THE EFFECT OF HAZARDOUS WASTE SITES ON PROPERTY VALUES IN ZONES OF HIGH INDUSTRIAL ACTIVITY: A HEDONIC APPROACH

by

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ABSTRACT

Hedonic pricing methods typically employ a distance-to-site variable to measure variation in exposure to environmental disamenities. Some environmental disamenities, like hazardous waste sites, may be spatially correlated with another prominent feature of the urban plain— zones of industrial activity. In these cases, failure to account for industrial activity is hypothesized to bias coefficient estimates of the distance-to-site measure. The data set includes a distance-to-site measure as well as a distance-to-industrial measure. These measures allow for empirical estimations of the hedonic price function that distinguish the property value effect associated with exposure to hazard from the property value effect associated with industrial activity. The results suggest that failure to account for industrial activity will overstate the effect of hazardous waste sites on property values and inflate benefit estimates associated with hazardous waste clean-up.

Key words: Superfund, Spatial Correlates, Industrial Activity, Hedonic Price Function

I. Introduction

A substantial amount of literature uses hedonic pricing methods to examine the extent to which exposure to environmental hazards and undesirable land uses are capitalized into the sales price of surrounding properties (for reviews of this literature see, Farber, 1998; Jackson, 2001; Boyle and Kiel, 2001). This literature generally supports the hypothesis that exposure to hazards and undesirable land uses will adversely influence surrounding property values (hereafter, known as the *hazard effect*). However, different studies have drawn different conclusions concerning the influence of clean-up and new information on the hazard effect. For example, in a seminal study by Kohlhase (1991) of residential housing sales in the Houston area, the author found evidence to suggest that housing sales prices rebounded after Superfund clean-up activities began. This finding is not consistent with those of Kiel (1995) whose empirical results did not find evidence of a rebound effect after clean-up activities commenced. Kohlhase (1991) also observed that nearby property values declined after the US EPA listed the site as a Superfund site. Dale et. al, (1999), on the other hand, observed a premium for increased proximity to a site after EPA designated those sites as a Superfund site.

One possible explanation for these discrepancies is the specification bias of an omitted variable. Distance-to-site, a measure of distance from the hazardous waste site to the property sale, is the standard measure of exposure used in hedonic property estimations (see Kohlhase, 1991; Kiel and McCain, 1995; Hite et. al., 2001; Kiel and Zabel 2001). While this measure is consistent with studies of health risk (Gayer et. al., 2000; Viscusi and Hamilton, 1999), in some cases, undesirable and hazardous land uses may be spatially correlated with another prominent feature in the urban plain; namely, zones of industrial activity are a feature that may also influence surrounding housing values. In Kohlhase's (1991) study of toxic waste sites, she notes that most of the toxic wastes sites examined in her analysis were once used as waste disposal dumps by manufacturing plants located on the site. This observation may suggest that these sites were formed in areas of industrial activity and therefore, these sites (and other contemporary hazardous waste sites) may be located in areas that continue to be characterized by industrial activity**.** Morris and Perle (1999) argue that a logical spatial relationship exists between areas of high industrial activity and hazardous waste sites. Their argument centers around two key observations: (1) hazardous waste is often a by-product of industrial processes and (2) transportation costs are positive. Given this logic, the authors are not surprised to find that industrial corridors are the location for the majority of hazardous waste sites in Wayne County, MI.

This paper disentangles the hazard effect from the property price effect that may result from exposure to industrial activities (hereafter known as the *industrial effect*). The study area (Lansing, MI) includes two Superfund sites as well as a number of areas zoned for 'highly industrial' activity. The hedonic price function was estimated using over 4,000 housing sales observations taken between 1992 and 2000, house and neighborhood characteristics, and distance variables. Not only does this study use the standard distance-to-site measure but, it also introduces a distance-to-industrial variable. The findings suggest that omitting a measure of a home's relative proximity to an industrial area from the hedonic price function inflates the hazard effect. This finding has significant implications for approximating the benefits of hazardous waste clean-up and evaluating previous research concerned with the response of housing markets to information provided by the U.S. EPA and clean-up efforts.

