

The Impact of Environmental Regulations on the Location of Firms in the Hazardous Waste Management Industry

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ABSTRACT. *This paper examines the relationship between environmental regulations and the location decisions of hazardous waste management firms. This industry provides a powerful test of the effect of state environmental regulations on location because environmental regulations significantly affect the cost of providing waste management. The results indicate that state spending on environmental programs can deter firms, as does potential public opposition. Spending affects the implementation and enforcement of regulations and thus is very important in firms' location choices. Hazardous waste management firms do not appear to be deterred by the stringency of regulations, but instead are attracted to more comprehensive policies. (JEL H73, R38, Q28)*

I. INTRODUCTION

There is a general feeling among many policymakers and legislators that strict environmental regulations are driving industries out of some states and into others. In California, for example, many people believe that the state's uniquely high environmental standards have driven a number of facilities to locate in neighboring Nevada.¹ Others have expressed concern that in a bid to attract waste-generating firms, states will adjust their own regulations downward in a "race to the bottom," the federally mandated minimum level of regulation.² However, to date there is no empirical evidence showing that environmental regulations have a significant impact on a firm's location decision. On the contrary, past studies of the location decisions of manufacturing firms have found that environmental regulations are relatively unimportant in a firm's location decision process.

One explanation for this result is that the cost differentials associated with differences

in state environmental regulations are small relative to the differentials associated with variations in the proximity to markets and input prices. A second explanation could be the difficulty in measuring the effect of environmental regulations for a sample of heterogeneous firms which are subject to different regulations depending on the nature of their manufacturing processes. The hazardous waste management industry should provide a powerful test of the effect of state environmental regulations on entry and location decisions because these two factors will be minimized. First, environmental regulations significantly affect the cost of providing hazardous waste management services. Second, although environmental regulations will affect hazardous waste management facilities differently depending on the types of waste managed and waste management systems, this industry is much more homogenous than the manufacturing sector. If environmental regulations do not affect the location decisions of firms in this industry, they are unlikely to affect the location decisions of firms in other industries.

This paper uses data from the U.S. Environmental Protection Agency on the location of hazardous waste management firms and fits a conditional logit model to identify the factors influencing the location decisions of

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¹ See, for example, the sentiments expressed in Farrah and Antonucci (1994).

² See Goetz and Rowland (1985).

commercial hazardous waste management facilities. I find that several different measures of environmental regulation can explain some of the differences in the state location choice of hazardous waste management facilities. Although some traditional factors such as the level of manufacturing activity and energy costs appear to be more important factors than environmental regulations in the location decision, environmental policy variables have a larger effect on location decisions than wages or taxes. In particular, state spending on the implementation and enforcement of environmental programs appears to be a relatively significant deterrent to firms, as is citizen participation in environmental organizations.

The remainder of the paper is organized as follows. Section 2 reviews the related literature and existing evidence on the effect of environmental regulations on location choice. Section 3 provides a brief background on hazardous waste regulations and the hazardous waste management industry. Section 4 describes the model of location decisions and Section 5 discusses the data used in the analysis. Section 6 presents the results of the analysis and Section 7 provides some conclusions.

II. RELATED LITERATURE AND EXISTING EVIDENCE

The literature on firm location choice analyzes the nature, magnitude, and direction of industry response to differential socioeconomic conditions across space. Studies in this area examine both the spatial determinants of industry location and the effect of public policy on the location decision. Much of the initial analysis of this problem used aggregate data on the levels of industrial activity such as employment growth or investment levels to examine the determinants of location decisions.³ However, studies using aggregated data are limited because they often cannot distinguish between changes caused by new firm openings, new plant openings, or firm expansions. Studies that look at individual establishment data can distinguish between these types of changes and

can examine more closely the determinants of these various occurrences.

Carlton (1979) conducted one of the first studies to use establishment level data to analyze location choice and established the conditional logit model as a standard method for analyzing location decisions.⁴ Since then a number of papers have looked at firm location decisions. Although the papers differ in terms of the industries analyzed, the locations examined (states, counties, etc.), and the independent variables used in the analysis, the consensus appears to be that if state and local policies such as taxes and expenditure levels have any effect on the location choice of firms, such effects are relatively small compared to other factors such as wages and the size of the market.

Only a few papers have analyzed the effect of environmental variables on location decisions.⁵ Bartik (1988) analyzes the effects of state environmental regulation on new manufacturing branch plants of Fortune 500 companies during 1972 to 1978. The author models environmental regulation using several alternative variables including two measures of water pollution regulations and four measures of air pollution regulations, but does not find any statistically significant relationship between environmental regulations and business locations. Levinson (1996) explores the relationship between environmental regulations and state location choice using data from the Census of Manufactures on establishments opened between 1982 and 1987. Levinson uses a variety of measures of environmental stringency, including qualitative indices of state environmental regulations, measures of state employees in environmen-

³ Wasylenko (1991) provides a survey of this literature.

⁴ Some papers use a multinomial logit model that is very similar to the conditional logit model. The conditional logit model only allows for differences in the characteristics of the locations being considered, while the multinomial logit allows for variation across both firms and locations.

⁵ A few papers (Friedman, Gerlowski, and Silberman 1992, for example) include environmental variables in their analysis of the location decisions of foreign direct investment in the United States. However, these papers do not focus on the effect of environmental regulations on the location decision.

tal agencies, and aggregate and industry-specific abatement costs.⁶ He finds that branch plants of large firms are deterred by more stringent environmental regulations, although the degree of aversion is relatively small. In general, the various environmental measures analyzed have the expected negative coefficients, although only one of the three qualitative indices and the industry abatement costs measure are statistically significant.⁷ Levinson does not find that the degree of aversion is correlated with the pollution-intensiveness of the industry.

McConnell and Schwab (1990) use Dun and Bradstreet data from 1973 through 1982 to look at the location decisions for new branch plants in the motor vehicle assembly industry. The authors look at a narrowly defined industry so that they can develop an accurate measure of the regional differences in the stringency of environmental standards. Because the key environmental issue for this industry is volatile organic compound (VOC) regulation, environmental stringency is measured by whether or not a county is in compliance with federal ambient ozone standards. The authors assume that out-of-compliance counties will enforce stricter standards in an effort to comply, and thus the costs of compliance will be greater in these counties. The analysis, which also includes state-wide measures of environmental regulations, provides mixed results as to the effects of environmental regulations on the location decision. In general, they find that environmental regulations do not matter, although they do find some evidence that firms may be marginally deterred from locating in areas with a particularly severe ozone problem. In contrast, Becker and Henderson (1997) examine plant births in 13 industries that emit significant levels of VOCs from 1963 to 1992 and find evidence that county non-compliance with ozone standards can reduce expected plant births by as much as 40%, depending on the industry.

The measures of environmental regulations used to study firm location choice vary considerably across studies, as does the ability of such measures to explain firm location choice. The measures that have had some ability to explain location choice include

qualitative measures of environmental stringency and quantitative measures of abatement cost. However, for the most part studies have found that environmental regulations do not affect the location decision of firms and, except for Becker and Henderson, those that have found a statistically significant relationship between environmental regulations and location choices have found that the effect is relatively small.

A possible explanation for these results may be endogeneity between environmental regulations and location decisions. One of the reasons for examining the effect of environmental regulations on location decisions is the fact that policy makers and regulators believe that environmental regulations do influence location decisions. If policy makers believe this influence exists, it is possible that some environmental regulations have been set either to encourage or discourage new facilities, and therefore it is possible that there is an endogeneity between business location and environmental regulations. Lester et al. (1983) analyze the determinants of environmental regulations in the states and find that the best predictors of state hazardous waste regulations are "technological pressures" (that is, the severity of pollution problems within a state), legislative professionalism, and the presence of a single agency to coordinate hazardous waste programs. Alternative explanations for state environmental policies include the wealth of the state, and political affiliation of the state's legislature (Lester 1994). However, no studies suggest that the presence of hazardous waste management firms influenced the promulgation

⁶ Levinson derives industry abatement costs using the Census of Manufactures and the Pollution Abatement Cost and Expenditures Survey. He estimates how much manufacturers in one state pay for pollution abatement relative to manufacturers in other states, controlling for the characteristics of the manufacturer including its industry. The aggregate abatement costs that he uses do not control for the composition of industry within a state, only the level of manufacturing in the state.

