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AN INTERREGIONAL HEDONIC ANALYSIS OF NOXIOUS FACILITY
IMPACTS ON LOCAL WAGES AND PROPERTY VALUES

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An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values

David E. Clark and Leslie A. Nieves¹

I. INTRODUCTION

Claims of property value loss are commonly raised by homeowners when noxious facilities are sited or when new information about the hazards of existing facilities is made public.² While the capitalization of externalities into land values is consistent with economic theory, empirical measurement of impacts has not generated consistent results. This is true both for hedonic measurements as well as other types of econometric analyses. While it is well established that job and site risks have similar impacts on regional labor markets, there are no studies relating the presence of a broad range of noxious facilities to local wage premiums.

In contrast, this study employs an interregional framework in a hedonic analysis of both wage and property markets and considers eight different facility classifications. The approach offers several advantages. First, since multiple facility types are controlled, we can be more confident of the marginal impact of a particular type of facility. Second, the technique provides insights into the relative impact of noxious facilities on property and labor markets. It also permits calculation of an implicit price for different types of noxious facilities, that is, a net of wage and property value impacts. The development of equitable compensation measures and the identification of social-cost-minimizing siting criteria for noxious facilities are both dependent on the accurate measurement of impacts.

The remainder of this paper is divided into four sections. In Section II we discuss the development of the hedonic model employed in this study.

¹ D.E.C.: Marquette University and Argonne National Laboratory.
L.A.N.: Argonne National Laboratory. Work supported by the U.S. Department of Energy, Office of Civilian Radioactive Waste Management, under Contract W-31-109-Eng-38.

² These facilities have been termed LULU's (locally undesirable land uses) by Popper (1983) and Smith and Devousges (1986).

Section III develops more fully the theoretical advantages of the intercity model and alternative methods of deriving implicit prices for environmental amenities and disamenities. The unique data base and the structure of the estimated model are described in Section IV, which also includes a discussion of the research findings. Major conclusions and suggestions for further research are presented in Section V.

II. OVERVIEW OF HEDONIC MODEL

A. Intracity Hedonic Model

The hedonic model has its origins in the work of Lancaster (1966) and Rosen (1974) and has been applied to value amenities such as air quality (Ridker and Henning 1967, Nelson 1978, Harrison and Rubinfeld 1978), airport noise (Nelson 1979), and public safety (Thaler 1979). It has also been used to consider the impact of various types of noxious facilities such as nuclear plants (Gamble and Downing 1981, 1982; Nelson 1981), coal-fired power plants (Blomquist 1974), hazardous waste facilities (Harrison and Stock 1984; Smith and Devousges 1986; Michaels and Smith 1990; McClelland, Schulze, and Hurd 1990), chemical manufacturing (Baker 1986), and radioactive materials production (Real Estate Counseling Group of Connecticut, Inc. and Financial Consulting Group of Ohio 1987). Often, proximity to the site is used to measure impacts. However, if distance is to provide an adequate measure, it must be the case that other amenities and disamenities, as well as employment opportunities, which are correlated with distance from the site, are adequately controlled.

Hageman (1981) notes that certain environmental goods (or bads) may have positive as well as negative impacts on property values, depending on their influence on employment. For example, proximity to a nuclear power plant may reduce property values because of the increased possibility of an accident, while at the same time property values may increase if the plant is an

important source of employment.³ McClelland, Schulze, and Hurd (1990) attempt to avoid this problem in their study of a hazardous waste site by using a more direct measure of perceived risk in a hedonic model. Their findings suggest that neighborhood risk perception does reduce local property value.

B. Intercity Hedonic Model

Rosen (1979) is the first to consider amenities in an intercity as opposed to intracity framework, and Cropper and Arriaga-Salinas (1980) note that the approach may be preferable to the intracity model when intracity variation in the amenity is slight. In addition, benefit estimates obtained from a single market may not be generalizable to other markets. However, when multiple market data are employed, the marginal prices are readily generalized to encompass all regions represented in the data, permitting national benefit estimates to be derived.

Since the early work of Rosen, the intercity model has been refined. Whereas the Rosen model avoids the issue of joint capitalization of amenities into intercity wages and land values by assuming home production theoretically and examining real wages empirically, Roback (1982) develops a general equilibrium model of intracity household and firm location. In Roback's model, wages and land rents are simultaneously determined by the actions of utility maximizing households and cost-minimizing firms. This model is further refined by Blomquist, Berger, and Hoehn (1988), who make city size endogenous. The models of Roback and Blomquist, Berger, and Hoehn derive implicit prices as a weighted sum of the capitalized influence in land and labor markets.