II. Background

The city of Lansing, MI encompasses an area of approximately 33.8 square miles with a total population of 119,128 persons (U.S. Census Bureau, DP-1, MI, 2000). Lansing is also the state's capital. The property value and household income levels in Lansing are lower when compared to the rest of the state. For example, the 1990 median value of housing in Lansing was $48,400 as compared to the median value of housing in the state which was $60,600 (Ibid., DP-1, Lansing City, 1990; Ibid., DP-1, MI 1990). Moreover, the 1990 median household income for the city of Lansing was $26,398 while the median household income for the state of MI was $31,020 (Ibid, DP-4, Lansing City, 1990; Ibid, DP-4, MI 1990).

Two hazardous waste sites that are historically and presently linked to industrial activity are Motor Wheel and Barrels, Inc. The Motor Wheel site served as a waste area for the Motor Wheel corporation from 1938 to 1978 (U.S. EPA, Motor Wheel, 2001). Barrels, Inc., recycled industrial metal barrels from 1964 to1981 (U.S. EPA, Barrels Inc., 2001). Both of these sites are located in the northern section of the city and in close proximity to areas that continue to be areas of high industrial activity. Figure 1, provides a map identifying Motor Wheel and Barrels Inc., as well as areas zoned for high industrial activity.

The forthcoming discussion summarizes detailed information from a number of EPA web sites (see, EPA, November 2001; EPA, March 2001) concerning Motor Wheel and Barrels Inc. Motor Wheel is a 24-acre site that was used primarily for industrial waste from 1938 to

