Spatial Heterogeneity in Environmental Regulation Enforcement and the Firm Location Decision among U.S. Counties

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Abstract

We estimate a negative binomial model with fixed effects to examine the impact of spatial differences in environmental regulation on manufacturing capital flows. Using a newly available data set, we find that stricter air quality standards deter births of polluting plants, suggesting heterogeneity in regulatory standards may create a temporal browning process. We also find that spatial differences in environmental regulation do not play a role in the location decision of non-pollution intensive plants.

Introduction

Prior to the creation of the Environmental Protection Agency in 1968, environmental regulation control was in the hands of state and local authorities. Opponents of local control over environmental regulation contested that this created a "race to the bottom" phenomenon where local legislators had incentives to set sub-optimum environmental regulatory standards in an attempt to attract polluting industries to the area. The decentralized status of air quality regulation and rising ambient concentration levels led to Congress creating administrative bodies such as the Environmental Protection Agency (EPA) and the Council on Environmental Quality to enforce new regulatory statutes. The EPA created national ambient air quality standards (NAAQS) under the newly formed National Environmental Policy Act and amendments to the Clean Air Act, designed to clean up source emissions for air pollution in the United States.

Since this time, a healthy policy debate has ensued regarding whether a relationship exists between federal air quality regulations and the capital flows of pollution-intensive manufacturing plants. The intuition behind the debate is that if spatial heterogeneity in environmental regulatory standards creates significant differences in private compliance costs, then these costs should be factored into a firm's location decision. As such, pollution-intensive manufacturers may be deterred from opening a new plant in areas with stricter regulations. Much of the earlier research

suggests that, at most, any relationship between environmental regulation stringency and the location decision of pollution-intensive births is negligible (see Bartik 1988; McConnel and Schwab 1990; Duffy-Deno 1992; Jaffe et al. 1995; and Levinson 1996). However, more recent work provides strong evidence that heterogeneous air quality regulation does impact capital flows for pollution-intensive manufacturers (see List et al. 1999; Becker and Henderson 2000; List 2001; and List et al. 2004a).

The results from recent empirical research has important policy implications as it suggests that federal air quality regulations essentially violate the overall purpose of the Clean Air Act by altering regional capital formation. If environmental regulations are an important consideration in pollution-intensive manufacturers' site location decisions, this may create a temporal browning process as polluting manufacturers are less likely to site new plants in areas with increased start-up costs.

The purpose of this research is to use a newly available county-specific data set on establishment births to examine the impact of air quality regulation on the location decisions of pollution-intensive manufacturing plants across the U.S. Following research by Becker and Henderson (2000) and List et al. (2003), we focus on pollution-intensive industries likely to be impacted by county-level air quality status under the Clean Air Act. Also, in a departure from most of the existing literature, we hypothesize that, as significant private compliance costs are imposed on pollution-intensive plants, "clean," non pollution-intensive plants should not be impacted by regulatory differences. We test for this by proving a second model to examine the relationship between county-level air quality status and clean plant births.

We follow other research (Henderson 1996; Becker and Henderson 2000; List and McHone 2000; List et al. 2004a) and use county-level annual ozone attainment status (under the 1977 Clean Air

Amendments Act (CAAA)) as our measure of air quality regulation. Ozone was chosen as, due to the relative lack of progress in reducing its concentration levels, it has received the most attention from regulators, and it is the only county-specific environmental regulatory measure available as a time series. Under the 1977 CAAA, each year, every county in the U.S. is designated as being either in-attainment or out-of-attainment with regard to federal air quality standards for each of five criteria pollutants.[1] Under the 1977 CAAA, new plants are subject to significantly different start-up costs dependent on the attainment status of the county. Firms locating new plants in a county designated as being out-of-attainment are subject to the Lowest Achievable Emission Rate (LAER) on equipment. This level of regulation is enforced without any cost consideration to the firm and can entail significant start-up costs relative to firms locating new plants within in-attainment counties that are subject to a less restrictive regulatory standard known as Prevention of Significant Deterioration (PSD). In this case, only firms that have the potential to emit more than 100 tons of a criteria pollutant (Class A polluters) in a year must install the Best Available Control Technology (BACT), where the cost burden on the firm is taken into account in the decision making process. Finally, low-polluting firms are not subject to regulatory standards in areas designated as in-attainment.