Whereas most hedonic analyses of noxious facilities concentrate attention on the influence within cities, at least one study investigates the intercity impact. Blomquist, Berger, and Hoehn (1988) consider the presence of Superfund sites; treatment, storage, and disposal sites; and the volume of

³ Bender and Hwang (1985) demonstrate that it is important to control for both primary and secondary employment centers when deriving the intraurban land rent function.

landfill waste on land values and wage rates in their derivation of an urban quality-of-life index. They find that all three facility types have a significant positive influence on housing expenditures as well as on hourly wage rates. The combined effect, which is reflected in the full implicit price, is negative as expected. Superfund sites have the strongest marginal impact.

III. THEORETICAL DEVELOPMENT OF INTERCITY HEDONIC MODEL

Following Roback (1982) and Blomquist, Berger, and Hoehn (1988), we develop the uncontrolled intercity model. A general model, which incorporates the effect of compensation for damages, similar to that developed by Hageman (1981) in an intracity model, is not considered in this paper. The reason is that this model is applied to 1979 data. While the possibility of compensation for damages existed in 1979, the probability was actually quite low. We assume that anticipated damages are treated as uncompensated so that the predictions from the Clark and Cosgrove (1990) model are appropriate here. It should be noted, however, that there are indications that such an assumption is less valid when looking toward the future.

We assume that households are mobile between cities and are aware of the intercity amenity differences, whereas the intracity amenity variation is assumed to be zero. Households maximize utility, which is a function of a composite good (X), land (L), and site-specific amenities (A), subject to the available budget. The wage is W , the price of land is R , and the composite good price is assumed to be the numeraire. This gives the following equation system.

$$U = U(X, L; A) \quad (1)$$

$$W = X + R \cdot L \quad (2)$$

Maximizing (1) subject to (2) across the two goods X and L gives Marshallian demand functions that are functions of market prices and income levels. Substituting optimal X and L back into the utility function gives an indirect utility function that can be considered equal to a constant given the

assumption of intercity mobility. The indirect utility function is a function of market prices and wages, as well as the amenity offerings between cities.

$$V^* = V(1, W, R; A) \quad (3)$$

Firms are also assumed to optimize with respect to inputs and location. Amenities can influence firm productivity directly. For example, if hazardous waste is generated in the production process, then an amenity such as low risk is costly to the firm. Assuming that the firm operates under conditions of constant returns to scale in competitive input and output markets, then cost minimization involves optimizing equation (4), subject to the production constraint (5), which gives the unit cost function (6).

$$TC = R \cdot L + W \cdot N \quad (4)$$

$$Q = f(K, N; A) \quad (5)$$

$$1 = C(W, R; A) \quad (6)$$

For a given level of the amenity, a simultaneous solution of equations (3) and (6) gives the equilibrium wage and rent levels.

$$W = W(R, A) \quad (7)$$

$$R = R(W, A) \quad (8)$$

The implicit price for the amenity derived from equations (7) and (8) is a joint function of the marginal impacts on wages and rents.

$$P^* = W \cdot k_1 \cdot d \ln R / dA - W \cdot d \ln W / dA \quad (9)$$

The fraction of income spent on land is represented by k_1 , so the expenditure on land ($W \cdot k_1$) provides the weight on the rent component of the implicit price⁴.

IV. AN EMPIRICAL MODEL OF HOUSING AND WAGE IMPACTS

A unique data base is developed for analysis that combines individual data on housing value and wages with a broad range of amenity and disamenity

⁴ Henderson (1982) shows that so long as the rent levels are controlled, equation (7) alone can be estimated and used to derive implicit prices. Clark and Cosgrove (1990) further establish that equation (8) can yield full implicit prices with wage control. We only derive implicit prices from uncontrolled intercity wage and rent functions in this paper.

measures to implicitly value eight different types of noxious facilities. After a discussion of the selection of study sites, we turn to a development of the empirical model.

A. Study Site Selection

Selection of study sites was a multistage process that started with the choice of a broad range of facility types defined for each region in the country. The eight categories of facilities are:

NUP	nuclear power electric generating plants
COP	coal-fired generating plants
GOP	gas- and oil-fired generating plants
CHM	military chemical weapons storage sites slated for decommissioning
HWS	hazardous waste sites ⁵
PCR	petrochemical refineries
RAC	formerly utilized, radioactively contaminated sites managed by the Department of Energy
LNG	liquified natural gas storage facilities ⁶

All of the chemical hazardous waste sites are presently listed on the National Priorities List. While they existed in 1980, public information about them may have been limited since they had yet to be identified as Superfund sites.⁷

After constructing the facility categories, the second step in sample development was the selection of specific sites corresponding in area to the data units of the 1980 U.S. Census Public Use Microdata "B" Sample (hereafter PUMS). Because the PUMS covers the entire 48 contiguous states, one goal of the sample selection process was to obtain a representative sample encompassing the full range of variation in site characteristics, population density, and amenities.