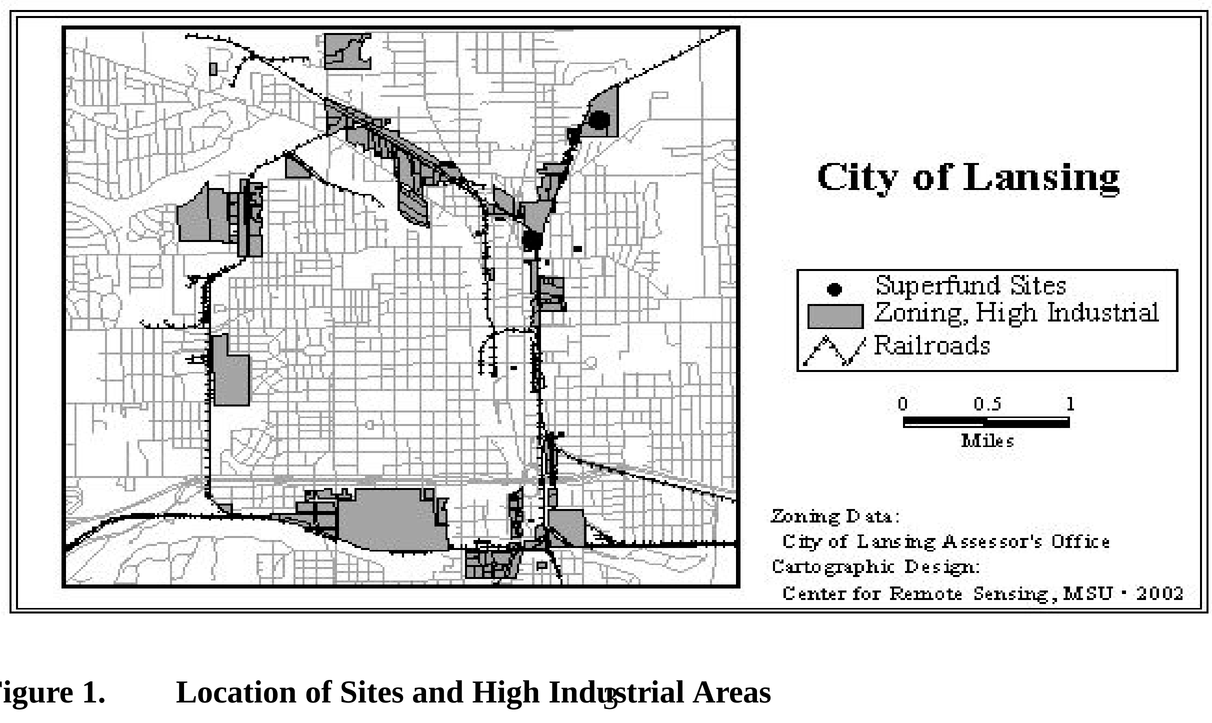

Figure 1. Location of Sites and High Industrial Areas

1978. In 1981 the EPA 'discovered' Motor Wheel and after further investigation it was placed on the National Priorities List (NPL) in 1986. During Barrels, Inc.'s active years (1964-1981), the company used its operation site for processing as well as disposal. In 1982 the EPA became aware of the site, but did not add it to the site until 1989.

A number of Superfund processes have taken place since the EPA listed these sites on the NPL. A record of decision (ROD), which outlines the general procedure for cleanup, was submitted for Motor Wheel in 1991 and Barrels in 1996. However, actual clean up does not begin until the submission of a remedial design (RD), which provides engineering details. The RD for Motor Wheel, though initiated in 1992, was not actually completed until 1997, and the RD for Barrels, Inc., is still under development. Currently, Motor Wheel remains in the remedial action phase of cleanup and the EPA has not closed-out either site.

III. Data Collection

The Lansing Assessor's office provided data on residential housing sales and associated structural characteristics for the years 1992-2000. The universe of sales available to the Assessor's office include all housing sales registered by the counties in which the city of Lansing lies. This study did not consider sales categorized as foreclosures, sheriffs' sales, quick claim deeds, and other non-conventional forms of sale to be 'arms length' sales and, therefore, omitted them from the data set. Additionally, housing sales that were closer to a Superfund site located outside the incorporated area of Lansing than either Motor Wheel or Barrels, Inc., were not included in the analysis.

Palmquist (1992) and others (i.e. Kiel and Zabel, 2001) argue that the externalities associated with hazardous waste sites are likely to be 'localized'; that is, the externality affects those in relative close proximity to the site. For this reason, and because of the difficulties inherent in correctly specifying a hedonic price function for an entire urban area, Palmquist estimates the hedonic price function over a smaller, more homogenous area than the entire urban market. Following Palmquist's reasoning this study focused on a smaller area. In the case of Lansing, the city is divided into a northern and southern segment by a major east-west expressway. Since the Superfund sites under examination are in the northern portion of that northern segment the universe of housing sales examined includes the area north of the expressway.

Geographic information systems (GIS) were used to determine the straight-line distance between housing observations and the perimeter boundary of the nearest Superfund site (either Barrels, Inc. or Motor-Wheel). The perimeters of the Superfund sites were mapped using a global positioning system. The coordinates were applied to the base map files using 1990 Tiger Base File maps and Michigan framework data. GIS was also used to measure the straight-line distance from each housing sale to the area zoned as 'highly industrial'. The assessor's office provided a boundary map of contemporary industrial zoning.

The police department provided the data enabling the specification of a crime variable. The number of malicious destruction of property violations that occurred in each block group for 1996, defines the crime variable. The neighborhood characteristics of income, education, race, ethnicity, rent, and commute (defined in Table 1 in the next section) come from the 1990 census summary tape files # 3 at the block group level for the city of Lansing, MI. GIS was used to link the location of each housing sale with its block group.

IV Examining Bias Using the Hedonic Price Function

Freeman (1993) provides a full discussion on the host of theoretical and empirical issues associated with hedonic pricing methods and estimation of the hedonic pricing function. These issues are not reviewed here. The primary concern of this empirical analysis is to examine the potential bias in the use of the distance-to-site measure when estimating a hedonic price function.