Estimates from a fixed effects negative binomial model indicate that the expected number of pollution-intensive plant openings decreases by approximately 9 percent each year that a county is out-of-attainment. Further, as our results indicate that the set-up costs imposed by the LAER standards significantly detract births of polluting manufacturers away from non-attainment counties, we hypothesize that clean births will not be impacted by spatial differences in regulation. Results from a non pollution-intensive model support this hypothesis.

[1] The five pollutants are carbon monoxide (CO), sulfur dioxide (SO_x), total suspended particulates (TSP), nitrogen oxide (NO_x), and ozone (O_3).

Data

We develop a county-level panel data set on establishment births and deaths from 1996 to 2000, across all counties in the contiguous United States. The data are collect under the Statistics of U.S. Businesses program at the U.S. Census Bureau. Establishment data are compared against the prior year to discern whether the business is new, i.e. a birth, or continuing. The data are verified to ensure that businesses that are merely renamed are not counted as new. The births data are arranged as inter-year flows, e.g. establishment births between 1996 and 1997. Each establishment is coded by geography and industry (Standard Industrial Classification (SIC) for the years covered in this research). While this provides a level of detail beyond most comparable studies, the micro level panel data set also avoids many of the data constraints and estimation biases apparent in previous studies. For example, the panel nature of our data set avoids the limitations and biases that are inherent in previous cross-sectional studies. Recall, these studies typically found an insignificant, or at best, a marginal relationship between environmental regulation stringency and firm location decisions. However, more recent studies have highlighted the failure of cross-sectional models to properly control for the simultaneous nature of firm location and pollution problems (for example, see List and McHone 2000; and Brunnermeier and Levinson, 2004). Essentially, cross-sectional studies consider differences in environmental regulations across counties at one point in time. As such, cross-sectional models do not fully disentangle the positive correlation between environmental regulation, higher pollution levels, and more stringent regulation. As a result, coefficient estimates are likely biased. In contrast, use of panel data allows the analysis to consider differences in new firm births in a county over time as a function of variation in the county's environmental regulation over the same period. As panel models can also control for county-specific fixed effects, they are able to overcome the limitations of previous cross-sectional studies.

Other advantages of this data set over earlier studies accrue from the micro level data on establishment births. For example, due to data limitations, some earlier studies used aggregate measures of establishment data and changes in the stock of plants as the dependent variable. As environmental regulatory measures based on attainment status are more stringent toward new plants locating in the area, use of aggregate plant stock data may miss the regulatory effects on the flow of plant births. Our data set uses plant births as the measure on changes in manufacturing establishments, which will be more sensitive to changes in environmental regulation at the county level. Also, many previous studies generate data from the Census of Manufacturing database that is only available every five years (Levinson 1996; Becker and Henderson 2000; and List 2001). As such, to generate the independent variable, plant births are aggregated across five-year intervals. However, as plants can open and close within the five-year time period, the temporal aggregation of births has potential problems in missing new plants that open and shut down within the five-year window.

Finally, we can also analyze the relationship between environmental regulation stringency and firm location, by pollution-intensity of manufacturing sectors. As the county-level attainment status is determined by air quality measures, we follow previous research by Greenstone (2002) and List (2004a) by focusing on a set of pollution-intensive industrial sectors based on their emission levels. Greenstone (2002) classifies sectors as ozone pollution intensive if they emit at least 6% of the total sector's emissions of the primary chemical precursors to ozone.[2] As establishment data are disaggregated by SIC code, we consider plants as being pollution-intensive if they are in the following SIC codes: 2611-31 (Pulp and Paper Mills), 2711-89 (Printing and Binding), 2812-19 (Industrial Inorganic Chemicals), 2911 (Petroleum Refining), 30 (Rubber and Misc. Plastics), 32 (Stone, Clay, and Glass), 3312-13 (Steel and Electrometallurgical Products),

[2] Namely, volatile organic compounds and nitrogen oxide.

3321-25 (Iron and Steel Foundries), 34 (Fabricated Metal Products), and 371 (Motor Vehicles and Equipment). All other industries are coded as non pollution-intensive.

The Model

We follow List and McHone (2000) in deriving the reduced-form model, using a flow concept of new births as the dependent variable, allowing the effects of increased stringency in environmental regulation to be captured in a partial equilibrium framework.