⁵ The hazardous waste category comprises of chemical and radioactive waste sites. In addition, this category includes the three operating commercial low-level radioactive waste disposal facilities.

⁶ The RAC sites have residual radioactive contamination from materials produced for the Manhattan Project or subsequent projects and are not associated with any ongoing operations.

⁷ The CERCLA legislation establishing Superfund was passed in 1980.

However, the PUMS county groupings may cover a wide geographic area.⁸ Thus, a second goal was to select sites that constitute a geographic area small enough so that average amenity levels within that area are representative for the resident population. In a few cases where a region and facility type could be represented by two alternative geographic areas of widely disparate sizes (in terms of square miles) within the same region, the smaller county grouping was chosen. Finally, when PUMS county groupings were composed of noncontiguous geographical areas, those areas were deleted from the sample.

There are a total of 84 PUMS study areas in the sample, of which 77 contain 293 noxious facility sites. All existing CHM facility sites and all major RAC sites with remedial actions plans are included, except those eliminated by PUMS geographical area definitions. Included facilities were either in operation or, in the case of a few large coal and nuclear plants, in the final stages of construction by 1980. Seven study areas are included that did not contain any facilities of the types studied. Other types of noxious facilities, such as sewage treatment plants, landfills, or industry, may also be located in any of the study sites.

The distribution among Census Regions of the noxious facilities in the 84 study areas is shown in Table 1. The Northeast contains the largest number of facilities (91) mainly due to the high proportion of hazardous waste sites in that region. The distribution of most facility types appears to reflect the distribution of the total population of facilities across regions.

⁸ To protect individual confidentiality, the geographical areas defined must have a population of at least 100,000. In sparsely populated areas this creates very large multicounty data units. There are 35 multicounty areas in the sample, of which nine have areas larger than six thousand square miles. These are primarily located in the Mountain, West North Central, West South Central, and Pacific regions.

Table 1. Number of Facilities by Facility Type and Census Region

<u>Region</u>	<u>Facility Type</u>								<u>TOTAL</u>
	<u>NUP</u>	<u>COP</u>	<u>GOP</u>	<u>CHM</u>	<u>HWS</u>	<u>PCR</u>	<u>RAC</u>	<u>LNG</u>	
NORTHEAST	7	10	14	0	47	5	4	4	91
NORTH CENTRAL	1	24	18	1	15	7	2	1	69
SOUTH	7	11	15	3	20	16	0	5	77
WEST	6	11	9	3	16	10	0	1	56
TOTAL	21	56	56	7	98	38	6	11	293

B. Empirical Model

Data from several sources were assembled to construct a data set that covers wage and property markets, local amenities and disamenities, and socio-economic structure. All of the data are for 1979-80. Data for wages, residential property values, and the range of associated individual attributes needed for a hedonic analysis are taken from the PUMS.

$$ANNWAGE=W(NOXIOUS,AMENITY,PRICE,DISEQ,HC\&IND) \quad (10)$$

$$VALUE=V(NOXIOUS,AMENITY,PRICE,DISEQ,STRUCT) \quad (11)$$

Independent variable headings include noxious facilities (*NOXIOUS*), control amenities (*AMENITY*), local prices (*PRICE*), and disequilibrium controls (*DISEQ*). Additionally, human capital and industry controls (*HC&IND*) are included in the wage equation, while housing structural characteristics (*STRUCT*) are included in the housing value equation.

The sample of workers used to estimate wage equations is composed of those 18 years and older who report wage and salary income or nonfarm self-employment income.⁹ The sample is confined to workers who earn calculated wages in excess of \$2.00 per hour¹⁰ and who live and work in one of the study sites. Because the PUMS income data distribution is truncated, the income category of "\$75,000 and up" is omitted from the analysis. The resulting sample size is 25,279 persons.

⁹ Farm income is omitted because it may incorporate returns to farmland and buildings.

¹⁰ Those who report hourly earnings of less than \$2.00 per hour are dropped due to the likelihood of underreported income.