The estimated hedonic price function is specified such that the price of a residential home is a function of the bundle of attributes that characterize the home and the year that the home was sold :

$$\ln(P_i) = \beta_0 + \beta_1 \ln(D_i^H) + \beta_2 \ln(D_i^I) + \Theta Z_i + \Phi Y_i + u_i \quad (1)$$

where, the price of house, i, is determined by: (1) proximity to hazardous waste sites, D^H; (2) proximity to areas of high industrial activity, D^I; (3) a vector of attributes that describes the house and the character of the neighborhood in which the house resides, Z_i; (4) and a set of dummy variables to account for the year in which the house was sold, Y_i. The error term, u_i, is assumed to have a conditional mean of zero and a constant variance. The specified functional form presumes a log-log relationship between price of the house and proximity to the hazardous waste site and proximity to areas of high industrial activity. Thus, the marginal effect of exposure to hazard, as measured by distance-to-site, is expected to decrease at a decreasing rate as distance between the site and the residence increases. The remaining relationships between housing price and housing attributes are specified as a log-level function, with the exception of floor area, age of the house, and income, which also appear in logarithmic form. Table 1 provides the full set of variables used to estimate the hedonic price function.

Table 1. Variables Collected for Regression Analysis and Description

Variable	Description of Variable
Dependent Variable	
Price	Final housing sale price for years between 1992-2000.
Hazard and Industrial Variables	
Hazard	Distance from each home to the nearest Superfund site in meters.
Industrial	Distance from each home to the nearest perimeter of an area zoned as 'highly industrial', in meters.
Housing Structure Variables	
Bath	# of bathrooms in each house sold..
Floor	Residential floor area in square feet.
Age	Effective age of the house when sold.
Acre	Total acreage sold with the house.
sty 11/4*	= 1, if 1.25 story home; 0 otherwise.
sty 11/2	= 1, if 1.5 story home; 0 otherwise.
sty 13/4	= 1, if 1.75 story home; 0 otherwise.
Sty2	= 1, if 2 story home; 0 otherwise.
dstyle	= 1, if raised ranch, tri-level, or 21/2 story home; 0 otherwise.
Neighborhood Variables	
Crime	# of Malicious Destruction of Property Violations by block group for 1996.
Income	Median household income, by block group.
Edu	Percentage of persons with a college degree, by block group.
Black	Percentage of the population that is black, non-Hispanic, by block group.
Hisp	Percentage of population that is Hispanic, by block group.
Rent	Percentage of the households that rent, by block group.
Commute	Percentage of those whose commute to work is less than 20 minutes; by block group.
Year Variables	
dum93**	=1 if year = 1993; 0 otherwise.
dum94	=1 if year = 1994; 0 otherwise.
dum95	=1 if year = 1995; 0 otherwise.
dum96	=1 if year = 1996; 0 otherwise.
dum97	=1 if year = 1997; 0 otherwise.
dum98	=1 if year = 1998; 0 otherwise.
dum99	=1 if year = 1999; 0 otherwise.
dum2000	=1 if year = 2000; 0 otherwise.

* 1 story house is the omitted variable.
**1992 is the omitted variable.

The hazard variable, D^H, measures distance from each house, i, to the nearest Superfund site. Reduced proximity to the hazardous waste site is expected to reflect reduced perceptions of exposure to the hazardous waste site. Increases in D^H are postulated to be positively associated with a higher housing price. Thus, β_1 is hypothesized to be positive.

Because high levels of industrial activity presumably produce environmental disamenities, residents are assumed to value reduced exposure to these areas. Decreased exposure to areas of high industrial activity, therefore, is expected to be associated with higher housing values. Thus, increases in the ‘industrial’ variable D^I, which measure each home’s straight-line distance to the perimeter of the nearest area zoned as highly industrial, are anticipated to be correlated with higher housing values. Therefore, β_2 is hypothesized to be positive.

If the hedonic price function does not take into account the industrial price effect and the spatial correlation between industrial activity and hazardous waste sites, then failure to include the industrial variable may bias the hazard coefficient estimate. Equation 2 specifies the expected value for β_1, when the industrial variable is omitted from empirical estimation of the hedonic price function.