⁷ Levinson uses three indices, the Conservation Foundation's 1983 Index, the Fund for Renewable Energy and the Environment (FREE) 1987 Index, *The State of the States*, and the 1991-1992 *Green Index*. Only the FREE Index is significant.

of hazardous waste regulations or that regulations were passed to keep hazardous waste management firms from locating in a state.⁸ Given the literature on hazardous waste policy and regulation, it does not appear that states make environmental regulations to either encourage or discourage firms in the hazardous waste management industry and thus there should not be a significant endogeneity problem in this analysis.⁹

III. BACKGROUND ON THE HAZARDOUS WASTE MANAGEMENT INDUSTRY

A hazardous waste is any solid waste or combination of solid wastes which "because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."¹⁰ The first major law that specifically addressed the generation and management of hazardous waste was the Resource Conservation and Recovery Act (RCRA) passed in 1976. RCRA's Subtitle C delineated the basic structure of the hazardous waste regulations and instructed EPA to establish criteria for identifying and listing hazardous waste, develop standards applicable to generators, transporters, and managers of hazardous waste, and promulgate guidelines to assist states in developing their own hazardous waste programs. RCRA also provided EPA with the ability to enforce the act by allowing it to assess civil penalties upon firms that violate RCRA requirements.

Because of increased knowledge about health and environmental impacts from waste disposal, Congress amended RCRA in 1984 with the Hazardous and Solid Waste Amendments (HSWA). HSWA expanded the scope of RCRA by requiring EPA to develop treatment standards for hazardous waste, develop minimum technological requirements for hazardous waste management units, and develop standards requiring corrective ac-

tion to remediate contamination at permitted waste management facilities. Together RCRA and HSWA provided the mandate for EPA's hazardous waste program as it is codified in Title 40, Parts 260 through 270 of the Code of Federal Regulations (CFR).

RCRA is just one piece of federal environmental regulations. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, commonly referred to as Superfund, is the closest environmental statute to RCRA as both address hazardous waste. CERCLA is response-oriented and covers environmental damages from hazardous wastes at inactive or abandoned sites and hazardous waste resulting from spills that require an emergency response. RCRA, on the other hand, is focused on the control of hazardous waste generated by ongoing operations so that environmental damage does not occur. Other statutes such as the Clean Air Act, the Clean Water Act, and the Safe Drinking Water Act complement RCRA by focusing on specific media. Facilities are often regulated under both RCRA and these media-specific statutes.

Although the federal government has established a minimum level of hazardous waste regulation, states can and do make additional regulations concerning hazardous waste management that are more stringent than the federal regulations.¹¹ Moreover, the intent of RCRA is for states to assume primary responsibility for implementing hazardous waste regulations (U.S. EPA 1998). EPA will authorize a state to run its own hazardous waste program only if the state's pro-

⁸ Other studies examining the development of state hazardous waste policy include Alberini and Austin (1999) and Ringquist (1993).

⁹ Although some states have passed legislation to discourage imports of hazardous waste (by imposing taxes on hazardous waste imports), such legislation represents a very small part of environmental regulations. The majority of environmental regulations are not designed to affect the location of hazardous waste management facilities.

¹⁰ 42 U.S.C. 6901. (P.L. 94-580, 90 Stat. 2799.) EPA codified the definition of hazardous waste in 40 CFR Part 261.

¹¹ For example, several states such as California and Massachusetts have additional regulations on the recycling of hazardous waste beyond the federal requirements.

gram is at least as stringent as the federal program and the state has demonstrated how it will enforce the program, disseminate information to the public, and fund the program's operation.

Once hazardous waste is generated it must be managed in accordance with RCRA regulations. The term "hazardous waste management" includes collection, source separation, storage, transportation, processing, treatment, recovery, and disposal of hazardous wastes.¹² RCRA does not allow hazardous waste to be stored indefinitely and ultimately requires that the waste be treated either to remove the constituents that render it hazardous or to immobilize the hazardous constituents so that they will not be released to the environment. There are many different hazardous waste treatment methods such as combustion, biological treatment, chemical precipitation, or metals recovery, and the type of treatment required depends on the characteristics of the waste.¹³ After treatment, the hazardous waste either must be disposed in approved units such as landfills or injection wells or it may no longer be subject to regulation, depending on the type of waste and the levels of hazardous constituents remaining in the waste. Generators can choose to treat and/or dispose their waste themselves or they can send their waste off site for treatment or disposal. Currently, the majority (over 90%) of hazardous waste generated is managed on site, although the majority of hazardous waste generators send waste off site to commercial hazardous waste management facilities for treatment (Stafford 1998).¹⁴

The evolution of the hazardous waste management industry is difficult to trace because prior to the 1980s there was no accurate estimate of the hazardous waste generation and management, as there was no common understanding of what constituted a hazardous waste.¹⁵ In 1985, EPA began conducting a biennial survey of hazardous waste generation and management, the Biennial Reporting System (BRS) and estimated generation to be around 250 million tons per year.¹⁶ From 1985 to 1989, generation decreased by about 50 million tons to 200 million tons. Then, in 1990, EPA expanded

the definition of hazardous waste to include additional wastes, increasing generation in 1991 to close to 300 million tons per year. From 1991, generation again began to decline to around 220 million in 1995. The decline during these two periods can be explained, at least partially, by increased industry efforts to minimize waste generation due to the cost of managing hazardous waste. The economic recession of the early 1990s is also responsible for some decreases in waste generation.

The supply of hazardous waste management services depends primarily on the demand for such services and the cost of providing the services. Prior to the passage of RCRA, there was little incentive for generators to manage their hazardous waste differently from their non-hazardous industrial waste.¹⁷ EPA's first survey of hazardous waste management facilities was conducted in 1981 and counted around 2,000 hazard-

¹² 42 U.S.C. 6901. (P.L. 94-580, 90 Stat. 2799).

¹³ Most waste must be treated so that each hazardous constituent in the waste is below a specified concentration level. However, for some wastes EPA has prescribed specific treatment methods that must be used. The treatment requirements for hazardous waste are collectively referred to as the Land Disposal Restrictions (LDRs) because waste must meet the LDR standards prior to being placed in or on the land (40 CFR Part 268).

¹⁴ Over 90% of hazardous waste (measured by weight) is generated by 50 generators who all manage their waste on site. Of the waste sent off site, a very small percentage of waste is sent off site to "captive" as opposed to commercial facilities. Captive facilities are facilities that treat waste generated at other sites, but generated by the same firm that owns the management facility.

¹⁵ A more detailed description of the history of this industry is provided in Stafford 1998.

¹⁶ EPA's BRS estimates suffer from coverage bias in that they do not include RCRA-regulated hazardous waste that is managed in units exempt from permitting requirements.

¹⁷ Although contaminated site liability was an issue, most generators did not realize that improperly disposed waste would require an expensive future clean up. It was not until the passage of CERCLA (also known as Superfund) in 1980 and HSWA in 1984 that parties responsible for environmentally unsound waste disposal could be required to clean up releases if the waste had not been disposed illegally. For the most part, generators only took special care in disposing wastes that could cause immediate damage such as ignitable or explosive wastes.

ous waste facilities.¹⁸ Beginning in 1985, the BRS also began tracking hazardous waste facilities, although these estimates of the number of hazardous waste management facilities only includes RCRA-permitted facilities.¹⁹ According to the BRS, the number of permitted hazardous waste management facilities hovered around 2,000 from 1981 to 1985, and after that there was a steady decrease in facilities as the MTRs and other design and operating standards became effective. For the most part, this decline in the number of facilities appears to be primarily the closure of on-site facilities, as the number of permitted off-site facilities appears to be relatively constant at around 500.

