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Can Stigma Explain Large Property Value Losses? The Psychology and Economics of Superfund★

KENT D. MESSER[1,*], WILLIAM D. SCHULZE[1], KATHERINE F. HACKETT[1], TRUDY A. CAMERON[2] and GARY H. MCCLELLAND[3]
[1]*Department of Applied Economics and Management, Cornell University, Ithaca, NY 14853, USA;* [2]*Department of Economics, University of Oregon, Eugene, OR 9740;* [3]*Department of Psychology, University of Colorado, Boulder, Colorado 80309; *Author for correspondence (e-mail: kdm22@cornell.edu)*

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Abstract. This research documents the long term impacts of delayed cleanup on property values in communities neighboring prominent Superfund sites. The research examines the sale prices of nearly 34,000 homes near sites in three metropolitan areas for up to a 30-year period. To our knowledge, no other property value studies have examined sites in multiple areas with large property value losses over the length of time used here. The results are both surprising and inconsistent with most prior work. The principal result is that, when cleanup is delayed for 10, 15, and even up to 20 years, the discounted present value of the cleanup is mostly lost. A possible explanation for these property value losses is that the sites are stigmatized and the homes in the surrounding communities are shunned. The results suggest that expedited cleanup and minimizing the number of stigmatizing events would reduce these losses.

Key words: hedonic models, property values, stigma, superfund

1. Introduction

This study evaluates the benefits (as captured in residential property values) of hazardous waste cleanup conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. When this legislation was passed in 1983, following Love Canal, the

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public imagined that the United States Environmental Protection Agency (EPA) would begin immediate cleanup of sites deemed hazardous to human and environmental health, using tax money collected from the petroleum and chemical industries. However, CERCLA's provision of joint and several liability requires that all previous and current owners could be responsible for cleanup costs regardless of the amount of hazardous waste deposited at the site. This legal complexity of CERCLA in establishing fair and just responsibility substantially delayed cleanup at many listed Superfund sites.

This research documents the consequences of that delay on property values in communities neighboring prominent Superfund sites. To explore the possibility that stigma can help explain public reaction to potentially hazardous sites, the communities neighboring sites in three metropolitan areas are examined: (1) the Operating Industries, Inc. (OII) landfill near the communities of Monterey Park and Montebello, California; (2) the radium pollution in Montclair, Glen Ridge, and East/West Orange Townships in northern New Jersey; and (3) the Industri-Plex and water Wells G & H sites in Woburn, Massachusetts. The research examines the sale prices of nearly 34,000 homes for up to a 30-year period, and describes the history of each site. While many Superfund sites have shown no or small property value losses in surrounding communities, the sites selected for this study all have shown large losses at some point in time. Furthermore, to our knowledge, no other property value study has examined sites in multiple areas with large property value losses over the length of time used here.

For these three case studies a variety of conflictual conclusions can be drawn, depending on the time period for which property values are examined. However, when examined over a longer time horizon, the results are both surprising and inconsistent with most prior work that looks at shorter time periods that suggest immediate benefits of cleanup actions (e.g., McClelland et al. 1990; Gayer et al. 2000; Gayer and Viscusi 2002). The results of this study are more consistent with studies that look beyond the completion of cleanup activities – studies which suggest property values may only recover some time after cleanup has been completed (Kohlhase 1991; Dale et al. 1999). The principal result of this research is that, over the long term, when cleanup is delayed for 10, 15, and even up to 20 years, the discounted present value of the benefits of cleanup are mostly lost since property values do not recover during the cleanup period itself. A possible explanation for these property value losses is that a Superfund site remains stigmatized and the homes in the surrounding communities are shunned as long as activity continues at the site.

This paper summarizes the key findings and is organized as follows. The second section briefly describes the Superfund sites in three distinct metropolitan areas of the United States. The third section discusses why residents of neighboring communities may have different beliefs about the health risks associated with these sites than do scientific experts, and outlines what is known about the psychology of risk perceptions and stigma. The fourth section integrates the psychology of stigma with the economic hedonic property value approach which, as noted by Adams and Cantor (2001), is a nontrivial task. The fifth section presents the key results of this study and, finally, the sixth section presents conclusions.

2. Case Studies

2.1. OPERATING INDUSTRIES, INC. (OII) LANDFILL, CALIFORNIA

The OII landfill reaches a height of 300 feet and covers 190 acres between the communities of Monterey Park and Montebello, California. Located 10 miles east of Los Angeles, the landfill received 30 million cubic yards of residential and commercial refuse, industrial wastes, liquid wastes, and a variety of hazardous wastes during its operating life from 1949 to 1984. Though the neighborhoods were originally promised the development of a golf course after the landfill was closed, this promise was never realized. In the early 1980s, residents near the landfill complained of odors, leachate seepage, and methane gas buildup. In October 1984, the landfill was closed and proposed for listing on the National Priorities List (NPL). In June 1986, the landfill was officially listed as an NPL Superfund site, and experts estimated that the cleanup could take as long as 45 years and more than $600 million to complete. As of 2002, the EPA had reached settlements with almost 4000 parties to pay for the cleanup work, with the total settlements reaching over $600 million.

The surrounding area consists of residential development with mostly middle income and multi-racial neighborhoods. Approximately 53,000 people live within three miles, 23,000 within one mile, and 2150 within 1000 feet of the landfill. Three schools are located within one mile of the landfill. For this case study, the data consists of sale prices, housing characteristics, and Census information for nearly three decades (1970–1999). The length of this sample enables an examination of how proximity to the landfill affected housing prices eight years *before* the problems began to arise in the late 1970s. A large area was selected for this study. The broader neighborhood surrounding the OII landfill includes 9279 dwellings ranging from a minimum distance from the site of 0.06 km and to a maximum of 8.5 km from the boundary of the site.