(2)
$$E(\tilde{\beta}_1) = \beta_1 + \beta_2 \frac{\sum_{i=1}^{n} (\ln D_i^H - \ln \bar{D}_i^H) \ln D_i^I}{\mathrm{Var}(\ln D_i^H)}$$

As Equation 2 demonstrates, the estimated coefficient for β_1, $E\left(\tilde{\beta}_1\right)$, will depend on the hazard effect, β_1, the omitted industrial effect as measured by β_2, and the correlation between the hazard and industrial variables.[1] Under the hypothesized relationships (i.e. $\beta_1>0$, $\beta_2>0$, Corr $(D^H, D^I)>0$

[1] Equation 2 implicitly assumes that the correlation between the other explanatory variables and the industrial or hazard variables is zero (see Wooldridge, p. 92 for a detailed discussion).

), an inflated estimate of the hazard variable should occur when the industrial measure is omitted.

Table 1 describes the additional set of variables used to estimate the hedonic price function. All else constant, increase in housing prices may occur as a result of increases in the number of bathrooms, square footage, floor area, and acreage of the home to be associated with increases in housing price. Increases in the age of the home may affect a decline in housing values, all else constant. The price effect associated with the style of the home (i.e. one-story versus two-story) is uncertain given the fact that the model controls for floor area. However, it may be that construction costs or preferences differ by housing style. Thus, categorical variables are included to account for different housing styles.

Quality-of-neighborhood measures such as crime, income, education, and percentage of renters were also included as variables in the hedonic price function. The occurrences of crime in a neighborhood may adversely affect housing values and therefore, one crime measure, the number of reported cases of malicious destruction of property, is included in the hedonic price function. Higher levels of neighborhood income and education are presumed to be valuable neighborhood attributes. Therefore, higher levels of income and education in a neighborhood are expected to raise housing prices. The percentage of renters in a neighborhood may also affect the price of housing in a neighborhood. Renters may have less of an incentive to invest in property or neighborhood maintenance than residential homeowners. Thus, higher percentages of renters in a neighborhood is hypothesized to adversely influence surrounding housing prices, all else constant.

Three further variables that this study uses are the race, ethnicity, and commute variable. The race and ethnicity of a neighborhood have been shown to influence housing prices, thus these variables are included in the analysis (Cutler, et al., 1999); (Massey and Denton, 1988). Greater proximity of households to areas of employment should reduce the costs of commuting and this savings may be capitalized into property values and potentially result in higher housing prices. The commute variable measures the percentage of those whose commute to work is less than 20 minutes in a specified neighborhood. Higher levels of the commute variable are expected to result in higher housing prices, all else constant.

V. Empirical Estimates and Regression Results

Table 2 provides the mean and standard deviation of the dependent and explanatory variables. The data's mean housing price and income level are consistent with US Census estimates provided in section 2 . Ordinary Least Squares (OLS) is used to estimate the hedonic price function. Table 3 presents the coefficient estimates of the hedonic price function. Model 1 estimates the hedonic price function without an industrial variable. Model 2 estimates the hedonic price function with an industrial variable. A Bruesch-Pagan test of the residuals rejected the null hypothesis of homoskedasticity. Therefore, a valid estimator of the standard errors was obtained using a method usually referred to as White, Huber, Eicker, (hereafter known as *robust* standard errors) (see Wooldridge, 1999).

The empirical findings in Model 1 suggest that increases in distance from hazardous waste sites resulted in higher housing prices, all else constant. Such a finding is consistent with previous literature and is generally interpreted to support the hypothesis that people are willing to pay to avoid the hazards associated with the site. In Model 1 a 10% increase in distance from a Superfund site is associated with a .3% increase in housing value. Moreover, the coefficient estimate is statistically different from zero at the 95% level. However Model 2, which includes a measure for a house's proximity to an area zoned as highly industrial, provides a decidedly different coefficient estimate for the hazard effect. In Model 2 the coefficient for hazard is approximately cut in half and the coefficient estimate is no longer statistically different from zero at the 95% level. However, the industrial variable is positive and statistically different from zero at the 95% level, the coefficient indicates that a 10% increase in distance from an industrial area is associated with a .28 % increase in housing values. Thus, Model 2 suggests that people are willing to pay a premium for reduced proximity to areas of high industrial activity. However, once the industrial effect is accounted for, proximity to one of the Superfund sites does not appear to influence housing values.

