Economic Analysis and Land Use Policy

PROCEEDINGS
--Session One--
Brownfields and Property Values

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Proceedings for Session 1

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Introductory Remarks of Stephen Lingle,

Director US EPA National Center for Environmental Research and Quality Assurance, Environmental Engineering Research Division -- Summarization

Mr. Lingle welcomed participants of the workshop, the fourth that has been jointly sponsored by the National Center for Environmental Research and Quality Assurance (NCERQA) and the former EPA Office of Policy, now the Office of Policy, Economics and Innovation. Mr. Lingle commented that the topic for today's workshop was a timely one, with the currently increasing realization of the link between land use and environmental quality. Mr. Lingle noted that a recent Washington Post article discussed the continuing Clean Air Act noncompliance of nine of the ten major metropolitan areas. The article noted that because the states in these cases will have to redevelop their implementation plans, some local governments may have to make difficult and unpopular decisions regarding urban sprawl. This is an example of the kind of issue that will come increasingly to the fore of environmental protection. Mr. Lingle noted that Harriet Tregoning, with the EPA Office of Policy, Economics and Innovation, has been on the forefront of this issue. For the Office of Research and Development, this workshop represents an opportunity to communicate some of the results that are being obtained from research funded by EPA's Science to Achieve Results (STAR) program, which has been part of EPA's extramural research program. For the past five year, this program has been jointly sponsored with the National Science Foundation. Three of the speakers today have been funded by the STAR program. Mr. Lingle closed by referring workshop participants to the STAR program website, where there are postings for requests for proposals and abstracts of grants funded, and summary reports of STAR research. Mr. Lingle also acknowledged Matt Clark, of who has been responsible for socio-economic research at NCERQA.

Environmental Contamination, Risk Perceptions, and Property Values

--Working Paper*--

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Environmental Contamination, Risk Perceptions, and Property Values

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I. Introduction

Stigma is a negative attribute of real estate acquired by the discovery of contamination and reflected in price (Elliot-Jones, 1996). Stigma in residential property values may be caused by path dependence or uncertainty. If path dependence is present, then cleaning up a hazardous waste site will not result in the same outcome that would occur if the hazardous waste site never existed. The presence and duration of stigma are tested for using hedonic price techniques with data from housing sales prices in Dallas County, Texas. The empirical evidence shows that stigma exists after cleanup only for houses in very close proximity to the hazardous waste site.

A related issue is that stigma may be caused by both scientifically assessed risk and perceived risk. In its prioritization of sites for cleanup, the EPA wishes to only consider risk as quantified by scientists. However, a perception of risk is enough to lower property values, as illustrated by the case of electromagnetic fields cased by high-voltage lines. Owners of properties near electrical transmission lines have claimed reductions in value due to stigma, caused by electromagnetic field-related health risks and heightened public perceptions of cancer risks (Gregory and von Winterfeldt, 1996). The public's beliefs are often very different from the experts (McClelland *et al.*, 1990). The public tends to not believe experts when they say that a previously-identified source of contamination is actually safe. An empirical analysis of the effect of perceived risk caused by environmental contamination on property values is also presented. We find empirically that media coverage increases perceived risk, and that increased perceived risk surrounding the site, in turn, lowers property values.

II. Previous Empirical Studies

The current body of literature on the empirical effects of locally undesirable land uses does not address whether the diminution of property values caused by these land uses is temporary or permanent or whether path dependence effects exist. Although there have been many previous studies which attempt to measure the effect of environmental contamination and cleanup on property values, they focus on a short-run phenomenon. Most importantly, existing studies have not analyzed post-cleanup property values. Typically, impacts of contamination on property values are examined with a cross-sectional data set at a single point in time.[1] By not including post-cleanup property values, these studies cannot structure the event analysis correctly to analyze the effects of cleanup.

Many authors have used property value data to value environmental attributes and, more specifically, study the impact of hazardous waste sites. Researchers, such as Ketkar (1992), Kiel (1995), Kiel and McClain (1995), Kohlhase (1991), Smith and Desvousges (1986), and Thayer *et al.* (1992) have consistently found that proximity to hazardous waste sites and other locally undesirable land uses (LULUs) has a negative impact on property values.[2]

Contingent valuation is an alternative approach to property value studies for estimating benefits from

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1 Exceptions include Kohlhase (1991) and Kiel (1995), who examine property values at more than one point in time, but do not consider post-cleanup property values. Kiel and McClain (1996) examine housing prices before and after a failed incinerator siting. However, for the latter analysis the incinerator was only hypothetical. Dale *et al*. (1999) do consider post-cleanup values, but they do not consider discontinuities in the price gradient on distance.

2 For additional cites and a comprehensive survey of empirical results, see Farber (1998).

the cleanup of hazardous waste sites. For example, Burness *et al*. (1983) and Smith and Desvousges (1986) have used contingent valuation to estimate willingness to pay to reduce the risk associated with a hazardous waste site. However, as Thayer *et al.* (1992) point out, “The efforts have had little success because respondents apparently have significant difficulties assessing changes in low probability events.”[3]

In contrast to previous empirical studies, this analysis examines impact of environmental contamination on residential property values by analyzing data from before identification of the hazardous waste site, and before, during, and after cleanup has been completed. Consequently, it is possible to consider the longer-run recovery prospects.

III. Statistical Model

The price of housing and land reflects consumers’ valuations of all the attributes that are associated with housing, including environmental quality. The level of environmental quality can be considered to be a qualitative characteristic of a differentiated good market. Consumers can choose the level of environmental quality through their choice of a house. Housing prices may include premiums for locations in areas with high environmental quality. If so, the price differentials may be viewed as implicit prices for different levels of environmental quality.

Following the standard hedonic price model, the price of housing, P, in Dallas County, Texas, is assumed to be described by a hedonic price function, $P = P(x)$, where x is a vector of structural,

3 Thayer *et al.* (1992), p. 266.

neighborhood and environmental attributes. The hedonic price of an additional unit of a particular attribute is determined as the partial derivative of the hedonic price function with respect to that particular attribute. Each consumer chooses an optimal bundle of housing attributes and all other goods in order to maximize utility subject to a budget constraint. The chosen bundle will place the consumer so that his indifference curve is tangent to the price gradient, P_x. The marginal willingness to pay for a change in a housing attribute is then equal to the coefficient of the attribute (Rosen, 1974).

Our study follows the previously sited literature and considered only linear and semi-log (natural logarithm of the dependent variable) functional forms. A linear specification has the obvious interpretation that a unit increase in an attribute causes the price to rise by an amount equal to the coefficient; while with a semi-log specification, the coefficients can be interpreted as a percent of the average house price. Given the presence of independent dummy variables, the following Box-Cox transformation of the dependent variable was used to choose between the linear or natural logarithmic forms for the dependent variable.

(1)

$$p(l) = \begin{cases} \dfrac{P^{l} - 1}{l}, & l \neq 0 \\ \ln l, & l = 0 \end{cases}$$

Using Box-Cox maximum likelihood analysis, l was estimated for each year. The yearly estimates of l range from -0.09 to 0.21. A value of l = 0 implies that a semi-log specification is best, and l = 1 indicates a linear form is preferred. Confidence intervals for l were also estimated. The hypothesis that l = 1 could be rejected for every year. Although the hypothesis that l = 0 could be rejected for most years,4 the estimates of l are always close to zero. Given this limited analysis of functional form, the semi-log specification below is reported:

$$\ln P(x) = b_0 + \Sigma\, b_i x_i + e \,. \qquad (2)$$

Where P is the sale price of the home, the x_i's are the various attributes of the house, and e is a white noise error term.

IV. The Data Set

The data set includes over 200,000 observations with variables describing price and attributes of all single-family, detached homes sold over the period 1979 to 1995 in Dallas County, Texas (Dallas County Appraisal District). Each observation includes information about the sale price5 of the homes and different variables which affect the sale price, including house, neighborhood and environmental quality attributes. As usual, housing quality is described by the square footage of living space, number of bathrooms, lot size, and dummy variables indicating the presence of a pool, central air conditioning, house condition and similar variables. Neighborhood quality is based upon variables such as percent below the poverty level, school quality, ethnic composition and accessibility to the Dallas-Ft. Worth airport, the Dallas central business district (CBD) and the Galleria Mall.

4 The large sample size results in very tight confidence intervals.

5 Prices were deflated using the shelter housing price index (1982-84=100) from the *Economic Report of the President.*

Environmental quality is described by proximity to the RSR lead smelter and three other sites. (Other environmental indicators, e.g., air and water quality, do not vary by location and were not included in this study). Using a Geographic Information Systems (GIS) database, Dallas County was set up as a grid of *X* and *Y* coordinates. Coordinates were assigned to each house, the airport, the CBD, the Galleria Mall, and selected hazardous waste sites. Distance could then be calculated between any two points. The GIS database was also used to link each house to its census tract (and the corresponding demographic information) and its school district. A media variable was created from a stratified random sample of issues of the *Dallas Morning News* in each year. From the newspaper issues sampled in each year, the media variable is equal to the number of newspaper articles about the RSR smelter site, weighted by inverse of the page number of the start of the article. A description of the variables used in the analysis and descriptive statistics are provided in Table 1.

The most important and publicized of the contaminated sites included in this study is the RSR lead smelter. The RSR lead smelter is located in the central portion of Dallas County, approximately six miles west of the CBD. The smelter operated from 1934 to 1984 and was purchased in 1971 by the RSR Corporation. The smelter emitted airborne lead, which contaminated the soil in the surrounding areas. Lead debris created by the smelter was used in the yards and driveways of some West Dallas residences. In 1981, the EPA found health risks, and RSR agreed to remove any contaminated soil in the neighborhoods surrounding the RSR site using standards that were considered protective of human health at the time. In 1983 and 1984, additional controls were imposed by the City of Dallas and the State of Texas. In 1984, the smelter was sold to the Murmur Corporation who shut the smelter down permanently. In 1986, a court ruled that the cleanup was complete.

In 1991, the Center for Disease Control (CDC) lowered the blood level of concern for children from thirty to ten micrograms of lead per deciliter of blood. Low-level lead exposure in childhood may cause reductions in intellectual capacity and attention span, reading and learning disabilities, hyperactivity, impaired growth, or hearing loss (Kraft and Scheberle, 1995). Also in 1991, the State of Texas found hazardous waste violations at the smelter. In 1993, the RSR smelter was placed on the Superfund National Priorities List (NPL).

Three other contaminated sites are also included in our analysis. These additional sites were selected on the basis of relative importance and proximity to active housing markets in the region. Each of these sites was listed on the EPA's Comprehensive Environmental Response, Compensation, and Liability Inventory List (CERCLIS) during the study period, and none was cleaned up or removed from CERCLIS during the study period. Information about these sites is presented in Table 2.

V. Estimation Methods and Empirical Results

The analysis covers the impact of the smelter on property values over four event-driven time periods: (1) pre-1981, when the smelter operated but health risks were not officially identified nor publicized; (2) 1981-86, when health risks from soil contamination were officially identified, cleanup was initiated and a Court ruled cleanup was completed; (3) 1987-90, after cleanup was ruled completed; and (4) 1991-95, when new concerns arose and additional cleanup occurred. Slovic *et al* (1991) provides support for the use of event-driven time periods. They write, "Social amplification [of risk] is triggered by the occurrence of an adverse event."6 Kiel and McClain (1995) also divide their data into event-driven time periods in order to analyze the effect of changes in information over time about an incinerator siting on property values.

In addition to considering division by event-driven time periods, Chow Tests were performed to evaluate whether structural changes occurred. The results indicate that almost every year is significantly different from the previous one. The exception is that the data from sales in 1993 was not significantly different from the data from sales in 1994. In addition, Wald Tests for structural change, which do not assume that the disturbance variance is the same across regressions were performed to test if the event-driven periods are the same. The results indicate that each period is significantly different. In order to partially control for the differences across years within the event-driven time periods, dummy variables are included to the indicate year of sale.

Distance Model Estimation Results: We estimated the standard distance model given by Equation 12. The estimation results are presented in Table 3. The estimated coefficients have the expected signs and are statistically significant in each period, with only a few exceptions. Our first hypothesis is that people pay a premium for distance from the RSR Smelter. This hypothesis can be rejected if the estimated coefficient for the distance variable is not significantly greater than zero. The price gradient starts out significantly positive before the EPA identification of the RSR site and during cleanup of the site, indicating that a buyer is willing to pay a premium for a location which is farther away from the RSR site. The positive sign on distance before EPA identification could be interpreted to mean that effect of the RSR site is already capitalized in property values in the 1979-1980 time

6 Slovic *et al.* (1991), p. 685.

period. However, after cleanup, this coefficient turns significantly negative. This differs from the expected sign of the distance coefficient, which is either positive or zero. There are a number of explanations for the negative sign in a straight distance model estimation.