The housing sample includes owner-occupied units and excludes units lacking individual access and residences used for commercial purposes. Owners with reported property values in the category "\$175,000 and up" are excluded. The final sample consists of 47,947 units.

The remaining data are taken from numerous sources, which are outlined in Table 2, and are typically defined for a city or county in the region. In all cases, the county and city data that most closely correspond geographically to the PUMS data unit for each study site are selected¹¹.

1. The Wage Model

Annual wages, the summation of annual wages and self-employment income (ANNWAGE), is the dependent variable in the wage model. A vector of human capital and industry characteristics (HC&IND) includes the sex of the worker (SEX), marital status (MARITAL), a sex and marital status interaction term (SEXMAR), years of education (EDUC), experience and experience squared (EXPER, EXPERSQ), race (WHITE), a dummy for full-time employment (FULLTIME), veteran status (VETERAN), and partial disability status (DISABLE). In addition, two sets of dummy variables represent the occupation and industry of the worker.¹² The latter category is included to control for differences in occupational risk across industries. Finally, annual hours of work (ANNHOURS) is included to proxy effort.

¹¹ It should be noted that the matching is not perfect since some PUMS data units are composed of subcounty or multicounty areas. While this can reduce the precision of the empirical findings, we do not believe it presents a serious problem here. We reestimated the models using the subset of sites for which the geographic match of PUMS and other data units is exact and found no appreciable difference in the findings.

¹² Occupation dummies are included for farming and fishing; managerial and professional specialties; operators, fabricators, and laborers; precision production craft and repair; service; and technical, sales, and administrative support. Industry dummies include agriculture, forestry, and fisheries; construction; entertainment and recreation services; business and repair services; mining; public administration; professional and related services; wholesale and retail trade; and transportation, communications, and other public utilities.

Table 2. Variables and Data Sources

<u>Variable</u>	<u>Definition/coding</u>	<u>Source</u>
Housing Model Variables :		
ACREGT1	1 if acres greater than 1	PUMS
BATHROOM	number; 3 = 2 or more complete baths	PUMS
BEDROOM	number; 5 = 5 or more bedrooms	PUMS
BLDNGAGE	building age interval in years	PUMS-calc
CENTAIR	1 if central air conditioning	PUMS
CONDO	1 if a condominium unit	PUMS
DETACHED	1 if detached one-family house	PUMS
HEATING	1 if central system	PUMS
OTHRROOM	number of rooms minus bedrooms	PUMS-calc
SEWAGE	1 if public sewer	PUMS
VALUEM	owner-estimated sales value monthly equivalent ¹³	PUMS-calc
WATER	1 if public system or private company	PUMS
YRMOVED	years since move to unit	PUMS-calc
Wage Model Variables:		
ANNHOURS	HOURS79 * WEEKSW79	PUMS-calc
ANNWAGE	INCOME1 + INCOME2 if WEEKSW79 != 0	PUMS-calc
DISABLE	1 if a work disability	PUMS
EDUC	highest year of school attended 14 = 12th grade	PUMS
EXPER	Age minus 6 minus grade	PUMS-calc
EXPERSQ	EXPER*EXPER	calc
FULLTIME	1 if HOURS79 > or = 40	PUMS
MARITAL	1 if now married	PUMS
SEX	1 if female	PUMS
SEXMAR	SEX * MARITAL; 1 if married female	calc
VETERAN	1 if veteran of the Armed Forces	PUMS
WHITE	1 if white	PUMS
Industry	dummy definitions available from authors	PUMS
Occupation	dummy definitions available from authors	PUMS
Disequilibrium and Price Control Variables:		
COLINDEX	cost of living index excluding housing	ACCRA-calc
UNEMPLOY	percent total labor force unemployed	CCDB
PCTUNION	percent of labor force unionized	K-S
VACANCY	percent of year-round housing units vacant	CCDB
Census Division	9 dummies for state location	

¹³ An effective mortgage rate of 10.78% was used in this conversion.

Table 2. continued

(Dis)amenity Variables:

CNTRLCTY	1 if central city of SMSA	PUMS
COAST	1 if sea coast location	calc
COOLDAYS	total cooling degree days	CCDB
CRIMES	violent crimes per 100,000 population	CCDB
HEATDAYS	total heating degree days	CCDB
PCTMFG	percent of employment in manufacturing	CCDB-calc
PCTSUN	realized percent of potential sunlight	NOAA
POPDENS	population per sq. mi.	CCDB
PRECIP	annual inches of precipitation	NOAA
RURAL	1 if outside SMSA	PUMS
TEMPDIFF	annual range of daily mean temperatures F	CCDB-calc
TSP	annual average total suspended particulates	SAROAD

Sources: ACCRA (American Chamber of Commerce Research Association) 1980 "Inter-City Cost of Living Indicators"; CCDB, 1983 County and City Data Book; K-S (Kokkelenberg and Sockell) 1985; PUMS, 1980 Bureau of the Census "Public Use Microdata Sample"; SAROAD, Garvey, Moser, and Streets (1982).