For the commercial off-site hazardous waste management industry, the period from 1980 to 1990 when RCRA was being phased in was marked by significant growth in industry revenues, much of this due to EPA-mandated changes in waste management technology. During this period, the largest firms started to consolidate market share within the industry by buying competitors or building new facilities. When growth rates started to flatten in the early 1990s, firms continued to consolidate and diversify through acquisition in the hopes of sustaining market share. Today in most sectors, a handful of large firms dominate, although smaller privately owned facilities also remain viable.²⁰ Despite the fact that some sectors are underutilized, there has not been not significant closures of facilities, in part because exit barriers such as cleanup liabilities made exit more expensive than remaining in the industry.

IV. A CONDITIONAL LOGIT MODEL OF INDUSTRY LOCATION DECISIONS

A commercial hazardous waste management firm is a firm that is paid to manage hazardous waste generated by other firms. This purpose of this study is to examine how a commercial hazardous waste management firm's decision to locate a facility in a state is influenced by the characteristics of that

state, including the stringency of state environmental standards. States can vary in the stringency and coverage of environmental regulations, as well as in the amount of resources devoted to implementation and enforcement of environmental regulation. State environmental standards and policies will affect the relative costs of hazardous waste management across locations and thus both the supply and demand for management services in a given location. Policies that make waste management relatively more expensive may result in shifting waste management out of a state and policies that make waste management relatively less expensive may result in increased imports of waste to the state. There is some evidence that state environmental regulations do affect the location of hazardous waste management. Deyle and Bretschneider (1995) find that New York's environmental policy initiatives in the 1980s resulted in a decrease in hazardous waste imports into the state and an increase in hazardous waste exports from the state. Given this evidence, one would assume that differences in environmental standards also would affect the location decisions of firms in the industry.

For this analysis, I assume that a firm first decides whether or not to enter the hazardous waste management industry (or whether to add an additional facility, if the firm has more than one facility) and then, if it decides to enter, selects a location based on the characteristics of that location. The analysis therefore focuses on the firm's location decision, and does not analyze the firm's decision

¹⁸ Westat (1984).

¹⁹ Not all hazardous waste management facilities require a RCRA permit. On-site facilities that treat waste in tanks and containers within 90 days of the waste's generation do not need to obtain a RCRA permit, although they are subject to hazardous waste management regulations. Also facilities that recycle hazardous waste and do not first store the waste are not required to obtain permits. In 1993, EPA estimated that there could have been as many as 1,200 non-permitted recycling facilities, and there is no estimate of the number of other non-permitted facilities.

²⁰ For example, Alberini and Bartholomew (1999) find that privately held firms play an important role in the management of solvent wastes in California.

to enter the market.²¹ Firms are assumed to be profit maximizers and thus select the location that provides the firm with the highest level of profit.

In equilibrium, the annual profit of a hazardous waste management facility is a function of the quantity of waste managed, the price the firm receives for waste management, the cost of inputs to the management process, and the annualized portion of initial capital costs for the facility. However, one cannot definitively say much about how these factors affect equilibrium quantity and price in the market for hazardous waste management services because of several key features of the market. First, the market is spatially differentiated. Therefore a facility's demand depends on its location as well as the location of competitors. This also means that the effect of competition depends on the location of competitors. Second, demand is not uniform. Third, the capacity of facilities is endogenous and fixed, that is, each facility decides how much capacity to build based on demand but once built capacity cannot easily be changed. For these reasons, this industry is extremely difficult to model and to date no one has developed a structural equation for profit in this industry. Therefore, for this analysis I assume a reduced form profit function that is linear in the characteristics of the location the facility selects. More specifically, I assume that profits are a function of the characteristics of the site as well as a random component and that the profits of facility i at location k can be represented by $\pi_{ik} = \beta'X_{ik} + e_{ik}$ where e_{ik} is a random disturbance term.²²

Obviously, the level of demand is a major determinant of profit in any market. Although the market for hazardous waste management is a national market, there is also a strong regional or local component to demand because transportation costs can be significant. Although hazardous waste is sometimes shipped across the country for management, over 80% of all shipments are within 500 miles. Therefore, one would expect regional demand, as well as national demand, to be an important determinant of profits.

There are several types of fixed costs associated with providing a hazardous waste management service. The key components are the cost of the land on which facility is located, the costs of building the system in accordance with environmental regulations, and the costs of permitting the system and obtaining the necessary insurance for the system.²³ Land costs are a function of the size of the facility as well as the local price of land. Building costs will depend on local construction costs, the size of the system, and the level of environmental regulations.²⁴ Finally, permitting and insurance costs will depend on the level of environmental regulations.²⁵

The profit for each facility also depends on the nature of the production function and the cost of inputs required to provide the hazardous waste management services. In the hazardous waste management industry, the

²¹ A number of studies have considered the entry decision of firms, including Carlton (1979), but none has focused on the role of environmental regulations in the entry decision. To analyze a firm's decision to enter the market, one must also look at potential entrants that did not enter the market. The data sets used in this study do not contain information on firms that considered the market but chose not to enter.

²² In making this final assumption, I am following the approach used for the majority of empirical studies of firm location decisions.

²³ Hamilton (1993) finds evidence that firms take the potential for local collective action into account when determining whether to expand an existing facility as collective action can increase the cost of permitting and decrease the probability of getting a permit. Hamilton measures the potential for local collective action using voting participation. In choosing between states, the potential for collective action on environmental problems should be reflected in the state's environmental regulations.

²⁴ RCRA lays out specifications for the various types of waste management units. For example, landfills, waste piles, and surface impoundments must have double liners, a leachate collection and removal system, and a leak detection system. Combustion units must be able to destroy and remove 99.99 percent of the principal organic hazardous constituents in the waste and emit less than 180 milligrams of particulate matter per day (U.S. EPA 1998).

²⁵ A facility must provide financial assurance that it has the resources to pay for bodily injury or property damage that might result from waste management. Financial assurance may be demonstrated through a trust fund, surety bond, letter of credit, insurance, financial test, or corporate guarantee.

key inputs are energy and labor. Environmental regulations can also serve as a restraint on the level of output. In particular, air and water pollution control devices can make a system less efficient, because they can require more energy or labor. Finally, the level of taxes at a given location will affect the net level of profit of the facility.

If the error terms on the profit function are identically and independently distributed according to a Weibull distribution, then the probability of locating facility i at location k is given by $P(ik) = e^{B^k X_i} / \sum_j e^{B^j X_i}$. This probability can then be estimated by maximum likelihood.