The relatively higher value of the hazard coefficient in Model 1, which omits a measure of industrial activity, is consistent with the hypothesized bias described in section four. In summary, the industrial coefficient estimate is positive and statistically different from zero at the 95% level. The correlation between hazard and industrial variables is positive (Pearson correlation coefficient for hazard and industrial is approximately .5). Given these relationships, failure to include an industrial variable in a hedonic price function is shown to inflate the estimate of the hazard coefficient.

The estimated coefficients of the other variables in the hedonic price function were generally consistent with a priori expectations. The floor area of the home and the age of the house were found to be important factors explaining variation in housing values. For example, both Model 1 and Model 2 coefficient estimates of floor area suggest that a 10% increase in floor space is expected to raise the housing price by approximately 7%. Moreover the floor area variable is statistically different from zero at the 95% significance level. Both models also suggested that increases in the age of the house affected a decline in the house's value. A 10% increase in the age of the house was associated with approximately a 2% decrease in the price of the home. Neither acreage nor the number of bathrooms were statistically different from zero at the 95% level.

The estimated coefficients for income, education, and commute variables suggest that homes located in neighborhoods characterized by higher incomes, higher levels of education, and in greater proximity to areas of work are associated with relatively higher housing prices, all else constant. These coefficient estimates are statistically different from zero at the 95% level. Increases in the percentages of minorities (black and hispanic) and renters in a neighborhood are associated with relatively lower housing prices. These finding are also statistically different from zero at the .05 significance level. Higher levels of crime, as measured by malicious destruction of property, was also hypothesized to be associated with lower property values, all else constant. However, the coefficient estimate of the crime variable is not statistically different from zero at the .05 significance level.

Table 2. Summary of Variables (4502 Observations)

Continuous Variables		
Variables	**Mean**	**Std. Deviation**
price	49055	28906
hazard	1670	723
industrial	894	646
bath	1.313	.534
sqft	1165	465
age	71.867	23.556
acres	.148	.102
income	24458	9728
educ	16.7	12.2
black	12.357	10.246
hisp	10.795	8.637
rent	43.983	19.771
crime	22.317	12.932

Categorical Variables		
Variables	**Mean**	**Std. Deviation**
sty1	.380	.485
sty 11/4	.091	.288
sty 11/2	.071	.258
sty13/4	.110	.313
sty2	.330	.470
dumstyle	.010	.100
92	.088	.284
93	.084	.278
94	.096	.294
95	.096	.295
96	.110	.313
97	.110	.313
98	.121	.326
99	.127	.333
00	.114	.318

Table 3. OLS Coefficient Estimates with Huber-White Standard Errors ( )

Dependent Variable = ln(price)	Model 1	Model 2
ln(hazard)	.033 (.012)**	.013 (.013)
ln(industrial)	-----------	.028 (.010)**
bath	-.001 (.016)	-.006 (.016)
ln(floor)	.689 (.037)**	.686 (.039)**
ln(age)	-.184 (.036)**	-.188 (.036)**
acres	.163 (.270)	.183 (.282)
sty11/4	.014 (.018)	.051 (.024)
sty11/2	-.052 (.024)	-.043 (.023)
sty13/4	-.073 (.0212)**	-.070 (.022)**
sty2	-.085 (.021)**	-.083 (.021)**
dumstyle	.092 (.055)	.097 (.056)
crime	.0003 (.0005)	.0005 (.0005)
ln(income)	.074 (.037)*	.095 (.037)**
educ	.008 (.0007)**	.007 (.0009)**
black	-.005 (.0007)**	-.005 (.0007)**
hisp	-.008 (.001)**	-.008 (.001)**
rent	-.004 (.0005)**	-.003 (.0006)**
commute	.0008 (.0008)	.001 (.0008)

Table 3:Continued...