The supply of entrepreneurs in any given time period is given by

(1) $$Y_{it}(\prod(X_{it}, e_{it}))$$

where Y_{it} is the flow of new plants (gross births), X_{it} are spatial attributes that affect the local profit function, $\prod$, and e_{it} is a random error component. The supply curve is upward sloping as an increase in per plant profit induces new births. A demand curve represents the change in plant profits due to an increase in births. We have

(2) $$\Pi^{d}(Y_{it})$$

The demand curve can be positively or negatively sloped as profit can be positively affected by births through localization or urbanization economies, or negatively affected by births as new plants may have a negative impact on local output price. Intersection of the demand and supply functions gives a reduced-form equation

(3) $$Y_{it} = f(X_{it}) + e_{it}$$

where Y_{it} is births in county i in time t; X_{it} is a vector of county attributes, including attainment status and time dummies, presumed to influence the spatial location function; and e_{it} is a contemporaneous independently and identically distributed error term.

As the dependent variable, new plant births, is a nonnegative integer with a high frequency of small numbers, Y_{it} is modeled as a Poisson distributed random variable. The probability that a plant will open in county i in time t is given by the basic Poisson probability function

$$(4) \qquad prob(Y_{it}) = \frac{e^{-\lambda_{it}} \lambda_{it}^{y_{it}}}{Y_{it}!}, \qquad y = 0,1,2,....$$

where λ_{it} is the expected value of new plant births and is assumed to be a function of the variables specified in the model. Usually, λ_{it} takes a log-linear form to ensure nonnegative birth counts and may be written as

$$(5) \qquad \lambda_{it} = e^{x_{it}\beta + \alpha_i} \quad ,$$

Where β is a vector of unknown coefficients to be estimated and α_i are unobservable county-specific factors that may affect the location decision. As α_i are important, we account for the county-specific unobservables by estimating a fixed effects panel data model. In estimation, county-specific unobservables that do not vary over time are accounted for in the model as each unit of observation is conditioned on total births for that county over the sampling period. As such, the likelihood function becomes

$$(6) \qquad prob\left(Y_{i1}, Y_{i2}, ...Y_{iT} \middle| \sum_t Y_{it}\right) = \frac{\left(\sum_t Y_{it}\right)!}{\prod_t \left(Y_{it}!\right)} \prod_t \left[\frac{e^{x_{it}\beta}}{\sum_t e^{x_{it}\beta}}\right]^{Y_{it}}$$

The fixed effects, α_i, are therefore conditioned out of the likelihood function and are unrecoverable. One potentially undesirable characteristic of the Poisson model is the restriction that the conditional mean and variance of the dependent variable, λ_{it}, are equal. This can be a limiting assumption as standard errors from a Poisson model are sensitive to under- or over-dispersion in the data. As such, the negative binomial model is a less restrictive, natural alternative to the Poisson model since it allows for differences in the mean and variance.

In estimation, we consider new plant births in 3,042 counties over a four-year time period from 1996 to 2000. Our explanatory variables follow the received literature and include attainment status under the federal standard for ozone, county-level population, manufacturing employment, property tax, highway expenditures, and time dummy variables. Descriptive statistics, definitions, and sources are shown in Table 1. As property tax and highway expenditures are not reported by all counties in all states, the missing observations reduce the total sample size for estimation.

Results

Table 2 presents results from the fixed effects negative binomial models. Our first model (pollution-intensive model) examines the impact of county attainment status for ozone levels under the 1977 CAAA and other location-specific regressors on births of polluting manufacturers. The second model considers all other (non-polluting or clean) manufacturers. Before discussing the results, some preliminary observations are required. First, in estimation, we assume our attainment status variable to be strictly exogenous. We recognize the potential for endogeneity of our attainment status variable. That is, new pollution-intensive firm births in year t in county i can push the county into out-of-attainment with respect to air quality levels in year $t + 1$. We follow List and McHone (2000) and empirically check for endogeneity by comparing the model results with those using lagged attainment status values. The coefficients don't change significantly, indicating that endogeneity isn't a serious issue with our data. Second, for both models we present the Hausman test statistic to support use of a fixed effects model. The null hypothesis is that random effects would be consistent and efficient. For both models, we reject the null, indicating that a fixed effects model is appropriate.