The assumption of independent error terms is necessary in this model (the conditional logit model developed by McFadden 1974) and leads to the "independence of irrelevant alternatives" restriction of the model. This assumption implies that if a given facility has higher profits in location j than in location k that are not explained by the independent variables in the model, there is no implication that the facility is more likely to have higher profits in location l than in location k . Therefore, if there are unmeasured or unobserved attributes that affect location decisions that are correlated across choices, this assumption will be violated. To mitigate the effects of the assumption of the independence of irrelevant alternatives (i.i.a.) I also include a set of regional dummies in the model.²⁶

V. THE DATA

The 1,548 facilities included in this study are those facilities in the continental United States that managed hazardous waste that was generated by another firm according to EPA's 1993 Biennial Reporting System (BRS).²⁷ Prior to 1976 and the passage of the Resource Conservation and Recovery Act, there were no federal requirements for hazardous waste management and therefore very few hazardous waste management facilities.²⁸ Therefore, this set of facilities is roughly the same as the set of facilities born during the period 1976 to 1993.²⁹ Each of the 48 continental states has at least one of the 1,548 facilities.³⁰ Wyoming and South Dakota are

the two states with only one facility, and California tops the list with 179 facilities. This group of facilities includes both RCRA-permitted and non-permitted facilities: there are 586 permitted facilities and 962 non-permitted facilities.³¹ On average, each facility offers six different treatment options, although almost 40% of the universe only offer one type of treatment. The single-treatment facilities are not particular to a specific treatment system and single-treatment facilities can be found for almost all of the various types of treatment. Of the facilities, 304 have a land disposal unit (either a landfill or a land treatment area), 685 have a combustion unit (an incinerator or industrial furnace), and 864 are engaged in some type of material recovery (solvent recovery, metals recovery, or organics recovery).

In 1993, these facilities managed anywhere from one ton of hazardous waste to over one million tons, with the average being approxi-

²⁶ If error terms are correlated only within regions, including region dummies will ensure that the i.i.a. restriction holds. I tested the i.i.a. restriction using a Hausman test and could not reject the hypothesis that i.i.a. holds.

²⁷ Facilities that only store or transfer hazardous waste but do not treat, recycle, or dispose hazardous waste are not included in the analysis. Also, facilities that recycle hazardous material in such a way that the material is excluded from EPA's definition of hazardous waste are not included.

²⁸ According to a study conducted for EPA in 1976, in 1975 there were only about 100 hazardous waste management facilities (Dawson and Mercer 1986).

²⁹ Although this period is slightly longer than the period used in most of the location studies, based on conversations with EPA regional staff, the data in earlier BRS Surveys are of significantly lower quality than the data available in the 1993 BRS. Therefore, I chose to extend the period of analysis rather than use the noisier data set. Also, the data set does not include firms that both entered and exited the industry during this period.

³⁰ There are seven facilities in Alaska and Hawaii. However, because of the significant distance between these two states and the continental states, I did not include these states in the analysis.

³¹ RCRA operating permits are required for all hazardous waste treatment, storage, and disposal facilities. Facilities which recycle hazardous waste without first storing the material are exempt from RCRA permitting requirements. Additionally, facilities in existence when RCRA permitting requirements were established were granted interim status which allows a facility to operate without a permit as long as it complies with RCRA standards.

mately 12,000 tons. There are only three facilities in the database that manage more than one million tons, while there are over 600 facilities that manage under 50 tons.³² The facilities handle a wide range of waste types and forms and, other than large liquid waste streams that are usually managed on site, are generally representative of the hazardous waste generated in the United States.

Data on state characteristics is drawn from a wide variety of sources. For these independent variables, I obtained data as close to the "middle" of the 1976 to 1993 period as possible. However, much of the data used in the analysis is collected during the decennial census, so some of the variables are evaluated towards the end of the period rather than at the middle. Table 1 lists the definitions and sources of all the variables. Following Bartik (1988) and Levinson (1996), I use the logarithmic form for all of the variables that represent factors of production.³³ The dependent variable, Location, is equal to one if facility i located in state k and is equal to 0 if it did not. Since there are 48 states in the analysis and 1,548 facilities, there are 74,304 observations in the data set.

The first explanatory variable, Demand, measures the level of demand for hazardous waste management in each state and is the total quantity of hazardous waste generated in the state in 1993.³⁴ This includes both waste managed on site at the generator and waste that is sent off site for management. Although waste generation may have changed over the period of analysis, I assume that the relative demand between states has not changed and thus waste generation serves as a proxy for the relative state demand. Neighboring Demand measures the level of demand for hazardous waste management in all of the neighboring states, that is all states that share a common border. In general, higher demand, *ceteris paribus*, implies higher profits and thus would make a location more attractive. However, I assume that the market is in equilibrium and thus a higher demand also would imply a larger number of firms in the market. More firms in the market would imply more competition and possibly lower prices. Therefore, it is not apparent what the sign on the coefficients of the two demand variables should be.³⁵

The Tax variable represents the mean corporate income tax rate in 1990.³⁶ Because the variable is already in percentage terms, I did not take the logarithm of this variable. I expect the coefficient on this variable to be negative, as a higher level of taxes implies lower after-tax profits. The Wage variable represents the average annual wage of all workers in the state in 1990. I expect the coefficient on this variable to be negative.

The Mfg variable represents the number of production hours worked in a state during 1990. Mfg can be interpreted in one of two ways. It may be proxying for location or agglomeration economies that have been shown to be present in concentrations of industry or it may capture some of the otherwise unobserved characteristics of states that make them more or less attractive to industry, such as a state's infrastructure. The Energy variable represents the weighted average price per BTU for energy in a state in

³² In general, liquid waste streams are much larger than solid waste streams although they are not necessarily more expensive to treat. Thus facilities which manage liquid waste generally take in much more waste than facilities that manage solid waste, which can account for the difference in facility sizes.

³³ Except taxes, which are expressed in percentage terms. Most papers assume a log-linear profit function, although there are a few, such as McConnell and Schwab (1990), that assume a linear profit function. The motivation for using a log-linear profit function is that if the production function is Cobb-Douglas, then under certain conditions the profit function will be log-linear. The basic estimation equation excluding environmental policy variables has higher explanatory power when the variables are logarithmic than when they are not.

³⁴ Given the data quality of earlier surveys of hazardous waste generation, I use 1993 data to derive the Demand variable rather than use lower quality data from an earlier year.

³⁵ This model assumes that the probability that a firm chooses a location depends on the relative profit of that location compared to all other locations. If higher demand does not imply higher profits, then it should not imply a higher probability of locating in a state according to this model.

³⁶ Most studies of location have to use relatively crude measures of state (and/or local) taxes, generally some measure of the average tax rate. A completely accurate measure would have to reflect all provisions of the tax code, including all of the various types of taxes such as corporate income taxes, property tax, and unemployment payroll tax. Since taxes are not the focus of this analysis, I use the average corporate income tax as a proxy for the effective tax rate on firms.

TABLE 1
DESCRIPTION OF VARIABLES

Variable	Definition	Source	Mean
Location	Equal to 1 if facility <i>i</i> located in the state and 0 otherwise	1993 Biennial Reporting System	NA
Demand	Ln(Tons of hazardous waste generated in the state in 1993)	1993 Biennial Reporting System	16.08
Neighboring Demand	Ln(Tons of hazardous waste generated in the neighboring states in 1993)	1993 Biennial Reporting System	17.24
Tax	1990 mean corporate tax rate (percentage)	1990–1991 Book of the States	0.06
Wage	Ln(1990 average annual wage in dollars)	1992 Statistical Abstract of the U.S.	10.05
Mfg	Ln(1992 million production hours worked)	1992 Census of Manufactures	6.52
Energy	Ln(1989 average cost of energy in dollars/BTU)	1992 Statistical Abstract of the U.S.	1.69
Energy × Recovery	Equal to Ln(1989 average cost of energy in dollars/BTU) if facility has a recovery system else 0	1993 Biennial Reporting System, 1992 Statistical Abstract of the U.S.	0.96
Construction	Ln(1990 weighted average construction cost)	1990 R.S. Means Building Construction Cost Data	4.56
Area	Total area (100 million acres)	1980 Census of Population	0.05
Population	Total population (100 thousand people)	1990 Census of Population	0.01
Spending	Per capita spending in 1988 on all environmental programs	1991–1992 Green Index	29.10
Policy	Measure of the number and stringency of environmental policies passed in the state	1991–1992 Green Index	33.94
Neighboring Spending	Average per capita spending of neighboring states in 1988 on all environmental programs	1991–1992 Green Index	29.72
Neighboring Policy	Average Policy measure for neighboring states	1991–1992 Green Index	28.80
Progressive	Dummy variable for state environmental commitment	Lester (1994)	0.37
Struggler	Dummy variable for state environmental commitment	Lester (1994)	0.11
Delayer	Dummy variable for state environmental commitment	Lester (1994)	0.40
Regressive	Dummy variable for state environmental commitment	Lester (1994)	0.13
Disposal Tax	Tax rate per ton on hazardous waste disposal in 1987	Sigman (1996)	17.77
College	Percentage of persons 25 years and older that have completed college (1989)	1991 Statistical Abstract of the U.S.	20.74
EnvOrg	Membership in environmental organizations (per 1,000)	1991–1992 Green Index	8.47
Republican	Percent of state voting for the Republican party in the 1988 Presidential election	1989 Statistical Abstract of the U.S.	54.31

Note: There are also 10 regional dummy variables included in the model. The regional dummy variables coincide with the 10 EPA regions.