The most compelling explanation for the negative sign on the distance coefficient after cleanup is that sphere of influence of the smelter is limited. This issue is explored with an examination of the continuity price gradient and a comparative analysis of the smelter area and a control area. Another possible explanation for the negative coefficients is that before identification, houses were sold as close as 0.17 miles from the RSR site. In the period after cleanup (1987-1990), no houses within a mile of the RSR site were sold.7 Therefore, in the first post-cleanup period (1987-1990), the discounted houses within one mile of the smelter no longer affect the coefficient on the distance variable.

Our next hypothesis is that the coefficient on distance does not change over the different event-driven time periods. This can be tested using F-tests. This hypothesis is a crude test of the duration of stigma.8 For example, if the coefficient on distance starts out positive, and then after remediation it is no longer positive, stigma is not permanent. Our results indicate that the coefficients on distance are significantly different in each of the four periods.

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7 The usual explanation for a lack of sales around a locally undesirable land use is that there are no buyers. However, it may also be the case that potential sellers are holding on to their properties with the hope that property values will rise in the future.

8 The reason that this is a crude test for the duration of stigma is that the price gradient for distance from the smelter will be discontinuous if the sphere of influence of the smelter dissipates rapidly with distance.

Continuity of the Price Gradient: Previous studies, such as McClelland, *et al*. (1990), have found that the impact of the waste site on property values dissipates rapidly with distance. Following Thayer, *et al*. (1992), two sets of estimations were completed to allow for discontinuity of the price gradient. First, the continuous distance variable was converted into five discrete indicator variables for distance, ranging from less than one mile to greater than four miles, in one-mile increments. These distance dummy variables were used in place of an intercept term in the hedonic regressions. The next distance models that were estimated include a linear spline function on distance, which allows for a discontinuity in the price gradient. The linear spline allows for there to be one premium for distance up to a critical point and then an adjustment to the premium after that point.

We tested the hypothesis that the effect of the smelter is constant with distance. Intuitively, we conjectured that the marginal premium paid for distance from the smelter will dissipate with distance. Using the discrete distance model, the hypothesis can be rejected if the coefficients on distance are significantly different from each other. The estimated coefficients on the discrete distance dummy variables are presented in Table 4. In each period, the intercept for houses sold within a one-mile radius of the RSR site is significantly less than the others, with the exception of the first post-cleanup period (1987-1990) when there were no sales within one mile of the RSR site.

The second set of estimations involved a linear spline function. Formally, let x_1 be the distance to the site, let x_2 be the distance at which the influence of the site diminishes, and let x_3 to x_n be the other attributes of the house. The linear spline can be represented as

(3) $$P(x) = b_0 + b_1 x_1 + b_2 d_2 \left(x_1 - x_2\right) + \sum b_i x_i \ .$$

Where $d_2 = \begin{cases} 1, & if \ \ x_1 > x_2 \\ 0, & otherwise \end{cases}.$

This model was estimated twice allowing for a discontinuity in the price gradient at both one mile and four miles.9 The estimation results with a linear spline function with critical points at one and four miles are presented for the distance coefficient, b_1, and the adjustment coefficient, b_2, in Table 5. The hypothesis that the effect of the smelter is constant with distance can be rejected if the coefficient on the adjustment variable is significantly different from zero. The coefficients on the adjustment variable are significantly different from zero in each period both for the one and four mile critical points.10

The duration of stigma in close proximity to the smelter can be tested again while allowing for a discontinuity in the price gradient. The coefficients on the distance variable are significantly different in each of the four periods. The price gradient for a distance of four miles or less starts out positive before the EPA identification of the RSR site and during cleanup of the site. After cleanup, this coefficient turns negative when the critical point is set at four miles. However, when the critical point is set at one mile from the RSR site, in the second period after cleanup (1991-1995), the coefficient on distance less than one mile from the RSR smelter is significantly positive, which indicates that

9 Recall that there were no sales with one mile of the RSR smelter in the first post-cleanup period (1987-1990).

10 The coefficient on the adjustment coefficient for the period 1991-1995 with a critical point of one mile is only significant at the ten- percent level.

there is a post-cleanup stigma within a very limited (no greater than one mile) sphere of influence.

Control Area verses Smelter Area**:** In order to isolate causality, a comparison between the smelter area and the control area is made. Two statistical models with an indicator variable were estimated, and the estimated coefficients for the indicator variable are reported in Table 6. The first statistical models has an indicator variable which is equal to one when the distance from the smelter is less than four miles and zero otherwise. The second incorporates an indicator variable which is equal to one when the distance from the smelter is less than one mile and zero otherwise. The rest of Dallas County is an appropriate control area because housing price trends in metropolitan Dallas were not in sync with other metropolitan areas of the U.S. (Abraham and Hendershott, 1996).

The tested hypothesis is that a location in the smelter area has no effect on property values. This hypothesis can be rejected if the coefficient on the smelter area indicator variable is significantly different from zero. The coefficient on the smelter-area location variable is negative and significant in the period before EPA identification of the smelter (1979-1980) for both a one-mile and four-mile radius smelter area. This means, of course, that homeowners received a discount for a smelter location. The magnitude of the discount increased in the period in which EPA identification and cleanup of the RSR smelter occurred (1981-1986). In the first post-cleanup period, the coefficient on the smelter-area location variable becomes slightly positive for the four-mile radius smelter area. However, there were no sales within one mile of the smelter during that period. This means that the houses within one mile of the smelter are no longer affecting the smelter area coefficient, and these houses are the ones likely to be the most stigmatized. In the second post-cleanup period in which there were new concerns about the smelter area, the coefficient on the smelter-area location variable again becomes negative and significant for the four-mile radius. We note that the discount for a location within one mile of the smelter is higher than the discount for a location within four miles of the smelter in each period (about three times as high in the period 1979-1980, almost eight times as high in the period 1981-1986, and about ten times as high in the period 1991-1995).

Effect of the Media: Gayer *et al*.'s (1997) analysis of risk tradeoffs at superfund sites includes a news variable based on Superfund newspaper coverage in a regional newspaper. They find that their news variable has a negative and significant effect on property values. A media variable was also created from a random sample of two issues per month of the *Dallas Morning News* in the years 1979-1995 for a total of 408 issues sampled.11 In our analysis, newspaper coverage serves as a proxy for media coverage. We acknowledge that in recent decades television coverage as a source of news has grown in importance relative to newspaper coverage. However, we justify our use of newspaper coverage because its content tends to be correlated with television coverage. A variable representing television coverage would be extremely difficult to obtain.

As Johnson (1988) points out, the impact of the media coverage depends on how prominently it is displayed. Johnson uses column inches of coverage to account for the differing impact of articles. Gayer *et al* (1997) uses the number of words on coverage to account for different impacts. In this analysis, we constructed a media variable by weighting each article to equal one plus the inverse of the page number of the start of the article. The weighted sum of articles during a given year is the media variable for that year. The media variable for year *t* is can then be expressed as the following

11 The *Dallas Morning News* is not indexed over the entire period of the data set (1979-1995), so the data was obtained by going through microfiche. Consequently, only a random sample of issues was used to construct the media variable.

(4) $$media_t = \sum_i article_i \left(1 + \frac{1}{\text{page number}_i}\right)$$

where *article*$_i$ is any article about the RSR hazardous waste site found in the sample issues in year *t*, and *page number*$_i$ refers to the page number at the start of *article*$_i$. Alternative methods of weighting articles should be correlated because front-page articles tend to be longer, while shorter articles are often buried in the back of the newspaper. In the period before EPA identification of the RSR site, there was no newspaper coverage in the sample. The bulk of the coverage occurred in the period in which identification of the site and cleanup occurred (1981-1986).

In order test whether the effect of the media on property values is different in the smelter area compared to the control area, two separate regressions are estimated for each time period, and the coefficients on the media variable are compared across the two regressions. The results indicate that the estimated coefficient on the media variable in this time period was negative and significant for properties sold within four miles of the RSR site, while the estimated media coefficient was positive and significant for properties sold greater than four miles away from the site. This is exactly what one would expect to be the case if increased media coverage caused people to choose not to live in close proximity to the smelter site but stay within Dallas County. Media coverage again increased in the period of new concern after cleanup (1991-1995). The media variable coefficient was again negative and significant for properties sold within the smelter area, while it was positive but insignificant for properties sold greater than four miles from the smelter. These findings could indicate an arbitrage away from controversy.

VI. Study of Perceived Risk

In order to analyze the evolution of perceived risk and its effect on property values, we estimated a system of two equations, which includes the following hedonic price equation:

(5) $$P_{ti} = b_{11} + \sum_{k=2}^{n} b_{1k} x_{kit} + b_{1n+1} \frac{R_t}{d_i^a} + e_{1t} .$$

Where the scalar P_{it} is the hedonic price of the house of the i^{th} observation at time t, adjusted for inflation, $\mathbf{x}_{it}$ is the vector of housing attributes of the i^{th} observation at time t, R_t is the scalar, unobserved variable, perceived risk, at time t, d_i^a is distance of the i^{th} observation from the hazardous waste site raised to the power a, and e_{1t} is a random variable error term. The distance from the hazardous waste site is used to individualize risk to a particular property. This variable is always greater than zero, so there is no division by zero problem in Equation 5.

Numerous previous studies, including those already cited suggest that distance between a house and a hazardous waste site can serve as a proxy for two effects--heightened perceived risk and/or general disamenities such as odor and visual disamenities. In this analysis, we include the estimated perceived risk in the hedonic equation weighted by distance to the hazardous waste site in order to individualize the perceived risk to each particular house. However, we follow McClelland *et al* (1990) and do not include distance separately in the hedonic regression because of potential problems resulting from multicollinearity with perceived risk. The functional form of the distance weighting is allowed to be flexible in a limited way. The distance is raised to the power a, which is chosen with a grid search based on minimizing the sum of squared errors.

To complete our model, we will add an equation describing the evolution of perceived risk. As Smith and Johnson (1988) argue, a complete behavioral model of how people form risk perceptions would incorporate the importance of the events at risk; the role of prior beliefs concerning the process that generates the risk; the implications of new information about that process; and the costs of acquiring that information.12 As with Smith and Johnson (1988), our model is best interpreted as a reduced form approximation of the outcomes from such a behavioral model.

Following a modified Bayesian learning approach, we assume that people update their prior risk beliefs in response to new information. To complete our model, we add a state equation that describes the evolution of perceived risk over time. Equation 6 below describes this process:

$$(6) \qquad R_t = b_{21}R_{t-1} + b_{22}media_t + e_{2t}\,.$$

Where R_{t-1} is lagged perceived risk, media is the weighted number of newspaper articles about the RSR hazardous waste site, and e_{2t} is a random variable error term. Using generalized maximum entropy techniques allows us to avoid making any assumptions about the distributions of the two error terms, e_{1t} and e_{1t}; and specifically, they are not required to have identical distributions.

12 Smith and Johnson, (1988), p. 2.

Perceived risk is unobservable and changes over time. Current posterior beliefs about risk are a function of prior beliefs about risk and current information obtained from the media. In Equation 5, people update their perception of risk with the information they receive from the media. If the media affects the public perception of risk, then media coverage of environmental damage should be a significant factor in determining property values.

In this study the problem is, given the observable variables (price, housing attributes, the distance to the smelter, and the media variable) to estimate the unobserved variable (perceived risk) and the model parameters. As with Golan, Judge, and Karp (1996), we apply generalized maximum entropy techniques to recover unknown parameters and an unobservable state variable. Golan, Judge, and Karp (1996) offer the problem of "counting the fish in the sea." They estimate a system of equations in which the dependent variable in their observable equation is fish harvest, which is a function of fishing inputs and the unobservable fish biomass in the sea. The system is completed with a state equation that describes the evolution of the fish biomass, which like perceived risk is an unobservable variable.

In order to make this dynamic estimation problem computationally feasible, a random sample, which was limited to forty observations per year for each of the seventeen years for a total of 680 observations. Each observation includes information about the sale price13 of the homes and different variables which affect the sale price, including house attributes and proximity to the RSR lead smelter. The square footage of living space, number of bathrooms, and lot size describe housing quality.

We also tested for serial correlation with the approach proposed by Burmeister et al. (1986). The residuals from both the hedonic price equation (5) and the state equation for perceived risk (6) were regressed on their lagged values up to the seventh lag. We found that the estimated coefficients on all lagged residuals are insignificant at the five-percent level. One can thus conclude that the residuals are uncorrelated with their lagged values, and that an assumed AR(1) process describing the evolution of perceived risk is appropriate.

The Dynamic Estimation Problem of Estimating Perceived Risk.