2. Housing Value Model

Annual housing value is derived from the owner's estimate of the market value of the residence.¹⁴ It can be expected that those who have purchased most recently will provide the most accurate value estimates. Accordingly, the time period since moving into the house (YRMOVED) is included in the equation to account for variation in accuracy over time. Structural characteristics (STRUCT) of the housing unit are controlled using several measures. These include the building age (BLDNAGE), number of bedrooms (BEDROOM), number of bathrooms (BATHROOM), number of other rooms (OTHRROOM), a dummy for central air conditioning (CENTAIR), and a dummy indicating whether the unit is a separate building (DETACHED). Features such as the type of water system (WATER), sewer system (SEWAGE) heating system (HEATING), and large lot sizes (ACREGT1) are controlled using dummy variables. Finally, condominium status is also controlled using a dummy variable (CONDO).

3. Control Variables

Equations (10) and (11) share many of the same variables. Before discussing the differences, the common variables are briefly reviewed. Control amenities (AMENITY) are related to safety, climatic, environmental, and recreational conditions in the region. The violent crime rate (CRIME) represents the public safety amenity, while several measures are used to control climate. These measures include the average annual percent of available sunlight (PCTSUN), the average annual inches of precipitation (PRECIP), the difference between the average mean daily July and January temperature (TEMPDIFF), the average total cooling-degree-days (COOLDAYS), and total heating-degree-days (HEATDAYS). The variable for total suspended particulates (TSP) approximates air quality in the region, and a dummy variable representing the coastal county groups (COAST)

¹⁴ The first term in equation (9) represents the rental flow. Since housing value is the asset price, we derive the rental price as the annual mortgage payment assuming an effective mortgage rate of 10.78% for 1979. This rate is reported in the 1987 "Economic Report of the President". It includes prepaid points and assumes repayment after 10 years. Land expenditures are assumed to be 19.6% of housing expenditures as estimated by Roback (198.) from FHA data.

approximates recreational amenities. Amenities and disamenities associated with urban scale are proxied by population density (POPDENS) and, in the housing model, dummy variables defining the metropolitan status of the county (CNTRLCTY, RURAL). Location in a Standard Metropolitan Statistical Area (SMSA) but outside of the central city is the reference case. Finally, the effects of industrial concentration (e.g., congestion, pollution) are controlled by the percent of total employment represented by manufacturing workers (PCTMFG)

The *DISEQ* category is included to control for the possibility of temporary disequilibrium. We include the unemployment rate (UNEMPLOY) and regional dummy variables representing the nine Census Divisions. The wage model includes the percentage of the labor force that is unionized (PCTUNION), and the housing model includes the percentage of year-round housing units that are unoccupied (VACANCY).

The *PRICE* category contains a cost of living index (COLINDEX) computed without the cost of housing to account for the relative cost of produced goods.

4. Facility variables

Noxious facilities are modeled in terms of facility density per 100 square miles for each PUMS data unit. Density is used to standardize the facility impact measure because of the large range of area covered by the PUMS data units. We include separate density variables for each of the eight separate categories of noxious facilities (NFDNSxxx) with the last three terms designating facility type.¹⁵

c. Empirical Findings

Because of the nonlinearity in the implicit price function, both models are estimated by using a double logarithmic functional form. This functional form

¹⁵ In the facility variables, the facility types are designated by the abbreviations used in Table 1: NUP=nuclear power plant, COP=coal-fired plant, GOP=gas- and oil-fired plant, CHM=military chemical weapons storage sites, HWS=hazardous waste sites, PCR=petrochemical refineries, RAC=radioactive contaminated sites, and LNG=liquified natural gas storage facilities.

is superior to the semilog form since it places fewer restrictions on the shape of the implicit price function. More flexible functional forms, such as the generalized quadratic (suggested by Rasmussen and Zuehlke 1990) were rejected because of the large number of interaction terms that would be required given the number of independent variables in each model. The resulting collinearity is likely to yield high standard errors and less precise parameter estimates.