1989. This variable accounts for state differences in the energy sources used, and I expect it to have a negative coefficient. Because facilities will differ in energy requirements depending on the type of systems the facility has, I also included an interaction between energy costs and whether or not the facility has a recovery system.³⁷ Although recovery systems use more energy than some system types such as landfills, they are probably not as energy intensive as other systems such as incinerators, so it is not obvious whether the coefficient on this variable will be positive or negative.³⁸ The Construction variable represents the weighted average construction cost in a state in 1990. I also expect the coefficient on this variable to be negative.

The total land area of a state is also included in the model. Area can serve as a proxy for the number of sites in a state, and thus the coefficient on this variable is expected to be positive. The Population variable measures state population according to the 1990 census. This variable may capture some aspects of the labor market as well as population density, given that area is also included in the specification. However, the availability of labor and the density of population work in opposite directions, so it is not obvious whether the coefficient on this variable should be positive or negative.

The next set of variables measures various aspects of a state's environmental regulations. One major difficulty in conducting analyses of the effect of environmental regulations is correctly and adequately measuring regulatory stringency. Because there is no one obvious measure of regulatory stringency, most studies employ several different variables. As Levinson (1990) points out, there are three broad types of measures that can and have been used in past analyses: qualitative measures of state programs, quantitative measures of state programs, and measures of compliance costs incurred by regulated entities. This analysis employs both qualitative and quantitative measures of state programs, but does not use measures of compliance costs, since data on compliance costs are not available.³⁹

EPA regulates the management of hazardous waste under Subtitle C of the Resource

Conservation and Recovery Act (RCRA). Most states also have specific hazardous waste management programs. In addition, other types of environmental regulations such as air and water pollution standards affect how facilities manage hazardous waste and the cost of such management. For this analysis, I selected broad measures of environmental regulations that include all media.⁴⁰ The first four environmental variables are taken from *The 1991-1992 Green Index: A State-by-State Guide to the Nation's Environmental Health* (Hail and Kerr 1991), compiled by the Institute for Southern Studies.⁴¹ The Spending variable measures the per capita spending of the state in 1988 on all en-

³⁷ I also considered interactions between energy costs and dummies for land disposal systems and combustion systems. However, these two variables did not increase the explanatory power of the model, so they were not included in the final specifications.

³⁸ Recovery includes systems that recover solvents, other organics, and metals from hazardous waste. It does not include "energy recovery" systems, that is, systems that burn hazardous waste as fuel.

³⁹ Studies that use measures of compliance costs (Levinson (1996) and Friedman, Gerlowski, and Silberman (1992), for example) use the Pollution Abatement Costs and Expenditures (PACE) Survey. However, the PACE survey only collects data from manufacturing industries, and the majority of firms in the hazardous waste management industry are considered service firms, not manufacturing firms. In addition, compliance costs may contain a selection bias or be endogenous to the model.

⁴⁰ Because broad measures of environmental regulations are highly correlated with more specific measures for hazardous waste regulations alone, one cannot properly interpret the coefficients on the broadly defined variables if more narrowly defined variables are included in the same model. Therefore, I only use the more inclusive environmental measures in the models presented in this paper. I obtained qualitatively similar results, however, when I performed the same analysis with environmental measures more specific to hazardous waste.

⁴¹ The 1991-1992 *Green Index* provides a number of other measures of environmental indicators, including an overall "Green Index," a Hazardous and Solid Waste Index, and a Toxic Chemical Waste Index. These measures are not used in this analysis because they all contain, to some degree, measures of the level of pollution and environmental degradation in the state. Therefore, they do not solely measure a state's environmental standards or stringency, but instead measure to some extent the need for environmental regulations or the outcome of firm behavior given the level of environmental regulation.

vironmental programs, including air quality control, water resources and pollution, hazardous and solid waste, and fish, wildlife, and forestry.⁴² Wyoming spends the most per capita with approximately \$270, while Texas spends the least, under seven dollars per person. I expect the sign on this variable to be negative, as I assume that higher levels of spending per capita imply a higher level of implementation and enforcement of regulations.⁴³ The Policy variable is a measure of the number and stringency of environmental programs and regulation in the state.⁴⁴ Each state is evaluated with respect to its policies on air pollution, drinking water, surface water, land use, ground water control, and hazardous waste. New Jersey has the highest score (50 points out of a maximum of 50) and Arkansas has the lowest score (13 points). I also expect the sign on this variable to be negative, as a higher score indicates more comprehensive or more stringent environmental policies.

For both of these variables, there is an analogous "Neighboring" variable which measures the average value of the variable in all of the neighboring states, that is all states that share a common border. I do not have any *ex ante* beliefs about the expected sign on the neighboring variables. There could be positive externalities associated with strict environmental regulations in neighboring states, such as generators in the neighboring states wanting to export waste to other states for management. On the other hand, if a neighboring state's environmental regulation make transport through that state more expensive, it could have negative externalities.

The next four variables, Progressive, Struggler, Delayer, and Regressive are dummy variables representing the commitment of states to environmental protection policies and their ability to carry out strong environmental programs. Lester (1994) groups states into these four categories based on the state's responses to existing and potential environmental responsibilities. Progressives are states with "a high commitment to environmental protection coupled with strong institutional capabilities" and include California, Florida, Maryland, Massachusetts, Michigan, New Jersey, New York,

Oregon, Washington, and Wisconsin. Strugglers are the states "with a strong commitment to environmental protection but with limited institutional capacities." Colorado, Connecticut, Delaware, Hawaii, Idaho, Iowa, Maine, Minnesota, Montana, Nevada, New Hampshire, North Carolina, North Dakota, Rhode Island, and Vermont are all classified as strugglers. Delayers are states with "a strong institutional capacity but with a limited commitment to environmental protection" including Alabama, Alaska, Arkansas, Georgia, Illinois, Louisiana, Missouri, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Finally, Regressives are states with a weak institutional capacity "as well as a limited commitment to environmental protection" and include Arizona, Indiana, Kansas, Kentucky, Mississippi, Nebraska, New Mexico, South Dakota, Utah, and Wyoming. For the empirical analysis, I omit the Delayer variable. I expect the Progressive and Struggler variables to have a negative coefficient as regulations and enforcement should be more stringent than in the Delayer states and Regressive to have a positive coefficient because regulations and enforcement should be less stringent than in the Delayer states. The last variable measuring environmental regulations is Disposal Tax. This represents the tax rate on disposal of a ton of hazardous waste in 1987. Levinson (1999) finds that

⁴² As an alternative to measuring spending per capita, I considered normalizing spending by the level of manufacturing in the state or by the quantity of hazardous waste produced. Neither of these normalizations significantly change the results of this analysis. Also, because households and service industries contribute significantly to environmental problems, manufacturing activity is not necessarily a better unit of evaluation than population. In addition, hazardous waste spending is a relatively small part of spending on all environmental problems, so using tons of hazardous waste as the unit of evaluation may be no more appropriate than using population.