Examination of the results shed some interesting insight into the impact of air quality regulation on firm location behavior. For pollution-intensive manufacturers, the results provide evidence that births are deterred by increased regulatory costs. Recall, plants locating within counties that are designated as being out-of-attainment with regard to the federal standards for ozone are subject to the Lowest Achievable Emission Rate (LAER) on equipment, and this is enforced without consideration of cost to the firm. This is in contrast to new plants locating within in-attainment counties that are subject to less restrictive start-up costs. The coefficient on the attainment status variable is negative and significant at the 10 percent confidence level. This point estimate suggests that the expected number of pollution-intensive plant openings decreases by approximately 9 percent each year that a county is designated as out-of-attainment. These effects are in line with Henderson's (1996) findings in which a county's out-of-attainment status deters expected births of new plastic manufacturing plants by between 11 to 12 percent. Although smaller in magnitude, our results also support recent work by List and McHone (2000) and List et al. (2004a). However, the larger coefficients in their research are somewhat expected as these studies consider a smaller geographic area (New York State), which can have less variation in site location factors, so the estimates are likely to be inflated relative to our larger, national sample. Based on our results, as each county receives, on average, 2.2 new pollution-intensive plant births each year, this represents a decrease of 0.21 expected births per year for counties designated as out-of-attainment. The policy implication of this finding is that, as an unintended consequence of the CAAA 1977, spatial differences in the federal standards for ozone may cause a temporal browning process as more stringent air quality regulations affect capital flows of pollution-intensive plants.

All of the location-specific variables are insignificant in the pollution-intensive model. On the demand side, an area's population and level of manufacturing employment have no influence on capital flows of polluting plants. While this is somewhat unexpected, perhaps the fixed effects are

accounting for the demand side factors. We also find that property taxes do not affect the pollution-intensive plant location decision. Results examining the impact of property taxes on firm behavior are ambiguous. As such, our results support the findings of Bartik (1995) and List and McHone (2000), but are contrary to those of Carlton (1983), and List et al. (2004a). Finally, we also included highway expenditures as an explanatory variable in an attempt to measure infrastructure impacts. These impacts have been extensively studied in the transportation literature with research typically finding that better accessibility to transportation infrastructure has a positive impact on the location decision of firms (Smith and Florida 1994; Coughlin and Segev 2000; List 2001). However, our results do support findings by List et al. (2004b) that highway expenditures have no effect on pollution-intensive births.

Another important component of the analysis is that we also examine the relationship between environmental regulatory stringency and capital flows of non-polluting, or clean manufacturers. We hypothesize that while the LAER on equipment imposes significant private compliance costs on dirty plants, environmental stringency should not influence the location decision of clean plants. To test this, we run a second model on non pollution-intensive (clean) births. In Table 2, attainment status is insignificant, suggesting that, in contrast to polluting plants, a county's attainment status has no impact on the location decision of clean plants. This implies that the regulatory costs imposed on new plants locating in out-of-attainment counties are not a significant component of the location decision for clean plants.

Also, for non-polluting plants, other county-specific factors form an important component of the location decision. Results indicate that more populated areas attract clean plants, as do areas with greater concentrations of manufacturing employment. Combined, these findings suggest that plants take advantage of labor-market economies and agglomeration factors by locating in more populated areas and by sharing a common labor pool. We also find evidence that higher property

taxes deter clean births, although, as with dirty plants, we do not find statistical evidence that highway expenditures influence clean births.

Conclusion

We investigate whether federal air quality standards impact capital flows. Under the 1977 CAAA, new plants locating in counties designated as out-of-attainment of the federal standards for ozone face stricter regulations. As the regulation is enforced without any cost consideration to the firm, this can impose significant start-up costs. As such, the intuition is that heterogeneous regulatory stringency could play a major role in a firm's location decision. While earlier research typically finds an insignificant or, at best, a marginal relationship between regulatory standards and capital flows, more recent research provides statistical support for this hypothesis. We use a newly available panel data set of county-level manufacturing plant births between 1996 and 2000, and find that more stringent air quality regulations deter births of pollution-intensive plants. This supports the idea that asymmetrical spatial environmental standards may create a temporal browning process.

Finally, if dirty plants are deterred from locating in out-of-attainment counties due to the high start-up costs imposed, spatial differences should not influence the capital flows of clean plants. Results from a second model on non pollution-intensive manufacturers support this hypothesis, finding that attainment status has no statistical effect on clean plant births.

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