)	6.453 (2.86)	3.001 (1.06)	5.344 (1.84)
PROPTAX	-1.454 (-1.02)	-1.004 (-0.73)	-2.392 (-1.37)	-3.345 (-1.88)
ELECDM	1.128 (1.16)	1.297 (1.37)	1.314 (1.10)	2.800 (2.30)
EDUCAT	0.274 (4.05)	0.249 (3.79)	0.235 (2.83)	0.294 (3.48)

Table 2 (cont.)

	All Industries		High-Pollution Industries	
	Birth Rate	Net Birth Rate	Birth Rate	Net Birth Rate
INCOME	0.411 (1.91)	0.110 (0.53)	0.286 (1.08)	-0.055 (-0.20)
UNEMPL	0.404 (5.10)	0.236 (3.07)	0.327 (3.37)	0.210 (2.12)
DIRTY	-0.524 (-2.34)	-0.036 (-0.17)	-0.950 (-3.47)	-0.037 (-0.13)
time period dummies:				
1963-1967	9.452 (5.39)	6.550 (3.84)	6.539 (3.04)	4.810 (2.19)
1967-1972	7.485 (4.75)	5.634 (3.68)	4.365 (2.26)	2.999 (1.52)
1972-1977	8.031 (5.94)	7.006 (5.34)	4.725 (2.86)	4.113 (2.43)
1977-1982	2.807 (3.33)	1.046 (1.28)	1.116 (1.08)	-0.081 (-0.08)
R^2	0.632	0.547	0.503	0.361

Table 3

Alternative Regulatory Measures
(t-statistics in parentheses)

	All Industries		High-Pollution Industries	
	Birth Rate	Net Birth Rate	Birth Rate	Net Birth Rate
ENVPOLICY	-0.930 (-4.24)	-0.653 (-3.07)	-0.766 (-2.87)	-0.368 (-1.36)
INSPECT	-1.208 (-1.03)	-0.988 (-0.88)	-1.983 (-1.42)	-2.294 (-1.64)
LCVOTE	-1.935 (-3.21)	-1.851 (-3.22)	-1.761 (-2.43)	-1.320 (-1.81)
CONSERVE	-0.139 (-2.67)	-0.112 (-2.26)	-0.155 (-2.50)	-0.111 (-1.77)
REGSPEND	0.000 (0.28)	-0.001 (-0.86)	0.003 (1.65)	0.002 (1.34)
PASPEND	-0.187 (-2.07)	-0.059 (-0.68)	-0.172 (-1.59)	-0.059 (-0.54)

Each coefficient represents a separate regression, including all the non-regulatory control variables in Table 2 and a single regulatory variable.

Table 4

Correlations Among Regulatory Measures

	DIRTY	ENVPOLICY	INSPECT	LCVOTE	CONSERVE	PASPEND	
DIRTY	1.0						
ENVPOLICY	-0.4262	1.0					
INSPECT	-0.3295	-0.3015	1.0				
LCVOTE	-0.3669	0.5605	0.0702	1.0			
CONSERVE	-0.7068	0.7057	0.1500	0.5632	1.0		
PASPEND	0.0366	0.1047	0.0308	0.1127	0.0412	1.0	
REGSPEND	-0.1770	-0.0149	0.0653	0.1300	0.1577	-0.1113	1.0

Note that only LCVOTE and PASPEND vary within states over time (the other regulatory variables are strictly cross-sectional).

Table 5

Panel Estimation Methods

	All Industries		High-Pollution Industries	
	Birth Rate	Net Birth Rate	Birth Rate	Net Birth Rate
		Fixed-effects models		
LCVOTE	-1.315 (-2.31)	-1.377 (-2.04)	-0.286 (-0.34)	-0.086 (-0.09)
PASPEND	0.052 (0.62)	0.096 (0.97)	-0.021 (-0.17)	-0.007 (-0.05)
ENVPOLICY	-	-	-	-
R^2	0.591	0.585	0.272	0.292
		Random-effects models		
LCVOTE	-1.391 (-2.60)	-1.494 (-2.52)	-0.781 (-1.05)	-0.930 (-1.20)
PASPEND	-0.018 (-0.24)	0.025 (0.30)	-0.082 (-0.76)	-0.031 (-0.28)
ENVPOLICY	-0.771 (-2.22)	-0.514 (-1.78)	-0.682 (-1.83)	-0.286 (-0.91)
R^2	0.565	0.533	0.383	0.332

Regressions include all non-regulatory control variables in Table 2.