The formulation in Golan, Judge, and Miller (1996) is used to convert the system of equations (5) and (6) to a form that is consistent with the maximum entropy principle. The system of equations in 1 and 2 is transformed so that each $\boldsymbol{b}_{1k}$ and $\boldsymbol{b}_{2k}$ is represented by proper probabilities $p_k^{b_1}$ and $p_k^{b_2}$, indexed by m, for $m = 1, \ldots, M$. The support spaces for $p_k^{b_1}$ and $p_k^{b_2}$ are $z_k^{b_1}$ and $z_k^{b_2}$, respectively, also indexed by m. The $\boldsymbol{b}_{ik}$ coefficients (i = 1, 2) can be expressed as

(7) $$\boldsymbol{b}_{ik} = \sum_m p_{mk}^{\beta_i} z_{mk}^{\beta_i}\text{, for } k = 1, 2, \ldots, t_{\mathrm{i}}\ (i = 1, 2)$$

The matrix $\boldsymbol{b}_i$ (i = 1, 2) can then be written as

13 Prices are deflated using the shelter housing price index (1982-84=100) from the *Economic Report of the President*.

(8) $$b_i = \mathbf{Z}^{\beta_i}\mathbf{p}^{\beta_i} = \begin{bmatrix} \mathbf{z}_1^{\beta_i\prime} & \mathbf{0} & \cdot & \mathbf{0} \\ \mathbf{0} & \mathbf{z}_2^{\beta_i\prime} & \cdot & \mathbf{0} \\ \cdot & \cdot & \cdot & \cdot \\ \mathbf{0} & \mathbf{0} & \cdot & \mathbf{z}_K^{\beta_i\prime} \end{bmatrix} \begin{bmatrix} \mathbf{p}_1^{\beta_i} \\ \mathbf{p}_2^{\beta_i} \\ \cdot \\ \mathbf{p}_K^{\beta_i} \end{bmatrix}.$$

Here, $\mathbf{Z}^{\beta_i}$ is a (K x KM) matrix, and $\mathbf{p}^{\beta_i} >> \mathbf{0}$ is a KM-dimensional vector of weights. Similarly, e_{it} (i = 1, 2) is represented by the discrete probabilities $w_t^{\varepsilon_i}$,(i = 1, 2) indexed by j, for j = 1 ,…, J. The support space for $w_t^{\varepsilon_i}$ is $v_t^{\varepsilon_i}$. The random variable error terms can then be expressed as

(9) $$\varepsilon_{it} = \sum_j w_{tj}^{\varepsilon_1} v_{tj}^{\varepsilon_1}$$

The two sets of T unknown disturbances may be written in matrix form as

(10) $$\varepsilon_i = \mathbf{V}^{\varepsilon_i}\mathbf{w}^{\varepsilon_i} = \begin{bmatrix} \mathbf{v}_1^{\varepsilon_i\prime} & \mathbf{0} & \cdot & \mathbf{0} \\ \mathbf{0} & \mathbf{v}_2^{\varepsilon_i\prime} & \cdot & \mathbf{0} \\ \cdot & \cdot & \cdot & \cdot \\ \mathbf{0} & \mathbf{0} & \cdot & \mathbf{v}_T^{\varepsilon_i\prime} \end{bmatrix} \begin{bmatrix} \mathbf{w}_1^{\varepsilon_i} \\ \mathbf{w}_2^{\varepsilon_i} \\ \cdot \\ \mathbf{w}_T^{\varepsilon_i} \end{bmatrix}$$

where $\mathbf{V}^{\varepsilon_i}$ is a (T x TJ) matrices, and $\mathbf{w}^{\varepsilon_i}$ is a TJ-dimensional vector of weights.

The support spaces for the coefficients on the explanatory variables are chosen so that they contain all reasonable possible parameter values and are symmetric around zero. By making these supports symmetric around zero, one is assuming that there is no prior information about these coefficients.

The support space range needs to be large enough so that the optimization problem is feasible given the other parameters. In this estimation, the support spaces, $z_k^{b_1}$ and $z_k^{b_2}$, have three points (M = 3) and are an equal distance from each other. Specifically, $z_k^{b_i}{}' = (-100,\ \ 0,\ \ 100)$, ($i$ = 1, 2). To calculate the width of the error support space, v_i, a three-standard-deviations rule around zero is used. The error supports range from -3σ_y to 3σ_y, where σ_y is the standard deviation of the dependent variable. In this estimation, the support spaces, $v_t^{e_1}$ and $v_t^{e_2}$, have three points (J = 3) and are symmetric around zero. For example, $v_t^{e_1}{}'$=(-3σ_y, 0, 3σ_y). Finally, in order to simplify the statement of the GME optimization problem, the independent variable R_t/d is defined as x_{n+1t}.

The entropy estimation then solves the following optimization problem with a state equation restriction:

(11) $$\max_{\mathbf{p},\mathbf{w},R_t} H(\boldsymbol{p},\boldsymbol{w}) = \{-\boldsymbol{p}'\ln\boldsymbol{p} - \boldsymbol{w}'\ln\boldsymbol{w}\}$$

subject to

$$P_t = \boldsymbol{x}_t'\boldsymbol{z}^{b_1\prime}\boldsymbol{p}^{b_1} + v_t^{e_1\prime} w_t^{e_1} \qquad for \quad t = 1,\ldots,T$$

$$\begin{cases} R_t = 1 & for \quad t = 1 \\ R_t = z^{b_{21}} p^{b_{21}} R_{t-1} + z^{b_{22}\prime} p^{b_{22}} media_t + v_t^{e_2\prime} w_t^{e_2} & for \quad t = 2,3,\ldots T \end{cases}$$

$$\mathbf{1}_K = (\boldsymbol{I_K} \otimes \mathbf{1}_M')\boldsymbol{p}$$

$$\mathbf{1}_T = (\boldsymbol{I_T} \otimes \mathbf{1}_J')\boldsymbol{w}$$

$$x_{n+1t} = R_t / d$$

Under this framework, the unobserved perceived risk variables and the unknown model parameters are simultaneously recovered.

Results of Perceived Risk Estimation

The GME estimation results of Equations 5 and 6 are presented in Table 7. All of the explanatory variables in the hedonic price equation (Equation 5) have the expected relationship with housing price and are statistically significant at the five-percent level. The variable of the most interest for this study, perceived risk weighted by distance, has the expected negative relationship with housing price. The explanatory variables in the state equation describing the evolution of perceived risk (Equation 6) also have the expected relationship with perceived risk and are statistically significant at the five-percent level. The coefficient on lagged perceived risk is positive and less than one, which means that perceived risk is a stationary time series process. Finally, the media coefficient is positive, which means that, as hypothesized, media coverage increases perceived risk.

Specification of the model was evaluated by following Mittelhammer and Cardell (1997) and analyzing the marginal values of the data constraints in the dynamic estimation problem. The values of LaGrange multipliers on the data constraints are non-zero, which means that the data constraints are binding. The implications are similar to rejecting an F-test to test whether the coefficients are jointly zero.

The estimates of the unobserved variable perceived risk are shown below in Figure 2. Initial perceived risk is normalized to one. In the period before EPA identification of the RSR site, there was no newspaper coverage in the sample. The intense media coverage that coincided with the identification and remediation of the RSR smelter site (1981-1986) increased perceived risk, which then decayed over time. There was a dip in perceived risk in 1985, which coincides with a lull in media coverage. In 1985, remediation had been progressing normally for a few years, and the RSR smelter was no longer fresh news. In 1986, when a court ruled that the cleanup was complete, the newspaper coverage and estimated perceived risk increased. After 1987, the estimated perceived risk falls and remains relatively low. This is despite a 1991 CDC announcement about concern over lower levels of lead in the blood and additional concerns about the safety of the site. One possible explanation that before identification, houses were sold as close as 0.17 miles from the RSR site. In the period after cleanup (1987-1990), no houses within a mile of the RSR site were sold. Therefore, in the years 1987-1990, the houses within one mile of the smelter, which are the most affected by the smelter, no longer affect estimated perceived risk.

Finally, in order to evaluate whether perceived risk changes over time, we tested whether the coefficient of the lagged risk is equal to one and whether the media coefficient is equal to zero. The generalized maximum entropy estimated coefficient less the hypothesized value divided by the standard error of the coefficient is asymptotically distributed as a t-distribution (Mittelhammer and Cardell, 1997). The hypotheses that the lagged perceived risk coefficient is equal to one and that the media coefficient is equal to zero can both be rejected at the five percent level. We conclude that perceived risk does evolve over time and is affected by media coverage.

VIII. Conclusions

In our empirical analysis, we analyzed whether a stigma equilibrium or a recovery equilibrium emerged for the residential properties in close proximity to the RSR hazardous waste site in Dallas, Texas. We tested several hypotheses regarding the existence and duration of stigma in order to determine which equilibrium emerged in the residential area surrounding the RSR hazardous waste site by estimating a hedonic price model over time using data from individual housing sales prices in Dallas County, Texas.

Our empirical evidence shows that permanent stigma exists in a very limited area. The sphere of influence of the smelter is no larger than a circle around the smelter with a one-mile radius. In the years directly following cleanup (1987-1990), no properties were sold within one mile of the RSR site. In subsequent years (1991-1995), properties within one-mile were sold, but at significantly lower prices than properties located farther away from the smelter. We also found that media coverage of the environmental damage caused by the hazardous waste site has a significant effect on property values in close proximity to the site.

In our study of perceived risk, we applied generalized maximum entropy techniques to estimate the unknown parameters from the statistical model and an unobservable state variable, perceived risk, given observable variables (price, housing attributes, distance to the hazardous waste site, and a media coverage variable). Our results indicate that media coverage and high prior risk perceptions increase perceived risk. Increased perceived risk surrounding the site, in turn, lowers property value.

In terms of efficient public policy, our findings that increased risk perceptions affect property values, which are a real loss, could be used to argue that the EPA should consider risk perceptions in their cost-benefit analysis for purposes of resource allocation for remediation of contaminated sites. Ignoring perceived risk, scientists at the United States Environmental Protection Agency (EPA) currently use dose-response relationships to calculate risk in their decisions about how to allocate resources for remediation of environmental contamination. Consequently, the real effect of hazardous waste sites on property values has been neglected in cost-benefit analyses. Based on our findings, incorporating losses in property values in the analyses could yield a different conclusion about the effectiveness of remedial actions.

Finally, McClelland et al (1990) have argued that there may be a policy role for government in mitigating losses from the overestimation of risk in the area of environmental contamination. Our findings that risk perceptions evolve over time and are affected by new information supports the argument that the government could take a more active role in risk communication. However, more research is needed in the area of risk communication. Lopes (1992) writes, "[A]lthough risk experts understand that they cannot impose their views on people in a democratic society, they do tend to define their problem as one of developing techniques for communicating correct assessments to an inexpert public."[14]

14 Lopes (1992), p. 67.

Table 1. Variable Definitions and Descriptive Statistics

Variable	Description	Mean	Std. Dev.
Price	Sales price of the home	104921	98168
Dprice	Deflated sales price of the home	86010	78940
Landarea	Lot size in square feet	9301.87	3969.60
Livarea	Living area in square feet	1797.43	755
Dalcbd	Miles to the Dallas central business district	10.90	3.92
Dfwair	Miles to Dallas/Fort Worth Airport	17.97	6.15
Galleria	Miles to the Galleria shopping center	10.89	5.76
Distsrs	Miles to the RSR facility	11.73	4.22
Age	Age of the house in years	19.97	16.18
Pool	1 if pool, 0 otherwise	0.14	0.34
Garg	1 if attached garage, 0 otherwise	0.87	0.33
Baths	Number of bathrooms	2.03	0.74
Pblack	% of the census track that are African Amer.	11.05	16.98
Phisp	% of the census track that are Hispanic	11.55	13.05
Pbpov	% of the census track below the poverty line	7.68	7.20
Heatcf	1 if central heat, 0 otherwise	0.88	0.32
Accf	1 if central ac, 0 otherwise	0.87	0.33
Good	1 if good condition, 0 otherwise	0.30	0.46
Average	1 if average condition, 0 otherwise	0.68	0.47
Site2	Miles to Site2	13.71	5.36
Site3	Miles to Site3	15.93	69.20
Site4	Miles to Site 4	11.49	5.08
Media	Weighted number of articles in the *Dallas Morning News* about the RSR site	0.60	1.22
	School Districts		
CF	1 if Carrollton/Farmers Branch, 0 otherwise	0.07	0.26
Dallas	1 if Dallas school district, 0 otherwise	0.32	0.47
Cedar Hill	1 if Cedar Hill, 0 otherwise	0.01	0.11
Garland	1 if Garland, 0 otherwise	0.14	0.35
HP	1 if Highland Park, 0 otherwise	0.02	.015
Irving	1 if Irving, 0 otherwise	0.06	0.23
LWH	1 if Lancaster/Wilmer Hutchins, 0 otherwise	0.01	0.11
No district	1 if no district, 0 otherwise	0.07	0.26
MS	1 if Mesquite/Sunnyvale, 0 otherwise	0.04	.021
Coppell	1 if Coppell, 0 otherwise	0.02	0.15
GP	1 if Grand Prairie, 0 otherwise	0.04	0.19
Richardson	1 if Richardson, 0 otherwise	0.13	0.34
Desoto	1 if Desoto, 0 otherwise	0.02	0.15
Duncan	1 if Duncanville, 0 otherwise	0.03	0.18