1. Wage Model

Results for the wage model are presented in Table 3 and for the housing model in Table 4. In the wage model, the estimated parameters for the human capital and industry control variables are all highly significant, consistent with prior expectations as to sign, and highly stable across model specifications. Annual wages are lower for females (SEX) and lower yet for married females (SEXMAR). Wages increase with experience (EXPER) but at a decreasing rate (EXPERSQ). Veteran status (VETERAN) and white racial status (WHITE) both increase wages, while education (EDUC) and effort (ANNNHOURS) display the strongest marginal effect on annual earnings. Among occupational categories, management and professional services have the highest income, and the highest industry wage category is for mining. This may represent compensation for the high risk of death and injury faced by miners.

The PRICE control variable (COLINDEX) is significant and positively related to wages, as are the disequilibrium control variables percentage of union members (PCTUNION) and the unemployment rate (UNEMPLOY). Most of the regional dummies indicate that income levels are not significantly different from those in the East North Central region (the omitted category). However, wages are significantly lower in the Middle Atlantic and New England regions and significantly higher in the West North Central region.

Among the AMENITY control variables, percentage of total employment in manufacturing (PCTMFG) and population density (POPDENS) both significantly increase wages. PCTMFG represents either productivity or disamenity effects of

Table 3. Wage Model Results

Dependent Variable: ANNWAGE
(Occupational and industry dummies omitted)

Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0
INTERCEP	-0.351993	0.66239335	-0.531
SEX	-0.230827**	0.01145266	-20.155
MARITAL	0.174262**	0.00955500	18.238
SEXMAR	-0.263079**	0.01314109	-20.020
EXPER	0.019822**	0.00075332	26.313
EXPERSQ	-0.000318**	0.00001571	-20.249
WHITE	0.022015**	0.00898802	2.449
EDUC	0.490949**	0.01826555	26.878
FULLTIME	0.023569**	0.00899288	2.621
DISABLE	-0.105699**	0.01456569	-7.257
VETERAN	0.044901**	0.00841633	5.335
ANNHOURS	0.775632**	0.00604419	128.327
COAST	0.027476*	0.01251886	2.195
CRIME	0.016791	0.00908736	1.848
PCTMFG	0.025256**	0.00831792	3.036
POPDENS	0.008589*	0.00397038	2.163
PRECIP	-0.036482*	0.01570079	-2.324
TEMPDIFF	-0.031967	0.04286765	-0.746
PCTSUN	0.013525	0.06291203	0.215
TSP	0.032103*	0.01429475	2.246
COOLDAYS	-0.003495	0.00817773	-0.427
HEATDAYS	0.007942	0.02303459	0.345
PCTUNION	0.113204**	0.01794124	6.310
UNEMPLOY	0.026822*	0.01106224	2.425
ESC	-0.025393	0.02378343	-1.068
SA	0.016650	0.02235477	0.745
WSC	0.037250	0.02353868	1.582
PAC	-0.034387	0.03313672	-1.038
MT	0.032853	0.02332711	1.408
WNC	0.049764**	0.01809122	2.751
MA	-0.075515**	0.01337714	-5.645
NE	-0.079664**	0.02168899	-3.673
COLINDEX	0.360995**	0.11872765	3.041
NFDNSNUP	0.002969**	0.00111027	2.674
NFDNSCOP	0.000187	0.00093111	0.201
NFDNSGOP	0.000008978	0.00099337	0.009
NFDNSCHM	-0.000290	0.00204766	-0.142
NFDNSHWS	-0.000369	0.00084748	-0.435
NFDNSPCR	0.006262**	0.00094977	6.593
NFDNSPRAC	0.000715	0.00146640	0.487
NFDNSLNG	0.005319**	0.00118037	4.506
R-square	0.6668	*significant at 5% level	
Adj R-sq	0.6660	**significant at 1% level	