Fixed-effects models effectively drop those variables with only cross-section variation (ENVPOLICY, AREA, and DIRTY).

A Hausman test finds significant differences between the fixed-effects and random-effects models for all of the dependent variables except the high-pollution industry, net birth rate model. This indicates the possibility that the random effects are correlated with the explanatory variables. However, the similarity of the LCVOTE coefficients between the two models suggests that the random effects are primarily correlated with the control variables.

Table 6

Alternative Estimation Methods

Dependent variable = Number of New Plants
(t-statistics in parentheses)

	All Industries			High-Pollution Industries		
	OLS	Poisson	Cond. Logit	OLS	Poisson	Cond. Logit
LCVOTE	-1.828	-0.770	-1.096	-1.796	-1.096	-1.221
	(-2.98)	(-5.80)	(-8.24)	(-2.04)	(-0.98)	(-1.10)
PASPEND	-0.018	-0.009	-0.013	-0.014	-0.012	-0.015
	(-2.03)	(-8.07)	(-10.94)	(-1.12)	(-1.18)	(-1.46)
ENVPOLICY	-0.024	0.539	0.111	-0.032	0.032	0.109
	(-0.71)	(8.37)	(18.85)	(-0.64)	(0.95)	(2.11)
R^2	0.984			0.965		
Log-likelihood		-5906	-7254606		-675	-60877

Regressions include all non-regulatory control variables from Table 2.

The OLS regressions used LOGOPEN as the dependent variable (to match the Poisson specification). LOGPLANT is also included as a control variable in the models (getting a coefficient of about 0.96, with a standard error of about 0.01).

Table 7

Time-Varying Regulatory Impacts
(t-statistics in parentheses)

	All Industries		High-Pollution Industries	
	Birth Rate	Net Birth Rate	Birth Rate	Net Birth Rate
LCVOTE	0.101	-1.005	-2.968	-3.795
	(0.06)	(-0.66)	(-1.54)	(-1.93)
63-67	-2.506	-1.408	1.918	2.826
	(-1.35)	(-0.78)	(0.84)	(1.21)
67-72	-1.027	-0.246	2.468	3.661
	(-0.55)	(-0.14)	(1.08)	(1.57)
72-77	-2.596	-0.567	1.523	2.705
	(-1.32)	(-0.30)	(0.63)	(1.10)
77-82	0.091	0.930	1.298	2.785
	(0.04)	(0.44)	(0.49)	(1.03)
PASPEND	-0.220	-0.136	-0.241	-0.118
	(-1.69)	(-1.08)	(-1.51)	(-0.73)
63-67	-0.061	-0.066	0.248	0.072
	(-0.19)	(-0.21)	(0.63)	(0.18)
67-72	0.207	0.363	0.248	0.150
	(0.64)	(1.16)	(0.63)	(0.37)
72-77	0.520	0.598	0.887	0.904
	(1.63)	(1.92)	(2.26)	(2.25)
77-82	0.072	0.110	0.099	0.048
	(0.37)	(0.58)	(0.41)	(0.19)
ENVPOLICY	-0.173	0.196	0.510	1.003
	(-0.37)	(0.43)	(0.88)	(1.70)
63-67	-0.378	-0.668	-0.649	-0.775
	(-0.64)	(-1.17)	(-0.90)	(-1.05)
67-72	-0.316	-0.543	-1.428	-1.886
	(-0.56)	(-0.98)	(-2.04)	(-2.64)
72-77	-1.318	-1.604	-2.317	-2.346
	(-2.20)	(-2.74)	(-3.14)	(-3.11)
77-82	-0.733	-0.511	-1.222	-1.202
	(-1.21)	(-0.87)	(-1.64)	(-1.58)
R-Square	0.666	0.588	0.546	0.329

Regressions include all non-regulatory control variables in Table 2.
The 'base group' for the interactions is the 1982-87 period.