Table 2. Contaminated Sites Included in the hedonic price analysis

Site	Type of Contamination	Year Listed on CERCLIS	Status
Site1: RSR Smelter	Soil	1981	Court ordered cleanup in 1983
Site2: Superior Site	Ground water	1981	Not contained
Site3: Dallas Naval Weapons Site	Ground water, soil, surface water	1984	Not contained
Site4: Crews Plating Site	Soil	1994	Not contained

Table 3. Distance Model Hedonic Estimation Results

Variable	1979-1980	1981-1986	1987-1990	1991-1995
yr79	9.815 (220.69)	--	--	--
yr80	9.817 (220.76)	--	--	--
yr81	--	9.900 (453.87)	--	--
yr82	--	9.916 (453.35)	--	--
yr83	--	9.966 (457.08)	--	--
yr84	--	9.998 (458.14)	--	--
yr85	--	10.012 (458.25)	--	--
yr86	--	9.961 (455.40)	--	--
yr87	--	--	9.764 (395.14)	--
yr88	--	--	9.653 (390.15)	--
yr89	--	--	9.585 (386.88)	--
yr90	--	--	9.522 (384.40)	--
yr91	--	--	--	8.886 (398.96)
yr92	--	--	--	8.837 (396.70)
yr93	--	--	--	8.816 (395.52)
yr94	--	--	--	8.817 (395.20)
yr95	--	--	--	8.847 (395.40)

Table 3. Distance Model Hedonic Estimation Results (continued)

Variable	1979-1980	1981-1986	1987-1990	1991-1995
Livarea	4.19E-4	4.17E-4	4.07E-4	3.89E-4
	(92.41)	(174.32)	(153.60)	(151.38)
Baths	0.100	0.074	0.069	0.080
	(24.39)	(32.60)	(26.87)	(30.53)
Pool	0.061	0.084	0.104	0.083
	(10.42)	(29.20)	(32.40)	(24.63)
Landarea	2.61E-6	4.32E-6	6.53E-6	8.16E-6
	(5.23)	(16.94)	(19.26)	(29.01)
Garage	0.081	0.083	0.087	0.129
	(19.27)	(31.50)	(24.59)	(37.87)
Central Air	0.091	0.109	0.126	0.185
	(13.30)	(24.99)	(20.69)	32.94)
Heat	0.110	0.087	0.112	0.169
	(15.68)	(19.27)	(17.61)	(28.68)
Good	0.233	0.299	0.455	0.645
	(17.39)	(36.75)	(45.01)	(82.35)
Average	0.166	0.177	0.297	0.441
	(13.17)	(22.35)	(29.87)	(57.81)
Galleria	0.005	0.005	0.001	0.010
	(2.07)	(3.97)	(0.87)	(6.58)
CBD	-0.084	-0.092	-0.043	-0.089
	(-20.54)	(-37.90)	(-14.23)	(-30.30)
DFWAIR	0.015	-0.002	-0.003	0.013
	(4.68)	(-1.54)	(-1.86)	(8.77)
Poverty	-0.008	-0.004	-0.003	-0.005
	(-14.16)	(-14.04)	(-10.01)	(-21.75)
Black	-0.003	-0.003	-0.004	-0.006
	(-17.99)	(-34.67)	(-36.98)	(-56.88)
Hispanic	-0.005	-0.005	-0.007	-0.005
	(-15.16)	(-30.22)	(-40.35)	(-41.57)
Site2	0.043	0.044	0.039	0.06
	(27.85)	(44.54)	(33.88)	(58.36)
Site3	-0.005	0.012	0.034	0.023
	(-1.43)	(6.83)	(18.91)	(13.12)
Site4	-0.021	-0.008	0.011	-0.010
	(-5.95)	(-4.52)	(4.96)	(-4.86)
Distance	0.053	0.033	-0.052	-0.011
	(8.86)	(9.97)	(-13.66)	(-3.08)

Table 3. Distance Model Hedonic Estimation Results (continued)

Variable	1979-1980	1981-1986	1987-1990	1991-1995
School Districts				
Carrollton/	-0.122	-0.111	-0.098	-0.073
Farmers Branch	(-4.09)	(-15.67)	(-16.16)	(-11.58)
Dallas	-0.103	-0.011	-0.017	-0.025
	(-3.45)	(-1.41)	(-2.28)	(-3.27)
Cedar Hill	-0.174	0.078	0.043	0.052
	(-5.23)	(5.89)	(3.64)	(4.73)
Garland	-0.205	-0.096	-0.145	-0.154
	(-6.81)	(-12.32)	(-20.34)	(-22.52)
Highland Park	0.240	0.432	0.301	0.345
	(7.42)	(42.02)	(29.68)	(32.63)
Irving	-0.062	-0.004	-0.080	-0.003
	(-2.06)	(-0.41)	(-8.51)	(-0.30)
Lancaster/	-0.056	0.082	0.036	0.021
Wilmer Hutchins	(-1.76)	(6.84)	(2.86)	(1.82)
Mesquite/	-0.121	-0.008	-0.048	0.013
Sunnyvale	(-3.97)	(-0.97)	(-5.62)	(1.56)
Coppell	-0.095	-0.060	-0.028	0.056
	(-2.56)	(-4.72)	(-2.44)	(5.13)
Grand Prairie	-0.073	0.005	0.017	-0.033
	(-2.28)	(0.40)	(1.41)	(-2.97)
Richardson	-0.117	-0.076	-0.072	-0.078
	(-3.99)	(-10.62)	(-11.16)	(-11.76)
Desoto	-0.025	0.161	0.057	0.110
	(0.80)	(14.89)	(5.50)	(10.99)
Duncanville	-0.051	0.084	0.008	-0.010
	(-1.67)	(8.00)	(0.80)	(-1.07)

Table 4. Estimated Coefficients on Dummy Distance Variables from Discrete Distance Model

Distance from RSR	1979-1980	1981-1986	1987-1990	1991-1995
Less than 1 mile	9.365 (98.12)	8.806 (67.49)	N/A	8.560 (44.42)
Between 1 and 2 miles	9.899 (178.74)	9.957 (366.12)	9.630 (301.20)	9.082 (305.75)
Between 2 and 3 miles	9.667 (198.25)	9.820 (395.49)	9.492 (321.82)	8.817 (325.08)
Between 3 and 4 miles	9.766 (204.77)	9.885 (410.63)	9.539 (355.86)	8.847 (336.01)
Greater than 4 miles	9.842 (214.81)	9.986 (442.75)	9.508 (370.12)	8.893 (379.29)

Table 5. Hedonic Estimation Results with Linear Spline Function

Variable	1979-1980	1981-1986	1987-1990	1991-1995
Discontinuity at four miles				
Distance1	0.073	0.065	-0.025	-0.019
	(9.22)	(14.62)	(-4.52)	(-3.61)
adjustment	-0.043	-0.064	-0.048	0.014
	(-3.91)	(-10.75)	(-6.51)	(2.05)
Discontinuity at one mile				
Distance1	0.528	8.329	N/A	2.746
	(2.22)	(8.05)		(1.79)
adjustment	0.477	-8.298	N/A	-2.757
	(-2.00)	(-8.01)		(-1.79)

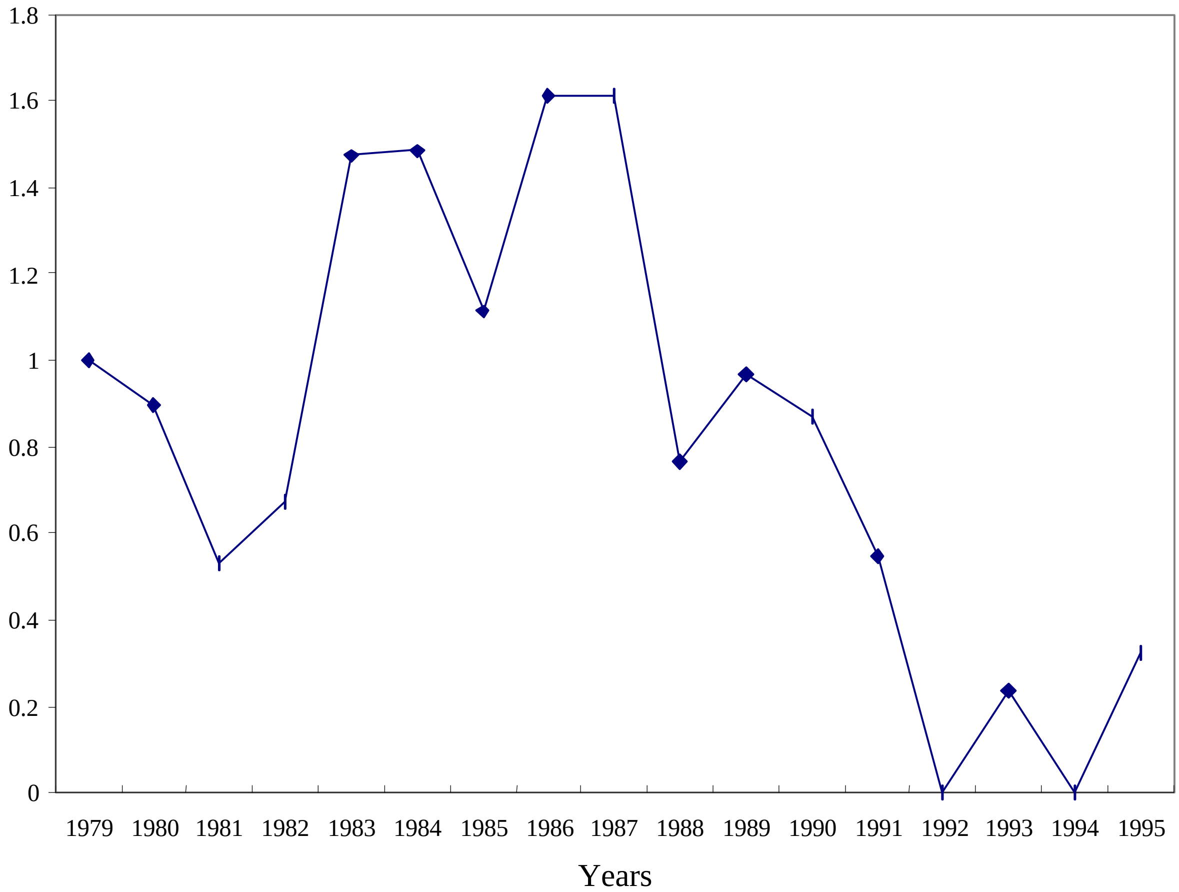
Table 6. Hedonic Estimation Results, Dummy Variable for Smelter Area Model

Variable	1979-1980	1981-1986	1987-1990	1991-1995
Four-mile radius				
Smelter Area	-0.142	-0.145	0.033	-0.029
	(-14.65)	(-23.95)	(4.07)	(-3.75)
One-mile radius				
Smelter Area	-0.438	-1.06	N/A	-0.291
	(-5.07)	(-7.91)		(-1.48)

Table 7. Perceived Risk, Generalized Maximum Entropy Results

Variable	Estimated Coefficients	Standard Errors
Intercept	9.231	0.017
Living Area	5.609E-4	1.02E-5
Bathrooms	0.052	0.0107
Land Area	2.751E-5	1.68E-6
Weighted Risk	-0.787	0.0316
Lagged Risk	0.785	0.105
Media	0.053	0.0244

Figure 1: Estimated Perceived Risk



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Undesirable Facilities and Non-Host Community Effects

--Working Paper*--

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Undesirable Facilities and Non-Host Community Effects

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ABSTRACT

Solely focusing on the host community may seriously underestimate the full costs associated with the siting of an undesirable facility. This analysis demonstrates that non-host community house values are adversely affected by undesirable facilities located in neighboring towns.

INTRODUCTION

The two most common techniques for measuring the effects of an undesirable facility on house prices are to restrict attention to one political jurisdiction or to use a distance-from-site measurement. The first technique, usually justified on the grounds that host communities receive preferential treatment, implicitly assumes that the impacted area is bounded by a political jurisdiction, regardless of the nature of the facility or its location in the community relative to other communities. The second technique assumes that the existence of political boundaries has no effect on the impact area, even though some communities may be receiving benefits while others are not. Stoffle, Stone, and Heeringa [1993] have found that such *a priori* definitions of boundaries are inaccurate in social impact assessments and may ignore important impacts and result in ongoing disputes with omitted communities.

Although neighboring non-host communities typically do not receive the same preferential treatment or compensation as a host community, their house values may be similarly affected. The residents of Conklin, NY, only one mile from a proposed county-wide incinerator in Kirkwood, NY, were offered no compensation. However, neither environmental externalities, undesirable effects, and their associated costs are likely restricted by political boundaries. Solely focusing on the host community may seriously underestimate the full costs associated with the siting. If the facility is viewed as a disamenity whose negative effects are directly related to the distance between the site and the house, then prices in nearby real estate markets should fall regardless of their political jurisdiction. Conversely, if a facility primarily impacts the host community, spillover demand from residents moving away from the facility may increase house prices in neighboring communities.