Table 4. Housing Model Results

Dependent Variable: VALUEM			
Variable	Parameter Estimate	Standard Error	T for H0: Parameter=0
INTERCEP	-3.684191**	0.49855659	-7.390
DETACHED	0.205662**	0.01149625	17.889
ACREGT1	0.112555**	0.00765448	14.704
CONDO	0.129864**	0.01652464	7.859
WATER	0.005008	0.00846437	0.592
SEWAGE	-0.027142**	0.00710033	-3.823
BLDNGAGE	-0.087041**	0.00273288	-31.850
BEDROOM	0.251398**	0.00786022	31.984
BATHROOM	0.351477**	0.00556632	63.143
YRMOVED	-0.024836**	0.00220058	-11.286
HEATING	0.230846**	0.00697646	33.089
CENTAIR	0.179819**	0.00588588	30.551
OTHRROOM	0.284745**	0.00699891	40.684
COAST	0.148482**	0.00916940	16.193
CRIME	0.080204**	0.00714697	11.222
CNTRLCTY	-0.124415**	0.00649633	-19.152
RURAL	-0.043118**	0.00825912	-5.221
PCTMFG	-0.001832	0.00627551	-0.292
POPDENS	-0.009383**	0.00308888	-3.038
HEATDAYS	0.394780**	0.01877449	21.027
COOLDAYS	0.068237**	0.00625340	10.912
PCTSUN	-0.000643	0.04314873	-0.015
TEMPDIFF	-0.650148**	0.03135414	-20.736
TSP	0.042391**	0.01084818	3.908
PRECIP	-0.028055*	0.01210479	-2.318
ESC	-0.114451**	0.01811245	-6.319
SA	-0.106490**	0.01485843	-7.167
WSC	-0.130917**	0.01527086	-8.573
PAC	0.049031*	0.02427114	2.020
MT	0.227323**	0.01714354	13.260
WNC	0.006137	0.01307672	0.469
NE	-0.106149**	0.01662927	-6.383
MA	0.027673**	0.01014300	2.728
VACANCY	-0.046172**	0.00954088	-4.839
UNEMPLOY	-0.254357**	0.00838562	-30.332
COLINDEX	1.893453**	0.09164892	20.660
NFDNSNUP	-0.002275**	0.00082650	-2.752
NFDNSCOP	-0.006834**	0.00067515	-10.123
NFDNSGOP	-0.004534**	0.00077916	-5.819
NFDNSCHM	-0.003246	0.00162075	-2.003
NFDNSHWS	0.004045**	0.00065956	6.132
NFDNSPCR	-0.008684**	0.00067220	-12.918
NFDNSRAC	-0.000023767	0.00098612	-0.024
NFDNSLNG	0.006261**	0.00091381	6.851
R-square	0.5682		*significant at 5% level
Adj R-sq	0.5678		**significant at 1% level

industry other than the types specifically represented in the model. COAST, which may represent both climatic amenity and productivity effects, is positive and significant. Among the other climate variables, only precipitation (PRECIP) is significant and unexpectedly negative.

The significant coefficients on noxious facility density variables are positive. These include nuclear plants (NFDNSNUP), refineries (NFDNSPRC), and liquified natural gas storage facilities (NFDNSLNG).

2. Housing Value Model

In the housing value model (Table 4), the estimated parameters of the (STRUCT) variables are generally highly significant and consistent with expectations. Detached housing units, condos, and homes on lots larger than an acre (ACREGT1) are higher valued, other things being equal. Central heating (HEATING) and central airconditioning (CENTAIR) increase home value, but access to public sewers (SEWAGE) lowers it. The sign on SEWAGE is counterintuitive, indicating that this variable may be reflecting an association between public sewers and smaller lot sizes or higher taxes associated with provision of these services. Value increases with home size as represented by BEDROOM, OTHERROOM, and BATHROOM. It is unclear why an additional bathroom contributes more to value than an additional bedroom, but this may be related to the phenomenon of larger, multibath homes with additional features. Value decreases with increasing building age (BLDNGAGE) and also decreases with the length of the owner's residence there (YRMOVED).

Most of the regional dummies controlling for disequilibrium effects are significant, and they indicate that housing prices are higher in the Middle Atlantic, Pacific, and Mountain regions relative to the East North Central region. In contrast, prices are significantly lower in all of the southern regions and New England. Homes in both central city (CNTRLCTY) and nonSMSA (RURAL) locations are priced significantly lower than comparable suburban housing, with a more pronounced negative price effect due to central city location. Higher unemployment rates (UNEMPLOY) are associated with significantly

lower house prices, while the cost of living (COLINDEX) is positively related to housing costs.

All of the climate amenity variables are significant except the percentage of sunny days (PCTSUN). Coefficients on both HEATDAYS and COOLDAYS are positive while TEMPDIFF is negative, indicating a preference for either hot or cold climates over those with both temperature extremes.¹⁶ The magnitude of the coefficient of HEATDAYS is larger than that of COOLDAYS, perhaps reflecting some of the higher costs of structural adaptation to cold climates. While total suspended particulates (TSP) and CRIME are both positive, POPDENS is negative, making it likely that these variables proxy a variety of productive or amenity factors.