⁴³ Although some firms may prefer to deal with well-run, well-informed (and thus probably more highly funded) state environmental agencies, I believe the net effect of the spending variables will be negative.

⁴⁴ Information on the status of policies was compiled from a number of sources. Most of the sources are based on policy status as of 1987 to 1990, although some are as recent as 1991.

taxes discourage generators from shipping waste into a state and thus I expect a negative coefficient on this variable.

The final three variables do not measure environmental regulation directly but instead measure the climate of the state with regards to environmental regulation. Many environmental regulations allow for public participation. If the public opposes the construction of a facility or requires additional controls on a facility, this will increase the cost of a waste management facility. College represents the percentage of the population over the age of 25 that has completed college. Assuming that more highly educated people are more likely to participate in matters concerning a hazardous waste management facility, I expect the coefficient on this variable to be negative. EnvOrg measures participation in environmental organizations, and thus I also expect this coefficient on this variable to be negative. Finally, Republican measures the percentage of votes cast for the Republican presidential candidate in the 1988 election. Because the Republican party is known for its pro-business stance and had a weaker position on the environment in 1988 than the Democrats, I expect the coefficient on this variable to be positive.

VI. EMPIRICAL RESULTS

Table 2 presents the results from the conditional logit model for a number of different specifications. The first specification does not include any environmental policy variables. The other specifications include various combinations of the environmental policy variables. Standard errors are in parentheses and statistically significant coefficients are indicated with one asterisk for significance at the 5% level and two asterisks for significance at the 10% level. To save space, region dummy variables are not reported.⁴⁵

First consider the results for the variables that are commonly used in location studies. Although the absolute values of the non-environmental coefficients vary across all of the specifications, for the most part changes in the explanatory environmental policy variables do not drastically change the values of the coefficients or affect whether the coeffi-

cients are statistically significant. The coefficient on the tax variable is almost always negative, as expected, and statistically significant for half of the specifications. This is consistent with many industry location studies including Bartik (1988) and McConnell and Schwab (1990), although a number of studies, including Levinson (1996), have not found any statistical significance. The coefficient on energy is also consistently negative and statistically significant, a result which almost no other studies have found.⁴⁶ Energy costs may be statistically significant in this model because energy is a larger percentage of costs in this industry as compared to the entire manufacturing sector.⁴⁷ The coefficient on the interaction between energy and recovery systems is positive and significant, although the net effect of the two energy variables for facilities with recovery options is still negative. This implies that facilities with recovery operations are less sensitive to energy costs than facilities without recovery operations.

Mfg has a positive and significant coefficient across all specifications, which could indicate that facilities locate in states where there is more significant manufacturing activity due to agglomeration economies or it could indicate unmeasured characteristics of the states that make the state attractive to the hazardous waste management industry as well as manufacturing industries. A third explanation is that this variable captures hazardous waste generation and, therefore, facilities are attracted to states with high levels of manufacturing because this means high levels of hazardous waste. The coefficient on

⁴⁵ A complete set of results including the regional dummies is available upon request from the author.

⁴⁶ In particular, the three studies of environmental regulations and location decisions have found energy costs to not be statistically significant. Carlton (1983) does find electricity prices to be statistically significant in a study of the location choices of firms in four narrowly defined industries.

⁴⁷ The primary inputs into waste management are labor and energy, as there are relatively few material inputs into the process. Most manufacturing industries, on the other hand, require raw materials and other inputs. Thus even though some waste management techniques, such as landfilling, are not energy intensive, energy costs may be a relatively large percentage of overall costs.

TABLE 2
RESULTS OF CONDITIONAL LOGIT MODEL OF LOCATION CHOICE

Specification	(1)	(2)	(3)	(4)	(5)	(6)
Demand	-0.0181 (0.0325)	-0.0065 (0.0328)	-0.0092 (0.0361)	-0.0086 (0.0344)	-0.0039 (0.0337)	-0.0044 (0.0336)
Neighboring Demand	-0.0065 (0.0355)	-0.0013 (0.0387)	-0.0072 (0.0406)	-0.0088 (0.0411)	-0.0150 (0.0393)	-0.0861** (0.0483)
Tax	-3.4899* (1.5554)	-3.8463* (1.5798)	-3.4497** (1.7731)	-5.0580* (1.9531)	-2.3806 (1.7582)	0.5739 (2.1303)
Wage	0.7856 (0.6117)	0.4622 (0.6377)	0.3725 (0.6540)	0.3861 (0.6875)	0.2877 (0.7433)	0.1958 (0.7458)
Mfg	0.7390* (0.0691)	0.6784* (0.0733)	0.6778* (0.0730)	0.6888* (0.0945)	0.6547* (0.0745)	0.6721* (0.0754)
Energy	-2.4164* (0.4133)	-2.6795* (0.4289)	-2.6836* (0.4288)	-2.5933* (0.4353)	-2.2798* (0.4670)	-2.5382* (0.4786)
Energy × Recovery	1.4033* (0.2864)	1.4003* (0.2861)	1.4014* (0.2862)	1.4069* (0.2868)	1.4049* (0.2866)	1.4029* (0.2864)
Construction	2.6998* (0.8513)	3.6169* (0.9378)	3.6955* (0.9457)	4.2173* (1.0328)	4.3272* (1.0307)	4.4341* (1.0444)
Area	0.1700 (0.1410)	0.1630 (0.1460)	0.2120 (0.170)	0.1320 (0.1540)	0.2520 (0.1640)	0.2880** (0.1660)
Population	-0.9180* (0.4200)	-1.1100* (0.4310)	-1.0700* (0.4330)	-1.2100* (0.5070)	-1.0300* (0.4360)	-0.8950* (0.4360)
Spending		-0.0052* (0.0025)	-0.0049* (0.0025)	-0.0052* (0.0025)	-0.0045** (0.0026)	-0.0048** (0.0026)
Policy		0.0136* (0.0065)	0.0122** (0.0069)	0.0212* (0.0086)	0.0160* (0.0069)	0.0099 (0.0073)
Neighboring Spending			-0.0033 (0.0055)			
Neighboring Policy			0.0022 (0.0105)			
Progressive				-0.1874 (0.1374)		
Struggler				-0.0192 (0.1555)		
Regressive				0.0478 (0.1197)		
College					0.0112 (0.0156)	0.0107 (0.0159)
EnvOrg					-0.0537** (0.0278)	-0.0317 (0.0298)
Republican					0.0082 (0.0082)	0.0019 (0.0086)
Disposal Tax						-0.0070* (0.0026)
Log-Likelihood	5348	5345	5345	5344	5342	5339
Pseudo R ²	.1075	.1080	.1081	.1082	.1085	.1091

Note: Standard errors are in parentheses; *Statistically significant at 5%; **Statistically significant at 10%.

Construction is consistently positive and significant, in contrast to the expected negative sign. Several other studies have found this same result, including Bartik (1985) and Schmenner, Huber, and Cook (1987). One possible explanation is that states that are attractive for unobserved reasons may tend to

have higher construction costs because of increased business demand.⁴⁸

⁴⁸ However, when I added a variable measuring growth in manufacturing from 1987 to 1992, there was little change in the coefficient on construction (or in any of the other coefficients) and the coefficient on growth was not significant.

The coefficient on Wage also has an unexpected positive sign, although it is never statistically significant. Both Levinson (1996) and McConnell and Schwab (1988) found similar results for wages in their models.⁴⁹ One explanation for the Wage result may be that there are unmeasured productivity differences between states that are positively correlated with wages. Other explanations might be that states with high levels of industrial activity have both high demand for hazardous waste management and higher wages, or that the hazardous waste management industry is relatively insensitive to wages rates because labor is not the most significant factor in their cost function.⁵⁰ Because Wage and Construction are also positively correlated (with an estimated correlation coefficient of 0.75), whatever is driving the result for wages could also be driving the result for construction costs.