Citizens are beginning to challenge the siting of facilities in neighboring communities. Residents of Hingham, MA protested the construction of a hazardous waste incinerator proposed for

East Braintree, MA, a community five miles away (Nealon [1989]). Residents are being urged to view the burning of 45,000 tons of toxins a year five miles away as a regional rather than local problem.

Many studies analyzing the effect of a hazardous or undesirable facility on nearby house values use the hedonic regression technique, where the value of a house is determined by its characteristics, including proximity to neighborhood amenities or disamenities. Gamble and Downing [1982], Kohlhase [1991], and Mendelsohn *et al.* [1992] detected positive, significant relationships between distance and house values. Kiel and McClain [1995] demonstrated that changes in the price levels vary across stages of the siting process.

These studies considered only the distance between the site and house and did not explicitly determine the extent of the impact area or whether houses from different communities were equally affected. Using case studies but little statistical analysis, Edmonds *et al.* [1994] found that proximity to the boundary between political jurisdictions affects property values. Differences in tax codes, liquor laws, or school districts lowered the value of properties close to a boundary line but not properties further away. Pollakowski and Wachter [1990] detected a spillover effect due to zoning restrictions from one community to another. The stricter the zoning requirements in surrounding communities, the higher house prices in the community in question. Thus actions taken by communities, especially which directly impact amenities, can influence house prices in neighboring communities. The existence or siting of a disamenity in one town could affect the real estate market in another.

BACKGROUND AND METHODOLOGY

Kiel and McClain [1995] measured the impact of an undesirable facility over the entire siting and life of a disamenity by dividing the siting process into five stages according to the level of risk as perceived by neighbors. The five stages are pre-rumor, rumor, construction, on-line, and ongoing operation. This methodology more completely measures the cost associated with a siting than methods which use only one or two points in time. They found some evidence of a drop in house values during the rumor stage and strong evidence of price declines in the groundbreaking, online, and operations stages of a waste-to-energy incinerator in North Andover, Massachusetts. The magnitude of the price responses did depend on the distance between a house and the incinerator. Only houses in North Andover were considered.

The North Andover incinerator, however, is a regional facility accepting trash from 22 nearby communities. Each member community guarantees a minimum quantity of waste, receives a fixed disposal fee (subject to inflation), and shares the revenues from the electricity generation. The host community, North Andover, receives no property taxes from the site but does receive a per ton discount on its disposal fees. The facility is located in the extreme northern corner of the town, closer to parts of Methuen, Andover, Haverill, and Lawrence than many residential parts of North Andover.[1] Refuse trucks travel through many of the surrounding communities enroute to the facility.

This study analyzes 7,120 house sales from Methuen and Andover, two towns which border North Andover and are similar socio-economically (see Table 1). The data was collected from the local Tax Assessor's offices. In addition to structural information, straight-line distances from each house to the North Andover incinerator, the Methuen and Andover central business districts, and the entrance ramps to Interstates 495 and 93 were calculated. A dummy variable was added for houses in Methuen located close to a high-crime area in nearby Lawrence, MA. Variable definitions are found in Table 2. Each town has a single school district and is relatively similar in size, population,

1 Map available from author.

race, and taxes. Prices are adjusted to control for the regional trend in sales prices over the period. The dependent variable is the natural log of the sales price in current dollars divided by an index based on the median sales price of existing single-family homes in the Boston MSA (current dollars; from the National Board of Realtors monthly series *Home Sales*, and Karl Case, private communication).

House values are typically modeled (in discrete form) as the sum, over the life of the house, of discounted rents (Phillips [1988]). If a local facility is perceived as a negative externality, rents fall when the plant goes on-line, and the value of the house falls. Assuming that the timing of the fall in rents is perfectly forecasted, the extent and the timing of the drop in values depends on the decline in rents and on discount rates. The impact of the incinerator over time can be estimated either with a separate regression for each of the five stages or over the entire sample with interaction terms of distance and time period to measure the changing impact of the incinerator. Previous results (Kiel and McClain [1995, 1996]) support the use of separate regressions for each phase. The data can also be pooled across communities, but separate regressions for each community allows the marginal impacts of house characteristics and distance to vary across communities.

RESULTS AND CONCLUSIONS

The general model is

$$\ln(PRICE/BI\ )_i = b_0 + b_1 X_{1i} + b_2 X_{2i} + b_3 LnDIST_i + e_i \quad 0$$

where *i* indexes the house, $X_1$0 is a vector of structural characteristics, and $X_2$0 a vector of neighborhood characteristics. Using natural log of distance from the incinerator allows the effect of the incinerator to decrease at a decreasing rate, yet increasing distance is always advantageous. A quadratic function of the distance from the house to the central business district was chosen because living close to downtown means congestion and heavy traffic, but living far away is inconvenient. The distance from each house to two major interstate highways were highly collinear with each other and the North Andover incinerator. Including instead the minimum distance from a house to any highway alleviated the collinearity problem but was nearly always insignificant and added little explanatory power.

In Methuen, the structural characteristics are generally significant with the expected signs over all time periods (Table 3). Residents prefer to live away from the central business district in all but the rumor phase, but living near the border of Lawrence's high crime area does not impact house values. The coefficient on LnNANDINC, which measures the impact of the North Andover incinerator on house prices, is not significant for any of the phases. Residents of Methuen apparently did not consider an incinerator close to their houses a negative externality. Methuen residents also appear indifferent to a Haverill incinerator. Restricting attention to only those houses in Methuen within two miles of the incinerator also detected no impact from the incinerator on house prices.[2]

Only the construction, online, and ongoing phases could be estimated for Andover because of data availability. The structural characteristics are generally significant with the expected sign, but residents of Andover prefer to live closer to the downtown. They are concerned with the neighboring North Andover incinerator. The coefficient on distance is positive and significant for all three time periods, although most houses in Andover are further from the incinerator than most houses in Methuen. Two factors may explain this seemingly unintuitive result. First, Andover is a slightly more

2 Statistical results available from author.

affluent town with higher education levels, per capita incomes, and median house values. Higher priced houses are commonly considered more sensitive to negative externalities, and higher income and better educated homeowners more adverse to environmental hazards (Zabel and Kiel [1995]). Second, Andover is one of the 22 member communities while Methuen is not. More public awareness was generated in Andover as town meetings were held to discuss the project and Andover's participation. Residents were better informed on the nature of the incinerator, the expected location and traffic, and its environmental hazards. The real estate market appears to have responded to this increased knowledge by discounting house prices. The persistence of a premium through the ongoing operations phase indicates that Andover residents view the facility as a permanent disamenity.3

The marginal impact of distance on the value of an average house in Andover can be calculated. The premium in Andover is $2884 per mile during construction, $3383 during online, and $4109 during ongoing operations. The corresponding premiums for North Andover were $2283, $8100, and $6607 (Kiel and McClain [1995], p. 250). The premiums were roughly similar during the construction phase, before evidence has accumulated on the incinerator's impact on residential life of the two towns. After the incinerator went online, residents of North Andover perceived the impacts more negatively than the residents of Andover.

CONCLUSIONS

These results confirm that non-host communities are affected by undesirable facilities located in neighboring towns. The town of Andover, a participant in the siting process and beneficiary of the energy revenues, placed a premium on houses located further from the incinerator site. House prices

3 An F-test rejects the pooled phase model, although the results are very similar. Methuen is unaffected by the incinerator

in the closer town of Methuen remained unaffected by the facility, although at no time was Methuen a member of the incinerator consortium, and its residents were probably less aware of specific siting issues and more removed from the siting process. While geographically closer to the facility, the reduced flow of information to Methuen residents and their emotional detachment appears to be reflected in the local real estate market. Although the flow of environmental toxins are unimpeded by the presence of political boundaries, this feature may place less of a role in the housing market than the flow of information and thus perceptions.

The results of this analysis add to the evidence that the costs associated with an unwanted facility are far more complex and varied than previously perceived. Not only are the costs more prolonged, but they reach out to encompass neighboring communities in addition to the host community. The results also show that while neighboring communities are impacted by an undesirable facility, the host community bears a larger, uneven burden when selected as the site of an undesirable regional facility.

Siting unwanted facilities may become more difficult and expensive if neighboring nonhost communities increase their participation in siting processes, viewing a siting as a regional rather than local event. Owners and operators of these facilities may be forced to extend compensation to the non-host communities as well as the host communities, raising their costs. In addition, they will have to contend with a broader and more diverse residential population, making the siting process more difficult.

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while Andover residents prefer to live further from the f~i1ity. The F-statistic for Methuen is 5.25 and for Andover is 3.35.

TABLE 1
Community Census Data

	Andover	Methuen	N. Andover
Population	29,151	39,990	22,792
Percent White	95%	95%	97%
Land Area	32.13	23.09	27.85
Per Capita Income 1989	$26,327	$15,598	$22,957
Average Teacher Salary 1993	$39,117	$41,762	$38,797
Per Pupil Expenditure 1993	$4,574	$3,939	$4,159
Residential Tax Rate 1994	15.14	15.27	11.35
Median Value Single Family Home, 1990 Census	$254,800	$151,300	$231,300

Data from Massachusetts Municipal Profiles: 1994-95, Information Publications, Palo Alto, CA.

Table 2
Variable Descriptions

Name	Description
SALES PRICE	Nominal transaction price of house
BOSTON INDEX	Nominal transaction price of existing single family homes for the Boston MSA in hundreds of dollars
PBI	House sales price divided by Boston house price index
AGE	Age of house in years
AREA	Living area in square feet
BATH	Number of bathrooms
BED	Number of bedrooms (Methuen only)
ROOM	Number of rooms (Andover only)
LAND	Lot size in square feet
NANDINC	Distance from house to N. Andover incinerator in feet
HAVINC	Distance from house to Haverill incinerator in feet
METCBD	Distance from house to Methuen's central business district in feet
ANDCBD	Distance from house to Andover's central business district in feet
CRIME	Dummy variable for houses close to Lawrence's high crime area (affects houses in Methuen only)

TABLE 3
Dependent Variable: Ln(PBI)

	METHUEN				ANDOVER		
	Rumor 1979-1980	Construction 1981-1984	Online 1985-1988	Ongoing 1989-1992	Construction 1981-1984	Online 1985-1988	Ongoing 1989-1992
CONST	4.217*	3.992*	4.421*	3.979*	2.676*	3.220*	2.939*
	(0.414)	(0.238)	(0.175)	(0.195)	(0.483)	(0.458)	(0.418)
AGE	-0.965E-02*	-0.671E-02*	-0.497E-02*	-0.479E-02*	-0.703E-02*	-0.493E-02*	-0.415E-02*
	((0.126E-02)	(0.668E-03)	(0.435E-03)	(0.701E-03)	(0.590E-03)	(0.567E-03)	(0.527E-03)
AGESQ	0.519E-04*	0.236E-04*	0.147E-04*	0.179E-04*	0.315E-04*	0.185E-04*	0.133E-04*
	(0.125E-04)	(0.505E-05)	(0.251E-05)	(0.614E-05)	(0.332E-05)	(0.309E-05)	(0.237E-05)
AREA	0.118E-03*	0.172E-03*	0.123E-03*	0.102E-03*	0.128E-03*	0.134E-03*	0.156E-03*
	(0.292E-04)	(0.211E-04)	(0.166E-04)	(0.181E-04	(0.145E-04)	(0.119E-04)	(0.126E-04)
BATH	0.056	0.034	0.115*	0.050*	0.129*	0.091*	0.083*
	(0.030)	(0.021)	(0.016)	(0.019)	(0.016)	(0.015)	(0.014)
LAND	0.108E-05	0.147E-05*	0.253E-05*	0.308E-06	0.145E-06	0.309E-06	0.615E-06*
	(0.575E-06)	(0.364E-06)	(0.512E-06)	(0.327E-06)	(0.422E-06)	(0.387E-06)	(0.306E-06)
BED	0.392E-02	0.043*	0.970E-02	0.041*			
	(0.019)	(0.015)	(0.011)	(0.013)			
ROOMS					0.035*	0.047*	0.049*
					(0.801E-02)	(0.773E-02)	(0.746E-02)
METCBD	0.120E-04	0.172E-04*	0.134E-04*	0.200E-04*			
	(0.107E-04)	(0.854E-05)	(0.597E-05)	(0.740E-05)			
METCBDSQ	-0.989E-09	-0.815E-09*	-0.922E-09*	-0.103E-08*			
	(0.515E-09)	(0.411E-09)	(0.275E-09)	(0.336E-09)			
ANDCBD					-0.228E-04*	-0.133E-04*	-0.194E-04*
					(0.435E-05)	(0.426E-05)	(0.399E-05)
ANDCBDSQ					0.491E-09*	0.322E-09*	0.411E-09*
					(0.117E-09)	(0.118E-09)	(0.114E-09)
LnNANDINC	-0.016	0.655E-02	0.012	0.023	0.162*	0.100*	0.120*
	(0.063)	(0.027)	(0.021)	(0.025)	(0.048)	(0.045)	(0.041)
LnHAVINC	0.013	-0.672	-0.045	-0.021			
	(0.087)	(0.033)	(0.025)	(0.029)			
CRIME	-0.057	-0.037	-0.028	-0.026			
	(0.033)	(0.024)	(0.019)	(0.023)			
Sample Size	347	509	1090	1141	1407	1378	1248
Adj R	0.34	0.48	0.42	0.27	0.488	0.537	0.542
LLF	14.19	115.77	130.05	-70.20	-182.80	-120.25	-38.301

*Significant at *5%.*

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Undesirable Facilities, Neighborhood Dynamics and Environmental Equity

--Working Paper*--

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“Undesirable Facilities, Neighborhood Dynamics and Environmental Equity”

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I. INTRODUCTION

The question this paper addresses is whether neighborhoods exposed to negative externalities such as an incinerator change differently from those neighborhoods which are not exposed, and if so, in what ways do they change? This question is relevant in the framework of environmental equity issues. In many cases, it has been found that locally unwanted land uses (LULUs) are sited near minority and/or poorer populations. This may be due to racism, or to the fact that property values are lower in those areas. We know that LULUs themselves lower property values (e.g. Kohlhase 1991, Kiel and McClain 1995, Kiel 1995). The question then becomes a 'chicken or egg' issue: are the sites there because property values were lower, or have poorer individuals moved near the site due to the lower property values? By looking at the demographics of neighborhoods over time, whether these communities change differently from more distant communities can be tested.