Dependent Variable = ln(price)	Model 1	Model 2
93	-.001 (.027)	-.004 (.027)
94	.105 (.023)**	.104 (.023)**
95	.136 (.023)**	.135 (.023)**
96	.174 (.023)**	.172 (.023)**
97	.244 (.023)**	.242 (.023)**
98	.315 (.022)**	.312 (.022)**
99	.363 (.022)**	.361 (.022)**
00	.461 (.023)**	.458 (.023)**
Constant	5.54 (.537)**	5.29 (.527)**
	Number of obs = 4502 F(25,4476) = 343.44 R-squared = 0.611	Number of obs = 4502 F(26, 4475) = 329.51 R-squared = 0.613

** Statistically different from zero at the .025 significance level.
* Statistically different from zero at the .05 significance level.

VI. Benefit Estimates

Freeman (1993) describes a special case in which the hedonic price function can estimate the benefits that result from non-marginal changes in the levels of an environmental disamenity. This case is relevant when the number of the properties affected by the disamenity is localized relative to the size of the housing market. Kiel and Zabel (2001) argue that the concept of localized, "is applicable to the cleanup of a hazardous waste site since the impact on house values will only be felt in the vicinity of the site" (pg. 170). In this scenario the hedonic price function is not expected to shift due to changes in the level of the disamenity.

In order to demonstrate some practical implications of omitting an industrial measure, the hedonic price functions, as estimated in Model 1 and Model 2, are used to estimate separate approximations of the expected benefits of cleaning-up the hazardous waste sites. The estimated coefficients of the hedonic price function are used to predict the logarithm of housing price for each housing observation. These values are transformed into expected prices using anti-logs (exponential).[2] In a similar manner the hedonic price function is used to predict the expected price of a house if complete clean-up of both sites were to occur. The post-clean-up price of a home is derived from the hedonic price function by predicting the price of each house at a distance from the sites where exposure to hazard is no longer expected to influence housing values. A conservative distance of one-half a mile is serves as this distance.[3] The difference between the post clean-up price of a home and the predicted value of each housing observation defines a benefit estimate for each observation. Each housing observation and associated benefit

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[2] The estimates are adjusted for biases that result from taking the anti-log of the predicted logged dependent variable (see Stynes, D. et al, 1986 for a complete discussion). The adjustment method used is outlined by Wooldridge, 1999, pg.. 202.

[3] Due to the log-log functional form, the marginal benefits of increased distance from the Superfund site approach zero asymptotically. Therefore, defining an exact point where there are no benefits for increased distance from the site is somewhat arbitrary. However, at ½ mile, using Model 1, the marginal benefits of increased distance from the site appear to level out.

estimate are then sorted into the associated assessor's neighborhood (as defined by the City of Lansing). The number of residential units in each assessor's neighborhood serves as an approximate density measure for houses within one-half mile of either Superfund sites. The mean values of the predicted benefits for each assessor neighborhood are multiplied by the number of residential units and these values are aggregated to derive an estimate of the benefit of clean-up.

The benefit estimates using Model 1 coefficient estimates is approximately $1,249,348. The benefit estimate using Model 2 coefficient estimates is approximately $492,532. Both estimates are in nominal dollars. Thus, failure to account for areas of high industrial activity leads to estimates that over-state the benefits of hazardous waste clean-up. Moreover, the finding that the hazard effect in Model 2 was not statistically different from zero implies that the benefit differences between Model 1 and Model 2 may be even greater than those approximated.

VII. Summary of Key Findings and Implications

Failure to account for spatial correlates, like areas of high industrial activity, may significantly bias examinations that are concerned with estimating the hazard effect or approximating the benefits of hazardous waste clean-up. This study's findings suggest that failure of hedonic analysis to account for zones of high industrial activity will lead to empirical results that overstate the property effect of a hazardous waste site and the benefits of clean-up. Zones of high industrial activity may produce disamenities to nearby residential areas such as noise, traffic congestion, odors, and risks to life and property from industrial and heavy transportation accidents. As a result, an industrial zone may constitute a portfolio of risks. The risks of a hazardous site are likely to be only an element of this portfolio. Hence, it is possible that discrepancies in the literature regarding the rebound effect may result from changes in the character of industrial activities in areas surrounding the toxic sites. Similarly, differences in the influence of an omitted industrial measure may help explain why some studies find a hazard effect after sites are listed on the NPL and other studies do not.

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