The coefficients for most facility types are negative and significant. In contrast, the signs on hazardous waste sites (NFDNSHWS) and liquified natural gas facilities (NFDNSLNG) are positive and significant, while that for radioactive sites (NFDNSRAC) is negative and nonsignificant. Although these facilities do not employ large numbers of people, they are frequently located in close proximity to employment centers, which may increase housing values.

3. Implicit Price Estimates

As was indicated in Tables 3 and 4, not all coefficients on facility densities are significant in both equations. Specifically, densities for petrochemical refineries, nuclear power plants, and liquified natural gas facilities are significant in both equations. Densities for radioactive sites are nonsignificant in both equations while all other facility types are statistically significant in one model.

Implicit prices are derived by using average values for control variables in the wage and housing value equations. For illustrative purposes, we present both mean and median prices in Table 5. A few comments are warranted. First, in

¹⁶ There is corroborating evidence for these findings in the migration literature. Graves (1979) found migrants were attracted to areas with either very warm or very cold climates, but they avoided cities with large temperature variations.

both cases the largest implicit price estimates are found for petrochemical refineries, nuclear power plants, and liquified natural gas storage facilities. It is interesting that these are the largest values since we have most confidence in those implicit price estimates that are derived from significant coefficients in both models. Second, the large mean value for petrochemical refineries is influenced by a location with very low facility density. Thus, the mean value exceeds the median by a factor of nearly four. The only other case where considering the mean rather than the median changes the ordinal ranking is for radioactive and chemical weapons storage facilities. Recall that the radioactive site price is derived from insignificant coefficients in both equations, so little confidence can be placed in its value.

Table 5. Implicit Prices for Noxious Facility Density by Facility Type
(Annual value in 1980 \$ per facility/100 square miles)

Facility Type	Median	Mean
Nuclear plants	-563	-639
Petrochemical refineries	-468	-1764
LNG storage	-214	-349
Coal-fired plants	-118	-219
Gas- and oil-fired plants	-45	-151
Radioactive sites	-34	-30
Chemical weapons storage	-12	-51
Hazardous waste sites	+49	+166

The remaining discussion focuses on the median values for these implicit prices. We find that nuclear power plants have a strong negative influence on local economies (\$563 for a representative household per facility density). This finding is inconsistent with results of authors who have applied an intracity modeling approach to data for relatively small local areas (Gamble and Downing 1981, 1982; Nelson 1981). Such studies have generally sought to identify an impact gradient that varies with distance from the plant, and have not been structured in a manner that could reveal broad area impacts. Our results are consistent with the psychometric literature on public aversion to living or working near noxious facilities. Maderthaner et al. (1976), Lindell and Earle (1983), and Mountain West (1989) all find relatively high public aversion to proximity to nuclear plants.

The relative size of the implicit price for petrochemical refineries is almost as great as that of nuclear facilities (\$468). Since refineries are major air emission sources of sulfur oxides and volatile organic compounds (U.S. EPA 1991), the implicit price may reflect the deleterious effect of these emissions on air quality and cancer risks. Liquified natural gas storage facilities have the third highest impact, although it is less than half that of refineries. These facilities mainly present a risk of explosion and fire.

A comparison of the nonnuclear power plants reveals that coal-fired plants produce median implicit prices which are twice the size of implicit prices on gas- and oil-fired plants. This may be due to a perception of greater air quality degradation associated with coal-fired plants because of their higher emission levels of sulfur oxides and particulates (U.S. EPA 1991).

The implicit prices estimated for the radioactively contaminated sites and the chemical weapons storage sites are of approximately the same magnitude as the implicit price for gas- and oil-fired plants. The radioactively contaminated sites have undergone initial decontamination efforts and are slated for further remediation. There is no ongoing activity at these sites and, in some cases, few visual clues are apparent as to their status. The chemical weapon storage sites also present few visual reminders of their existence. They are situated within restricted-access military facilities with large buffer zones.

Finally, the implicit price of hazardous waste sites is actually positive (\$49). This counterintuitive finding may indicate a lack of public awareness of these sites in 1980, prior to development of the National Priorities List of "Superfund" sites. In contrast, Blomquist et al. (1988) found a negative implicit price for Superfund sites using 1980 data, but did not control for the range of local characteristics or noxious facilities included in this study.

Recent methodological development has shown the importance of explicitly modeling migration in applying a hedonic framework to amenity valuation (Evans 1990, Greenwood et al. forthcoming). Use of this approach is a logical next step in examining the impacts of noxious facilities. The resulting impact estimates

have strong implications for regional development policy and noxious facility siting strategies.

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