A possible explanation for a community's adjustment to sources of pollution can begin when the community becomes aware of the hazards. Either a new facility can be introduced to the area, or a previously known site can be newly classified as hazardous, such as a Superfund site. Once the site is revealed as undesirable, residents who are more sensitive to the undesirable aspects of the facility will move away, possibly selling their houses at a discount if potential buyers share their concerns about the facility but are willing to buy at a lower price. As house prices fall, a lower income group may begin to dominate the area, less able to expend income on the upkeep of their properties. House values may fall again if the neighborhood deteriorates, and residential per capita income may continue to drop as the falling house prices continue to attract poorer residents, a process called 'filtering.' In this scenario, the presence of the undesirable facility starts the process of neighborhood deterioration.

Conversely, the site of a polluting facility may have been chosen in part because the area's land prices were already inexpensive (Hamilton, 1993). Lower income communities and minority communities are frequently regarded as 'weak' in terms of their effectiveness in staging successful public opposition to such sites. In this scenario the existence of a lower-status community plays a significant role in the site selected for the facility.

Knowing the answer to the question of how areas respond to polluters may lead to a better understanding of the situation concerning sited LULUs: if the neighborhood naturally changes toward a lower-income population, then that needs to be considered during the siting process. The issue becomes one of neighborhood dynamics. This is not to say that LULUs should be sited in poorer neighborhoods because the neighborhood will deteriorate regardless. Rather, those doing the siting must be aware that the LULU will cause some downward spiral, unless precautions are taken or compensation is offered (Kiel and Zabel, 1996).

Therefore this paper looks at how towns located around an incinerator changes over time, and will compare the neighborhoods close to the sites to those further away. This is done using census data from 1970, 1980 and 1990 on the population's income levels, unemployment rates, stability, and ethnicity. If neighborhoods closer to the site change differently from those further from the site, this will be evidence that the LULU affects not only property values, but the population residing there as well.

Neighborhoods will first be defined by grouping census tracts; this assumes that the Census Bureau does draw their boundaries around homogenous neighborhoods. Using a second definition, neighborhoods will be determined by rings of varying distance from the site; this approach implies that the incinerator is the focus of neighborhoods. Changes over time in each of the defined neighborhoods will then be calculated. The changes will then be compared across neighborhoods to test the hypothesis that the LULU affects the demographics as well as the values.

Literature Review

Previous literature on this issue has generally ignored the ‘causality’ issue by looking at the relationship between demographics and toxic sites at only one point in time. One of the earliest studies, by the United Church of Christ’s Commission for Racial Justice in 1987, found that race is the best predictor of the location of commercial hazardous waste facilities, even after controlling for income and house values. This finding has been reinforced by other studies. However, by looking at ‘snapshots’ in time, it is not clear whether the minority population was there prior to the siting of the polluting facility, or if they moved to the site later, due to lower land prices.

A few exceptions in the literature look at changes over time. Hamilton (1993) studies the expansion decisions of existing facilities from 1987 through 1992 and finds that firms did appear to consider the ability of residents to mobilize against the proposed expansions, as measured by income levels and voter turnout in earlier elections. However, this work is done at the county level, and does not look at demographic changes after expansion occurs.

Another exception is the work of Been (1993). She first examines socioeconomic data at the county level prior to, as well as after, the siting and finds that there was a disproportionate effect on minorities in the siting decision, but that the neighborhood does not experience an increase in minority population after the siting. She then uses census tract data to study another set of facilities and finds effects both before and after the siting. However, her data are quite aggregated and she does not control for other changes in the area, such as the existence of other polluters. In addition, she looks at data taken just prior to the operation of the facilities, whereas Kiel and McClain (1995a, 1995b) have shown that house price effects exist well before the facility goes on line, indeed as early as stages when there is merely a rumor that the facility is to be sited.

Methodology

This study considers how community populations change over time, and compares the neighborhoods close to the site to those further away. What defines a neighborhood is an empirical question (Kiel and Zabel, 1998), so two approaches are taken. First, following Been, census tracts will be taken as neighborhoods. The second approach considers neighborhoods to be defined by distance from the toxic site.

Census tracts are designed as homogenous areas with respect to the socio-demographic characteristics of the population. A tract usually has between 2,500 and 8,000 residents. Thus, it is possible to consider them as neighborhoods. By mapping the census tracts in the cities that contain or surround the undesirable facility, one can define census tracts as ‘near’ or ‘far’ from the facility. Then census information from those tracts is gathered and changes are computed so that one can see whether the facility leads to demographic changes in the surrounding neighborhoods.

It is possible that census tracts are too large to be considered neighborhoods. The second approach looks at all houses within a certain distance of the facility under consideration. By determining what census tract those houses are located in, one can take weighted averages of census information for all tracts within that distance, and examine changes in that information. For example, if 10 houses within one mile of the facility are in tract number one, and 30 are in tract number two, then:

$$average\ income = [(tract\ one\ income * 10) + (tract\ two\ income * 30)]/40$$

It is possible that one will get different answers from the two approaches.

Data

This study focuses on North Andover, Massachusetts, which is located approximately 20 miles north of Boston near several major highways and has a total area of 27.85 miles, see Figure 1. As the town's landfill moved to capacity in the late 1970s, an incinerator, which would turn refuse into electricity was proposed. The first mention of the facility in the local newspaper (The Citizen) was in 1978. A contract between the city and the provider was signed in early 1981. After much uncertainty about funding, groundbreaking for the facility took place in 1983, and the plant went on line in 1985.

The waste-to-energy incinerator includes an electrostatic precipitator to clean the emissions to the level required by existing environmental standards of the time. Regardless, articles in the local paper at the time the plant was proposed discussed the "environmental soundless of the plant" (September 14, 1978), as well as the possibility that the plant would present "a health threat to those living near the plant" (October 2, 1978).

Neighboring towns including Haverill, Andover, and Methuen may also suffer from environmental externalities from the plant. As discussed by McClain (1997), it is unlikely that environmental externalities will be "restricted by political boundaries" but that negative effects may be tempered by spillover demand from residents leaving the host community. She also points out that non-host communities do not generally receive compensation from the siting process. Thus the overall impact on house values in neighboring communities is unclear. Her results indicate that the incinerator in North Andover did not negatively affect Methuen house values, while Andover house values were impacted.   Haverill was not included in her study.

The data set employed in this study focuses on single family homes in the four towns that include and surround the incinerator. The data have been obtained from various tax assessors' offices and include information on the house and its physical characteristics. This study focuses only on houses which sold and where they are located relative to the site. Each sale has been geo-coded using ArcView 3.0 and the census tract in which is it located has been identified. The 'hit' rate for each town was at least 89 percent; there are 3,667 sales in North Andover, 4,990 in Andover, 3,983 in Methuen, and 3,442 in Haverill. The sales date from 1974 through 1995, so the period prior to the incinerator's existence, or even its rumored existence is included.

Census information from 1970, 1980 and 1990 is attached to each census tract, giving us information on the area from well before the incinerator until well after it had gone on line. The variables used are the percent of the population in the tract that is defined as 'poor', the percent of the population that is classified as 'unemployed', the percent of the population that moved into the census tract in the previous five years, the percent of the population that is self-reported as 'foreign born', and the mean family income for families in the tract.

Results

Table 1 indicates the percentage change in the census tract variables when neighborhoods are defined based on how close a census tract is to the incinerator. If the facility causes accelerated filtering then we should see neighborhoods that are closer increasing in poverty rates over time, relative to those neighborhoods that are further away. We do see that, if we look at tracts that are within one mile of the site, and compare them to tracts within two miles in both time periods. However, the impact is reversed at three miles, which suggests either that increased filtering is not occurring, or that the effect extends out to three miles.

The hypothesis suggests that there should be increased unemployment in closer tracts over time, relative to further tracts. The pattern here is similar to that observed when examining poverty rates. The increase in mobility that is observed to decrease over the first three miles in the first period, and then is see to be positive in the first mile in the second period while decreasing in size in the other tracts, suggests that the hypothesis holds. This variable indicates that the site does cause the neighborhood to become less desirable.

The results are mixed in the changes in percent foreign-born variable. The neighborhoods one mile from the site do see an increase, as do the tracts that are three miles away. It is possible that the effect extends out further than one mile.

The changes in mean family income seem to reject the hypothesis that filtering has increased. Here the neighborhoods closest to the incinerator have the largest percent increase in income. Thus although house prices are falling, incomes are increasing more rapidly than in tracts further from the facility.

Table 2 summarizes the results when houses within a certain distance from the incinerator define neighborhoods. Unlike the previous definition of a neighborhood, these results suggest that there is increased filtering in the first mile, but also in the second, third and even fourth. The largest percentage increase is in mile three, suggesting that the impact of the incinerator does extend further then previously thought. The percent unemployed and the percent foreign-born results mimic those for the poverty variable.

The increase in mobility indicates that the facility has an increased impact on the first mile, but then less of an impact further away. This is very similar to the results with the previous definition of a neighborhood.

The mean family income variable has the largest increase in the first mile in both periods. This rejects the hypothesis that the facility is an undesirable neighbor, as those neighborhoods closer in actually see an increase in income. This result is similar to that found in the previous definition of a neighborhood.

Conclusions

The findings reported here suggest that the total impact of an undesirable facility on its neighbors is the result of a complicated process. Although some of the variables suggest that the site does increase filtering so that the neighborhood is worse off after the site, others suggest the opposite. One also gets different results depending on how neighborhoods are determined.

These results suggest several things. The first is that looking at areas with such facilities at any one point in time is inappropriate. Clearly the process takes time, and some facilities may be placed in areas where filtering has already begun. This research, which has information on only three points in time, provides mixed results. It is possible that with more data points over time, the results would be stronger.

In addition, these results indicate that how the researcher defines a neighborhood can skew the results. It may be that the relevant neighborhood dynamics are played out on a much smaller scale; this would call for more studies on a micro level, rather than a continuation of studies that employ more aggregated data.

Finally, these results suggest that the siting decision and the final effect on the neighborhood may well be linked. Modeling this process is clearly the next step.