Area may serve as a proxy for the number of potential sites in each state. The positive coefficient on Area is consistent with this interpretation because it implies that the more potential sites, the more likely a facility is to locate in that state. However, the coefficient often is not significant, which could be interpreted to mean that intra-state differences among sites are relatively minor. The coefficient on Population is consistently negative and significant. Because total area is included in the model, this could imply that less densely populated states are more attractive.

Given the equilibrium assumption, it is not clear *ex-ante* whether the two demand variables should have a positive or negative effect on location decisions. Under all of the specifications, Demand in a state is negative, although it is never significant. Neighboring demand is also negative and generally insignificant, although it is statistically significant under specification six. The statistical insignificance could be due, in part, to the fact that Demand and Mfg are positively correlated with an estimated correlation coefficient of approximately 0.6 and thus some of the effect of demand on location choice is picked up by the coefficient on Mfg. When Mfg is removed from the model, both demand variables are positive and significant.

There are five specifications that include various environmental policy variables. In all

of these specifications, Spending appears as expected with a consistently significant negative coefficient. This suggests that the more money a state spends on implementing and enforcing its environmental regulations, the less attractive it is to hazardous waste management firms. The coefficient on Policy, on the other hand, is positive rather than negative as was expected, and is significant. One possible explanation for this result is that regulatory stringency and demand are correlated. Because Policy measures the comprehensiveness of a state's regulation, another interpretation is that facilities may prefer to locate in states where there is less uncertainty about the form of the regulations (because there is already a comprehensive set of regulations). Similarly, states that have passed a comprehensive set of regulations may be more likely to have a well-run bureaucracy in place to deal with environmental issues which may make it easier for firms to operate in those states.

Specification three includes the average values of the spending and policy variables in neighboring states, Neighboring Spending and Neighboring Policy, neither of which have significant coefficients. It is interesting that both of these coefficients have the same sign as the coefficients on the variables for the state itself (that is on Spending and Policy). This is consistent with a model where neighboring states' environmental regulation increases the cost of transport for customers and thus make the facility less attractive to generators. Specification four includes the dummy variables Progressive, Struggler, and Regressive (the dummy variable Delayer is omitted). Although the coefficients on these variables are not significant, they do have the expected signs.⁵¹

⁴⁹ Levinson obtains a positive coefficient on Wage for some specifications of his model and a negative coefficient for others, but the coefficient is never significant.

⁵⁰ I thank an anonymous referee for suggesting these explanations.

⁵¹ I did not include the results of the specification that included only these general measures (Progressive, Struggler, and Regressive). None of the coefficients on these general measures was significant, although they did have the expected signs, and their inclusion did not dramatically change the coefficients on the non-environmental explanatory variables.

Specification five includes three variables to measure the potential for public participation in environmental matters. College has a positive, but insignificant coefficient. This could be due to the fact that while people with college degrees are more likely to participate in public meetings and hearings, they are also attractive from a labor market perspective, especially for an industry that employs engineers. EnvOrg, which measures membership in environmental organizations, has the expected negative sign and is significant, which could indicate that environmentalists are more likely to oppose construction of hazardous waste facilities. Finally, Republican has the expected positive sign, but it is not significant.

Specification six is the same as specification five except that it includes a measure of the taxes on disposal of hazardous waste, Disposal Tax. The coefficient on this variable is negative and significant as expected. One should be cautious in interpreting these results, however, as states may have implemented taxes in response to the presence of waste management facilities and thus there is potential endogeneity between Disposal Tax and the location decision of firms. Note that in this specification the coefficients on both Policy and EnvOrg are no longer significant although they have the same signs and similar magnitude of the coefficients in specification five.

To save space, region dummy variables are not reported. Region 10 (Washington, Oregon, Idaho, and Alaska) is the omitted region. The coefficients on the regional dummies are all positive and almost always significant at the 5% level. These dummy variables were included in the model to attenuate any potential problems with the assumption of the independence of irrelevant alternatives. However, it is likely that the regions are also picking up some of the correlations between state environmental programs and attitudes. For example, Georgia, South Carolina, and North Carolina spend similar amounts on environmental regulations and are all in Region 4. Five of the six states in Region 1 (the Northeastern United States) are classified as Strugglers. Also, even if a state is authorized to implement and enforce

its own hazardous waste program, facilities do have to interact with the regional EPA offices, and some offices may be considered easier to work with than others.

To get a sense of the effect of these variables on the location decision beyond their statistical significance and direction of effect, it is necessary to interpret their magnitudes. In the conditional logit model, the probability of locating facility i at location k is given by

$$P(ik) = \frac{e^{\beta'x_k}}{\sum_j e^{\beta'x_j}}$$

Taking the derivative of this probability with respect to a state characteristic z_k yields

$$\frac{\partial P(ik)}{\partial z_k} = P(ik) \cdot (1 - P(ik)) \cdot \beta_z$$

Thus the interpretation of a coefficient depends on the characteristics of the state being analyzed.

Table 3 presents the change in the probability (in percentage points) of any one facility locating in a state with median characteristics that would result from an increase in each of the listed parameters by one standard deviation for the fifth specification.⁵² For example, the results suggest that increasing per capita spending on environmental programs by one standard deviation, or \$39, while holding all other parameters constant, would decrease the probability that a facility would locate in a state with average characteristics by 0.225 percentage points from a probability of 1.314 to a probability of 1.089.⁵³ Although this may seem to be a small change in terms of percentage points, the probability

⁵² The probability is evaluated at the median of all of the continuous variables. Since there is no median for the dummy variables, I assume that the state is in Region 5 (which is the region that generally has the median coefficient of the ten regions). I chose specification five for this analysis because it appears to be the best fit.

⁵³ The last row of this table shows the probability that a facility would locate in a state with average characteristics under each of the specifications.

TABLE 3
INTERPRETATION OF COEFFICIENTS FROM THE CONDITIONAL LOGIT MODEL OF
LOCATION CHOICE FOR SPECIFICATION FIVE

Variable	Value of Coefficient	Change in Probability From Increase of 1 Standard Deviation
Demand	-0.0039	-0.010
Neighboring Demand	-0.0150	-0.027
Tax	-2.3806	-0.089
Wage	0.2877	0.048
Mfg	0.6547*	1.023
Energy	-2.2798*	-0.540
Energy $\times$ Recovery	1.4049*	1.549
Construction	4.3272*	0.465
Area	0.2520	0.082
Population	-1.0300*	-0.139
Spending	-0.0045**	-0.225
Policy	0.0160*	0.189
College	0.0112	0.061
EnvOrg	-0.0537**	-0.250
Republican	0.0082	0.058
Probability of Locating in Average State		1.314%

Notes: This table presents the predicted change in the probability of locating in a state with median characteristics as a result of a standard deviation in each independent variable.

* Coefficient is statistically significant at 5%; **Coefficient is statistically significant at 10%.

of locating in the state decreases by almost 20% in response to the one standard deviation increase in per capita spending. In terms of the absolute number of facilities, such a change in spending would imply three fewer facilities given a total universe of 1,548 facilities.

To determine the relative importance of environmental regulations to the location choice, one needs to compare the effects of environmental regulations to the effects of the other explanatory variables. Although changes of the same relative magnitude (that is, one standard deviation) in manufacturing level, energy costs, and construction costs generally appear to have a more sizeable effect on location choice than changes in the environmental policy variables, changes in demand, taxes, and wages generally appear to have a less sizeable effect. Also, increases in spending have a larger effect than changes in the stringency of environmental regulations.