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Figure 1

Table 1

Using Tracts within Certain Distances

Percentage change in Percentage Poor	Between 1970-1980	Between 1980-1990
Within One Mile	0.076596	1.34476285
Within Two Miles	-0.2127	-0.0411794
Within Three Miles	0.435294	1.63491803
Within Four Miles	0.507185	0.51174282
Percentage change in Percentage Unemployed		
Within One Mile	-0.03731	0.481415
Within Two Miles	0.03125	0.296439
Within Three Miles	0.27717	0.650936
Within Four Miles	0.27149	0.2709
Percentage change in Percentage Moved		
Within One Mile	-0.06688	0.00721
Within Two Miles	-0.00596	-0.03431
Within Three Miles	-0.11758	-0.06776
Within Four Miles	-0.0682	-0.21297
Percentage change in Mean Family Income		
Within One Mile	0.97570922	1.401826
Within Two Miles	0.94319385	1.084181
Within Three Miles	0.65903421	1.143706
Within Four Miles	0.52267045	1.288634
Percentage change in Percentage Foreign Born		
Within One Mile	-0.22388	0.195048
Within Two Miles	-0.14465	-0.06096
Within Three Miles	-0.27711	0.22725
Within Four Miles	-0.03169	0.018655

Table 2

Using Houses within Certain Distances

Percentage change in Percentage Poor	Between 1970-1980	Between 1980-1990
Within One Mile	0.10102	0.36246752
Within Two Miles	0.005004	0.36450764
Within Three Miles	-0.00981	1.35813301
Within Four Miles	0.133707	1.15711963
Percentage change in Percentage Unemployed		
Within One Mile	0.00341	0.693287
Within Two Miles	0.03248	0.451903
Within Three Miles	0.02967	0.71639
Within Four Miles	0.08066	0.410246
Percentage change in Percentage Moved		
Within One Mile	-0.04791	0.024797
Within Two Miles	-0.04355	0.005169
Within Three Miles	-0.03032	-0.0604
Within Four Miles	-0.03207	-0.03615
Percentage change in Mean Family Income		
Within One Mile	1.02779208	1.52839
Within Two Miles	0.98229245	1.296183
Within Three Miles	0.95140291	1.108982
Within Four Miles	0.92228325	1.400198
Percentage change in Percentage Foreign Born		
Within One Mile	-0.23015	0.17297
Within Two Miles	-0.18864	0.076455
Within Three Miles	-0.18938	0.136946
Within Four Miles	-0.23567	0.149573

Policy Discussion of Session One

By Robin R. Jenkins, US EPA Office of Economy and Environment

All of these papers are valuable contributions to a literature that is helping government understand the neighborhood impacts of locally unwanted land uses. McCluskey and Rausser's paper studies the impact of one particular locally unwanted land use that's especially important to the EPA -- a hazardous waste site. They also study the impact of cleaning up the site. Kiel and McClain study the impact of an incinerator.

The McCluskey and Rausser and the McClain papers both examine neighborhood impacts via hedonic property value models. Kiel, on the other hand, simply examines percentage changes in socio-economic variables at varying distances from an incinerator. I enjoyed reading each of the papers. As a group they illustrate nicely the wide range of questions that can be addressed with property value and other neighborhood quality data.

The remainder of my comments are directed at individual papers going in the same order in which they were presented.

McCluskey and Rausser's paper is the furthest along and thus was the most provocative. I spend a bit of a disproportionate amount of time of it.

A unique contribution of the McCluskey and Rausser paper is to study property values from before identification of a hazardous waste site, and then before, during, and after cleanup of the site. Having data for these different time periods permits them to examine how permanent the property value effects of a hazardous waste site are. McCluskey and Rausser conclude that properties are only permanently stigmatized in a very limited area -- a 1-mile radius of the site. This conclusion is based on the finding that distance from the site has a positive effect on property value before identification of the site by EPA and during clean-up of the site. After clean up, distance actually has a negative effect for a 4-mile distance, but it's still positive for a 1-mile distance.

Accepting their conclusion as correct that stigma persists for the nearest properties, this is mixed news to an EPA policy maker. On the positive side, the paper **is** finding that most property values rebound following site remediation. On the negative side, this rebounding might not occur for the properties closest to the hazardous waste site. Or in the language of McCluskey and Rausser, stigma persists for the nearest properties.

However, I wonder if perhaps the fact that the values of the closest properties remain depressed is indeed a result of a stigma. Instead of stigma maybe the properties values stay depressed because they are experiencing continued negative effects that are unrelated to health and thus not remedied by cleanup. I'm not talking about ecological or non-use effects but the more mundane negative effects -- such as truck traffic and noise for an active site or just unsightliness for a closed site. In fact, this alternative interpretation can also explain a second of McCluskey and Rausser's findings B that distance positively affected property values even in the period before identification of the hazardous waste. In other words, even before the health risks from the site were known, people paid a premium to live further from it. Again, the reason could be other negative, though non-health, effects like unsightliness. Of course, these other negative effects are outside the purview of the EPA. They are not addressed by clean-up actions. I think this alternative interpretation gives better news to the policy maker -- Clean-up and reducing health risks is not futile even for close-in sites but it also isn't a panacea since other negative effects not within the purview of the EPA should be expected to persist and to depress property values.

Another important finding by McCluskey and Rausser is that media coverage of the hazardous waste site lowers property value. It does this both directly and indirectly by increasing households perceived risk from the site. The authors suggest that because increased risk perceptions affect property values and these declines in prop values are a real loss, that the EPA should consider risk perceptions in their benefit-cost analyses used to determine which sites to clean up first. And that the real effect of hazardous waste sites on property values has so far been neglected by the EPA. However, I think to some, the finding that media coverage is important might suggest just the opposite of the conclusion reached by the authors. The economics literature states that the validity of the property value method for valuing different levels of environmental quality rests on the assumption that property owners understand the risks posed by a nearby hazardous waste site. And that they understand the reduction in these risks caused by site cleanup. It's not at all clear that the EPA should determine the value of its programs by relying on the perceptions of householders when its been demonstrated that those perceptions are manipulable by the press.

This is not to say that EPA's current method of assessing such programs as RCRA and Superfund which consists of counting and then sometimes valuing health effects is ideal either. Perhaps the most valuable contribution of McCluskey and Rausser's paper is that it suggests a practical alternative -- to value a site cleanup by estimating the changes in property values that clean up induces. This would be an improvement over the current method because it would be more comprehensive by capturing all the health as well as any non-health benefits from clean up like ecological or non-use benefits. (Even though EPA clean up is directed at improving human health, usually there are ecological and resource preservation benefits as well. These are typically not valued by the EPA simply because they are so hard to value.) However, using property values to estimate the benefits of RCRA or Superfund, for example, would be criticized, I fear, because the method's credibility rests on householders having a clear understanding of the actual risks of the site. Which leads to another valuable contribution of this paper -- the suggestion that government would do well to improve its ability to communicate effectively with the public about health risks. Right now the public is very suspicious of government and other outside experts. However, the current Envirofacts program which includes the Toxics Release Inventory, Surf your Watershed and other data bases is a big success and hopefully marks a trend towards more successful risk communication.

Katherine McClain's paper is in-between the other 2 in terms of how far along it is. She does conduct hedonic property value analysis. She studies the same region and unwanted land use as Kiel an incinerator in North Andover, Massachusetts but asks a different research question:

will non-host communities experience negative house price effects from the incinerator? Since environmental and other negative externalities are not restricted by political boundaries, property value effects might not be either. The facility she studies is located in the Extreme northern corner of the town, closer to parts of 2 other towns, Methuen and Andover, than to many residential parts of North Andover. Thus she analyses house sales from these two other communities. She finds that the incinerator did not effect house prices in the nearer but lower income Methuen but that it did affect prices in the further but higher income Andover. She offers two theories B the higher income community was also more educated and more sensitive to negative externalities. And/or, this community was one of the communities contributing to the incinerator and so was included in the public discussion of the incinerator project. She concludes that her results confirm that non-host communities are affected by undesirable facilities located in neighboring towns. However, her results also show that the host community's property values are most strongly affected.

What are the implications for policy? Her findings corroborate McCluskey and Rausser's -- that the media or other forms of public discussion are important to property value impacts. As an EPA analyst with an immediate interest in relying on property values to estimate the benefits of site clean-up, the results suggest that we need to be careful to include a media or other public discussion indicator variable on the right hand side of property value models alongside the risk variable.

There are additional policy implications of this paper for local government. I'll leave the bulk of that discussion to the next speaker. I just wanted to mention a 1995 paper in JEEM by Daniel Ingberman which argues that unwanted land uses will be disproportionately sited at jurisdictional borders precisely because such locations export the negative externalities to non-host communities. He looks at the locations of landfills in PA and finds that a significant number are near borders. It is usually the decision of the host community to cooperate or fight a siting decision since it's the host community who has jurisdiction over the property. Nearby but non-host communities do not have nearly as strong a say over zoning decisions or other decisions that could make siting difficult. McClain's finding suggests that non-host communities should perhaps be given a bigger voice in siting decisions. How that would happen I have no idea and as I say I'll leave the bulk of this discussion to the next speaker. However, an interesting policy question is at what point do the non-host externalities become serious enough that there is a legitimate case for state or even federal oversight?

Katherine Kiel's paper is very preliminary, not based on a hedonic property model just on changes in socio-economic variables as you move further from an unwanted land use.

Katherine Kiel's paper investigates whether communities respond to the introduction of a unwanted land use by filtering that is by prop values spiraling downward which ultimately could lead to neighborhood deterioration. My first comment from a policy perspective is that if filtering is a common response, then there are immediate implications for the policy assessment suggested by the McCluskey and Rausser paper. That is, if identification of a hazardous waste site, for example, causes property values to spiral downward, then site clean-up might not result in restored property values since by the time clean-up occurs, property values might already have spiraled downward below what could be attributed to the presence of a health risk. In this scenario, clean up would not be expected to restore neighborhood property values. In fact, there might be so many secondary and tertiary effects that relying on property values to assess clean up would involve too much noise.

However, Kiel does not find clear evidence of filtering. If she had, perhaps one policy response would be to hurry-up clean-up efforts. In fact Superfund cleanups used to take forever. Reportedly they are now moving more quickly. Other than speeding up clean ups, however, its not clear what other policy response would follow. After all, siting decisions are private sector choices. At present it is not the EPA's role to intervene in the siting process because of neighborhood effects that are only indirectly related to health. Rather, the role of EPA is to ensure that the unwanted land uses are safe and we are doing that with both RCRA, Superfund, air quality regulations, etc. If anything, we err on the side of making at least hazardous waste sites too safe from an economists perspective. Evidence suggests that remediation costs greatly exceed monetized benefits at most Superfund sites. However, a relevant policy implication of Kiel's paper (since she does find partial evidence of filtering) is that RCRA and Superfund might be policies that disproportionately benefit the poor.

In closing, I enjoyed the opportunity to read this interesting set of papers and appreciate the researchers' efforts to expand policy makers' knowledge of neighborhood effects from unwanted land uses.

Policy Discussion of Session One

Joseph Schilling, International City/County Management Association B Summarization

Mr. Schilling began by saying he would try to broaden the policy context of the discussion and provoke thought about the larger policy implications. Mr. Schilling's organization, the International City/County Management Association (ICMA) is the professional membership organization for city and county managers, so ICMA's members are the people who implement these policies, and rely upon these studies to try and make these studies work at the ground level.

Mr. Schilling posed a question for the panelists: how can this information impact environmental decision-making at all levels of government, but also in non-governmental organizations, to the extent that they have become involved in the process of developing policies for redeveloping brownfields and contaminated properties? Mr. Schilling also observed that these papers illustrate the increased integration between what happens at the local land use level with federal environmental regulations. This occurs on a number of fronts, including debates over smart growth and brownfields redevelopment. It is sometimes difficult, however, for federal agencies to become involved with decisions that are essentially local in nature, sometimes at the neighborhood level. Mr. Schilling noted that Dr. Kiel had expressed a desire to look at data the census block level, and commented that this is an example of how necessary it is to integrate local land use decisions with state and federal policies. There is no easy way to do this, as the lead smelter example presented by Dr. McCluskey illustrates. Coincidentally, ICMA is performing research on EPA's 16 showcase brownfields sites, including a site in Dallas, and Mr. Schilling was one of the researchers assigned to talking to local residents to assess the impacts of facilities such as the lead smelter. Mr. Schilling noted that this was a highly time-consuming exercise, illustrating again the difficulty in integrating the local impacts of such undesirable local land uses with federal decisions.

Mr. Schilling expressed agreement with Dr. Jenkins's observation that there are many other variables involved in assessing the impacts of land use decisions, as ICMA's research has uncovered. West Dallas and its planning history (or lack thereof) provides a good example of this complexity. The West Dallas area is across the river from the heart of Dallas, and as recently as the post-World War era, has been the home of people of color and other socio-economically disadvantaged populations of the city. The fact that a smelter was located there thus introduces a number of additional variables, perhaps those that are outside of EPA's regulatory jurisdiction. The question is thus: what role should EPA play in the land use planning process? EPA has been playing the role of a facilitator, providing information on public health risk, and working as a convening party in bringing different parties together. While EPA's participation has been positively received in some instances, EPA has played a positive role in many cases. For example, in some cases in EPA's Superfund recycling initiative, EPA is playing the role of the catalyst, bringing together local regulators, developers, environmental organizations, engineers, and integrating the re-use plan with the cleanup process. There may be room for further study on the relationship between the re-use and the cleanup. The Dallas lead smelter is a good example because even though it has been cleaned up, it is still idle, so that the stigma is apparently persistent. Thus, policies to expedite the re-use of such sites and integrate the re-use with the cleanup process will only accelerate the revitalization of the neighborhood, which appears to be the direction that EPA is taking with its Superfund recycling initiative. Another observation or issue for further examination is the impact of brownfields generally, in terms of the planned re-use. The planned re-use will be tied very closely to cleanup, in that the cleanup standards will be different for different re-uses. This is another reason for integrating the re-use plan with the cleanup process.

Mr. Schilling also noted that the papers illustrate the micro and macro views of these siting and cleanup issues. Dr. McCluskey's paper focused on the neighborhood level, in looking at the impacts of properties very close to the smelter, while Dr. McClain's and Dr. Kiel's papers focused on the impacts on a more regional level, so these papers provide different viewpoints on the same question. As Dr. Jenkins noted, this is clearly a large challenge for local governments. Mr. Schilling also noted that it is interesting to compare Massachusetts, which has very small incorporated towns (potentially making siting decisions more controversial and difficult), to Texas, which has local governments with very large boundaries (at least reducing the number of jurisdictions that need to agree on a siting decision), although siting decisions are still difficult in both cases. One conclusion from these studies is still that agreement on unwanted land uses will have cross-boundary effects and will still be difficult, and bringing together these different cities, communities and constituencies will be difficult. One possible model for accomplishing this can be found in a fairly complex process for siting low-level hazardous waste sites in Massachusetts, which has delegated a large part of the responsibility for handling these types of cases to their state office of dispute resolution. Neutral mediators were thus brought in to help these communities making more collaborative decisions for siting low-level hazardous waste facilities.

The papers also illustrate the need for risk communication. All of the studies show that perceived risk is very influential, not only in property values and siting, but also in terms of choosing a cleanup remedy. There are a number of different avenues of risk communication, but one example that Mr. Schilling provided was the Isles Group in Trenton, N.J., a non-profit organization which does some brownfields redevelopment, but also provides public education for neighborhoods with brownfields issues. The Isles Group has established brownfields academies, in which they hold seminars in people's homes for eight to ten week sessions, and teach people about brownfields redevelopment, going over the definition of a brownfield and the land use and legal issues involved with brownfields redevelopment. This has the effect of empowering the community, and has had a very large impact in Trenton which has a Superfund-sized site. Mr. Schilling held up this model as an example for other communities to follow in working out brownfields decisions. Mr. Schilling closed by complimenting the papers for their relevance and helpfulness in informing ongoing brownfields debates.

Question and Answer Period for Session One

Don Snyder, Utah State University, expressed some concern that analysts' estimates of the cost of undesirable facilities on housing prices, as estimates for the social cost of the undesirable facilities were quite high, higher perhaps than a scientific assessment would justify. Dr. Snyder asked if Dr. McClain or Dr. McCluskey were concerned with this discrepancy between perception and the scientific reality. Dr. McCluskey replied that as long as the cost could be considered a true economic loss, there was no discrepancy, regardless of whether scientific evidence deemed the loss to be reasonable. As long as the housing prices reflect public perception of the value of the property, and as long as the decrement in housing price attributable to the undesirable facility was actual, then she saw no problem with any inconsistency with scientific evidence on harmfulness of undesirable facilities.

Dr. Snyder asked if it was bothersome that there was a difference in the perceived risk and the actual risk based upon science, and that the perceived risk served as the basis for determining social costs of undesirable facilities. Dr. McClain acknowledged that there was an extensive literature in the psychology field on the difference between perceived risk and the scientific assessments of risk, and that public perceptions of high risk are persistent despite strong scientific evidence to the contrary. Dr. Snyder wondered if such estimations of risk are thus appropriate for determining social costs. Dr. McClain replied that if she were a homeowner, then she would say yes. Dr. Bockstael commented that economists worry a great deal about people’s perceptions when doing revealed preference studies. The housing market is even more complicated than a revealed market problem, because it is not just one’s own perception that matters, but also other people’s perception that matter, much like the stock market. It doesn’t matter if a homeowner has an Accurate perception if everybody else has an inaccurate perception, because those perceptions affect the homeowner’s welfare. Dr. McCluskey reiterated this point, noting that her research was an example of a problem of self-fulfilling expectations. As in the stock market, the homeowner can wind up a loser because everybody else is scared. Dr. Kerry Smith, North Carolina State University, commented that the stock market analogy is imperfect because a homeowner has a use value in her home. Even if other people have negative and inaccurate perceptions about the value of a home, the homeowner still can use the home as a residence. There is thus a difference in the way that renters perceive a danger and owners that occupy their homes. The issue, Dr. Smith stated, is how informed people need to be. At a certain point, it becomes a public policy matter to say that people are insufficiently informed.

Sid Wolf, Environmental Management Support, noted that from EPA's perspective in regulating Resource Conservation and Recovery Act (RCRA) sites and Superfund sites, there seem to be four aspects of damages accruing from these sites: the ecological value loss, the human health aspects, the property value loss (although Mr. Wolf acknowledged that this is evidently a complicated matter) and the neighborhood effects. Mr. Wolf noted that the research presented in this first session measured the willingness to pay to avoid some, but not all of these four aspects of damages from undesirable facilities. Mr. Wolf asked if there was any effort to measure the human health aspects and ecological loss of undesirable facilities, and if there is any overlap that would be picked up by any such research design. Dr. McCluskey responded that these aspects are inter-related, that there should certainly be some research as to the human health aspects, and that it would help alleviate the problem of perceptions being different from scientific assessments. Dr. McClain added that the advantage of using property value data to measure damages was that the data consist of actual transactions, where someone actually writes a check, reflecting a greater reliability than other types of data.

Pamela Bingham, US EPA, asked if the researchers are proposing as a policy matter that the kinds of losses identified by this research will be an actual cost of doing business for companies engaging in undesirable land uses, in that compensation be paid for homeowners negatively impacted by such undesirable land uses. Ms. Bingham also noted that US EPA's Office of Solid Waster and Emergency Response has guidelines on relocation costs and asked if this was a cost that facilities will incur as a cost of doing business (http://www.epa.gov/superfund/tools/topics/relocation/index.htm. Dr. McCluskey acknowledged that there needed to be a mechanism for sorting out which people were actually harmed by an undesirable land use or siting decision. In response to Ms. Bingham's question, Dr. McClain noted that there will be pressure not from the federal government but from the local level that the property value losses of undesirable land uses should indeed be a cost of doing business. Some of these issues are still to be determined in the courts. As local entities become more savvy it is likely that these costs will be internalized by companies attempting to site undesirable land uses, as illustrated by Kirkwood, N.Y., a community that had rejected an undesirable land use siting.

Steve Winnett, US EPA Region 1, commented that he was having trouble understanding the economic jargon that was being used in discussions, and expressed a desire to have some of the economic concepts explained. Mr. Winnett also wondered if, in the McClain research, Haverhill was downwind of the undesirable land use, and whether that affected Haverhill residents' property values. He offered a regional analogy in that some Northeast states are suing Midwestern states and utilities because of acid rain problems that originate from power plants in the Midwest. Mr. Winnett also asked Dr. McCluskey if there was a smell associated with the smelter studied in her research or if there were other signals such as increased garbage truck traffic. Mr. Winnett also wondered if there couldn't be some mitigation undertaken to alleviate the property value impacts. Dr. McCluskey replied that there was no smell, but that the smelter produced lead that posed a risk to children, through contact with the soil. Dr. McCluskey also replied that the people in the vicinity of the smelter knew of the smelter and of the risk posed by the smelter. Dr. Kiel replied that in the New England study, they tried a windrows variable to capture a downwind effect, but the variable was not statistically significant. Dr. Kiel also noted that there has not yet been a non-host town taking action against a host-town for compensation, but believed that this could be forthcoming. Dr. McClain also commented that in another situation south of Boston, an undesirable facility approached the problem as a regional one, and contacted a number of potential stakeholders as far away as ten or fifteen miles away. Dr. McClain added that they could not figure out why the windrows variable did not work, except that they used the windrows from Boston's Logan Airport, and not the windrows from the actual site.

Ted Su, US Bureau of Land Management, posed environmental justice issues. A program that relies upon property value as the only variable and seeks to find the optimal choice of siting may well choose to locate all undesirable facilities in poor or minority communities. Dr. Su also noted that it may be worthwhile to consider the benefits from siting decisions, since an economist is charged with equating marginal social costs with marginal social benefits. Dr. Kiel agreed that there is a danger when using property value as the criteria for determining optimal sites. There are several alternatives, however, including the use of a percentage change in property value rather than absolute changes property values. Dr. Kiel agreed that it is difficult to talk about equity in terms of equating marginal social costs with marginal social benefits, because equity and social considerations are left out of that consideration. Dr. Kiel added that it is important when making siting decisions to also ask what can be done to mitigate the harm from such facilities. Dr. Kiel added that it was interesting, but probably the exception rather than the rule, that a wealthy community such as North Andover would want construction of a facility such as an incinerator.

Matt Clark, US EPA, commented that it should not be overlooked that the Superfund program has an insurance value for the country as a whole. This program provides some assurance that if there is a hazardous waste site, someone will assume the role of coming in and cleaning up the site and making the "bad guys," or polluters pay for the clean up. While Dr. Clark admitted that he did not know how to conduct research to estimate this value, he noted its importance. Dr. Clark made a second comment that although equity considerations are important, it is not necessarily a problem if lower-income people are getting higher-quality housing as a result of this transfer. If a transfer payment is made, it may be important for a researcher to tease out what fraction of a compensation payment is a transfer and what fraction is deadweight loss. Dr. Kiel noted that her point was not that devaluation of property was occurring, but rather how quickly it occurred. Dr. Jenkins responded that she was only proposing that using property value as the means of estimating the cost of siting undesirable facilities be considered a lower bound of the cost estimate. Dr. McCluskey agreed that lower-income people can evaluate their own trade-off of housing quality with environmental risk, but pointed out that as a society, it is still necessary to establish some minimum level of exposure. Although Dr. McCluskey acknowledged that this might seem paternalistic, she pointed out that this is often the role of government.

Dr. Kerry Smith proposed drawing a lesson from the sulfur dioxide emissions trading permit program and implementing a tradable permit scheme for houses near an undesirable land use. Dr. Smith proposed an endowment-equalizing payment whereby the highest-valued house gets zero, and other houses get a payment equal to the difference between the house value and the value of the highest-valued house. The effect is to provide an equal endowment among all the homeowners, so that heterogeneous preferences can be accommodated. Dr. McCluskey noted that it is still desirable to establish a lower bound for risk. Dr. Smith agreed, but pointed out that this mechanism ensures that compensation is actually made to those who lose out from the siting decision.

Dr. Smith posed a question as to whether any work had been done on the time pattern of effects and how hedonic data changes over time. There are now firms that sell hedonic data, and that this could lead to a Lucas, rational expectations phenomenon, in that people will anticipate changes in value of property and react accordingly, the effect being that property values will go to an equilibrium value more quickly. Dr. McCluskey agreed this was possible, that this hedonic information could present arbitrage possibilities, but that there were also temporary changes in neighborhoods that could have long-term effects.

Eric Slaughter, a Washington, D.C. businessman, asked if there was any evidence of redlining by lending institutions or other financing anomalies that might have affected property value changes. Dr. Kiel responded that they only looked at completed sales, so that they do not know if there were substantial failed sales. Although their research also looked at raw numbers of sales in other areas, there was no way to infer that lenders were more hesitant to issue loans for certain areas due to the siting of undesirable facilities. Dr. McCluskey also noted that there is some data on how long houses were on the market, giving some indication as to whether there was trouble selling the house. Again, however, this is not definitive data as to the salability of a house.

Ms. Bingham asked for a clarification of a remark by Dr. Jenkins regarding why it was that the poor disproportionately benefit from the Superfund program. Dr. Jenkins responded that the evidence seems to indicate that sites are disproportionately located in lower-income minority neighborhoods, so any program designed to clean up these sites naturally confers more benefits to those located near the sites. Ms. Bingham pointed out that it is more accurate to refer to lower-income and minority neighborhoods separately, since the two are not necessarily one and the same. Sven-Erik Kaiser speaker also proposed the clarification that perhaps it is more accurate to say that these programs *proportionately* benefit lower-income and minority people, since these people bore a disproportionate burden to begin with.

Ken Acks, Environmental Damage Valuation and Cost Benefit News, asked if people might get used to the stigma of undesirable facilities, and that properties might appreciate over time, reflecting the convergence of public opinion with scientific opinion. Dr. McCluskey replied that this was similar to the situation of the engineers who lived near the nuclear facility in Hanford, Washington, who knew what the risk was and were thus not unduly afraid of the stigma of being near the facility. Dr. McClain pointed out that mobility also still matters, that even if people know the actual risk, they still cannot easily simply move, because of the perceptions of others of property values near undesirable facilities.

Mr. Wolf noted that in the Kiel research, the decrement in housing value appeared to be on the order of $2,000 to $8,000 per mile from the facility and queried whether that was enough to change the neighborhood. Dr. Kiel noted that their research got mixed results, and that she had no definitive answer to that question. Dr. McClain added that their research indicated that housing value appreciation rates did seem to be affected by the undesirable land use.