To test the robustness of these results, I analyzed several different subsets of the data. As discussed previously, the data set includes

all facilities that managed hazardous waste that was generated by another firm according to EPA's 1993 Biennial Reporting System (BRS), both permitted and non-permitted. Because obtaining a permit is very expensive and will depend on a state's environmental regulations and the level of public participation in the process, permitted facilities might be differently affected by environmental regulations than non-permitted facilities. Therefore, I ran specification five separately for permitted and non-permitted facilities. The results of these analyses are presented in Table 4.

The results for permitted facilities are very similar to the results for the whole data set (except for the sign of the insignificant coefficient on the demand variables). For the non-permitted subset, none of the environmental policy variables are significant although all but College have the same sign and are of similar magnitude. These results suggest that environmental regulations are maybe more significant factors for facilities that have to obtain a permit than for facilities that do not.

TABLE 4
COMPARISON OF RESULTS FOR PERMITTED AND NON-PERMITTED FACILITIES

Specification	Complete Data Set	Permitted Facilities (586)	Non-Permitted Facilities (962)
Demand	-0.0039 (0.0337)	0.0520 (0.0536)	-0.0479 (0.0443)
Neighboring Demand	-0.0150 (0.0393)	0.0629 (0.0652)	-0.0841** (0.0510)
Tax	-2.3806 (1.7582)	-2.6767 (2.9837)	-1.6921 (2.2055)
Wage	0.2877 (0.7433)	-0.5347 (1.2036)	1.0454 (0.9628)
Mfg	0.6547* (0.0745)	0.5722* (0.1187)	0.8036* (0.1067)
Energy	-2.2798* (0.4670)	-2.4853* (0.7767)	-2.3526* (0.5982)
Energy × Recovery	1.4049* (0.2866)	1.9262* (0.4963)	1.6381* (0.3771)
Construction	4.3272* (1.0307)	3.5691* (1.5973)	4.9940* (1.3881)
Area	0.2520 (0.1640)	0.2240 (0.2570)	0.3610** (0.2180)
Population	-1.0300* (0.4360)	-0.0702 (0.0572)	-3.4600* (0.0983)
Spending	-0.0045** (0.0026)	-0.0074** (0.0046)	-0.0026 (0.0032)
Policy	0.0160* (0.0069)	0.0172 (0.0117)	0.0132 (0.0089)
College	0.0112 (0.0156)	0.0319 (0.0246)	-0.0092 (0.0206)
EnvOrg	-0.0537** (0.0278)	-0.0833** (0.0450)	-0.0297 (0.0363)
Republican	0.0082 (0.0082)	0.0050 (0.0134)	0.0099 (0.0105)

Note: Standard errors are in parentheses; regional dummies are not reported; *Statistically significant at 5%; ** Statistically significant at 10%.

Because the requirements and regulations vary for different systems, I also ran the fifth specification on three different subsets of the data based on the types of systems at the facilities: (1) facilities with land disposal units (landfills and land treatment); (2) facilities with combustion units (incinerators and BIFs); and (3) facilities with recovery units (solvent recovery, metals recovery, other recovery). Remember that facilities often have more than one waste management system, so there is some overlap of facilities across these subsets. Table 5 presents the results of the analysis for the system subsets.

For facilities with land disposal units (304 facilities), none of the environmental policy variables were significant, and the signs for

Spending and College were opposite those for the entire database. However, the coefficients on both tax and wage are significant for this subset although they are not for the whole data set. For facilities with combustion units (685 facilities), none of the environmental policy variables were significant although the signs were consistent with the signs for the entire data set. For facilities with recovery units (864 facilities), the signs were consistent with the signs for the entire data set and Spending, Select, and EnvOrg were all significant.⁵⁴

⁵⁴ For this run, the interaction between energy costs and recovery was dropped because of perfect collinearity with the variable for energy costs.

TABLE 5
COMPARISON OF RESULTS FOR DIFFERENT TYPES OF FACILITIES

Specification	Complete Data Set	Land Disposal	Combustion	Recovery
Demand	-0.0039 (0.0337)	-0.0669 (0.0813)	-0.0204 (0.0508)	0.0423 (0.046)
Neighboring Demand	-0.0150 (0.0394)	-0.0042 (0.1058)	-0.0434 (0.0624)	-0.0418 (0.0535)
Tax	-2.3806 (1.7583)	-8.6489* (4.148)	-1.8359 (2.9825)	2.2685 (2.5094)
Wage	0.2877 (0.7433)	4.8060* (1.8456)	0.4829 (1.151)	-0.3938 (1.012)
Mfg	0.6547* (0.0745)	0.7904* (0.1799)	0.8345* (0.1153)	0.5288* (0.1015)
Energy	-2.2798* (0.4671)	-3.4839* (1.1284)	-3.2235* (0.7367)	-0.6995 (0.6471)
Energy $\times$ Recovery	1.4049* (0.2866)	1.9850* (0.6847)	1.8544* (0.441)	—
Recovery Construction	4.3272* (1.0308)	2.2701 (2.335)	2.9966** (1.5515)	6.6527* (1.4511)
Area	0.2520 (0.164)	-0.2950 (0.392)	-0.0979 (0.267)	0.5990* (0.241)
Population	-1.0300* (0.436)	-0.2790 (0.931)	-0.9280 (0.608)	-0.1670 (0.636)
Spending	-0.0045** (0.0026)	0.0014 (0.0043)	-0.0050 (0.0044)	-0.0087* (0.0043)
Policy	0.0160* (0.007)	0.0002 (0.0164)	0.0118 (0.0111)	0.0340* (0.01)
College	0.0112 (0.0157)	-0.0175 (0.0371)	0.0289 (0.0241)	0.0164 (0.0218)
EnvOrg	-0.0537** (0.0279)	-0.0299 (0.0758)	-0.0345 (0.0454)	-0.1090* (0.0387)
Republican	0.0082 (0.0082)	0.0300 (0.021)	0.0143 (0.0129)	0.0095 (0.0112)

Note: Standard errors are in parentheses; Regional dummies are not reported, *Statistically significant at 5%; **Statistically significant at 10%.

VII. CONCLUSIONS

Unlike many other studies of the effect of environmental regulations on firm location choice, this analysis finds that a number of different measures of environmental regulations can explain some of the differences in state location choice for hazardous waste management facilities. While other variables such as the level of manufacturing activity and energy costs may be more significant determinants of location choice, environmental regulations are not insignificant. For this industry, environmental regulations appear to have larger effects on the location decision than some other more traditional factors such as wages and taxes.

In particular, I find relatively strong evi-

dence that spending on environmental programs can deter firms from locating in a particular state. Since spending on environmental programs affects the implementation and enforcement of environmental regulations, these results suggest that the intensity with which states enforce environmental regulations may be a very important factor in affecting firms' location choices. On the other hand, using qualitative measures of state environmental regulatory stringency, it appears that more stringent environmental regulations attract hazardous waste management facilities. This may be due to correlations between regulatory stringency and demand for hazardous waste management services or it may indicate that facilities prefer states where there is less uncertainty about require-

ments due to the comprehensiveness of the state's regulations.

I also find that states with a high number of environmentalists deter facilities from locating in a state, perhaps because the facility is concerned about opposition from the public or public interference with operations. Finally, taxes on the disposal of hazardous waste appear to deter facilities, although this evidence must be interpreted cautiously given the potential for endogeneity between hazardous waste taxes and the presence of hazardous waste management facilities. The results for various subsets of the data set are generally consistent with the results for the entire data set, although in many cases the coefficients are not significant.

While this analysis concludes that environmental regulations affect the location decision of firms in the hazardous waste management industry, and not that environmental regulation affects the location decisions of other types of firms, the results of this analysis suggest that any future analyses of environmental regulations and location choice should include state spending on environmental programs and measures of public participation in environmental matters as well as more traditional measures of the stringency of environmental regulations.

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