2.2. MONTCLAIR, WEST ORANGE, AND GLEN RIDGE, NEW JERSEY

These townships are located about eight miles from Newark Airport in northern New Jersey. Several industrial plants once occupied the area, the largest of which was the U.S. Radium Corporation, which operated between 1915 and 1926. Because of its luminescent properties, radium was added to the paint used for numbers on glow-in-the-dark watch dials and instruments, which became especially popular during World War One. As the neighboring townships developed, an estimated 200,000 cubic yards of soil, which was contaminated by waste generated from the radium processing, was placed around homes and in public areas in the communities. Radium can result in high levels of radon gas and gamma radiation.

Residents became aware of the problems associated with radium deposits in 1983 when a television news report broke the story. Subsequent new reports frequently referred to the radium contamination as "another Love Canal" since both residential areas were built on contaminated soil. Later, the Centers for Disease Control and the New Jersey Department of Health declared the depositional sites to be a public health hazard due to concerns about lung cancer. In 1985, Montclair/West Orange and Glen Ridge were listed on the NPL. The initial cleanup efforts were hampered by legal problems, and by 1999 (nearly 20 years after the initial identification of the problem and 12 years after being placed on the NPL) cleanup activities were still in process and the EPA investigated the possibility of additional groundwater contamination. By 2004, over 300 houses had been remediated and 80,000 cubic yards (5000 large truck loads) of contaminated soil had been removed. Estimates of total cleanup costs exceeded $200 million.

These towns are densely populated and approximately 50,000 people live within one mile of the two sites. The Montclair/West Orange Radium site consists of 366 residential properties on 120 acres. The Glen Ridge Radium site is comprised of 306 properties on 90 acres of residential land. The data used in this study consists of selling prices, housing characteristics, and Census information for one decade (1987–1997), which started two years *after* the sites were listed on the NPL. These data enabled the changes in housing prices over time to be analyzed *during* the multi-phase cleanup process. The data for this case study includes sale prices for 11,940 houses, 526 that were located directly on the site and 11,414 houses within a maximum of 6.7 km of the site.

2.3. INDUSTRI-PLEX AND WATER WELLS G & H, WOBURN, MASSACHUSETTS

Founded in 1640, Woburn is a predominantly blue-collar community with a long industrial heritage. Located 12 miles northwest of Boston, Woburn became a leader in the tanning industry in the 1800s as it was home to 26 large tanneries that employed approximately 1500 employees. At the peak of Woburn's tanning industry, from 1900 to 1934, an estimated 2000 to 4000 tons of chromium was dumped directly into local water resources, as well as 65–140 tons of copper, 85–175 tons of lead, and 40–75 tons of zinc. Woburn has a long history of public health problems, including elevated rates of kidney and liver cancer, colon–rectal cancer, child and adult leukemia, male breast cancer, melanoma, multiple myeloma, and brain and lung cancer. Woburn is also the location of two large Superfund sites: Wells G & H and Industri-Plex. Together the sites cover almost 600 acres of land in the 14 square-mile community. Pollution problems at both sites were discovered within a few months of each other. Both sites were evaluated by the EPA and added to the NPL in the early 1980s.

The 330-acre Wells G & H site was once ranked as the 10th worst site on the EPA's NPL list. The site is the location of two public drinking water wells for the city of Woburn, which were built in 1964 (Well G) and 1967 (Well H). These wells were located near an automobile graveyard, an industrial barrel cleaning and a reclamation company, a waste oil refinery, a tannery, a dry cleaner, and a machinery manufacturer. Despite public complaints about water quality from these wells, the City of Woburn continued to use the wells, especially during dry summers. Both wells were closed in 1979. Soil and groundwater at the site are contaminated with volatile organic compounds (VOCs), such as trichlorethylene (TCE) and tetrachloroethylene (also called perchlorethylne, PCE, or 'perc').

The Industri-Plex site, the location of Woburn's most intensive industrial activity since the 1850s, consists of 245 acres in an industrial park and once ranked as the fifth worst site on the NPL. Contamination includes heavy metals and hydrocarbons. The soil is primarily contaminated with arsenic, lead, and chromium and the water with benzene, toluene, arsenic, and chromium. Additionally, hydrogen sulfide gas once permeated the air, emanating from wastes and buried animal hides from the tanneries.

In 1979, the discovery of two major hazardous waste problems in one town prompted strong media interest and an active response from Woburn's residents. Area newspapers and TV stations ran multi-part stories about Woburn, referring to it as a "toxic wasteland." A civil lawsuit regarding child leukemia in Woburn commanded front-page national media attention. The book describing this lawsuit, *A Civil Action*, was published in 1996 and became a bestseller. In 1999, the book was made into a movie starring John Travolta.

Approximately 34,000 people live within three miles of both sites. The data for this case study consists of sale prices of 12,444 homes, housing characteristics, and Census information from 1978 to 1997. The sample begins one year *before* the discovery of contamination at Industri-Plex and Wells G & H and extends throughout the lengthy litigation and cleanup activities. Homes in the sample ranged from a minimum of 0.4 km to a maximum of 8.4 km, where distance was measured as the shortest distance to either one of the two sites.

3. Expert Error, Perceptual Cues, Risk Perception, and Stigma

Hamilton and Viscusi (1999) argue that residents living near Superfund sites judge risks to be of a magnitude consistent with EPA expert opinions and that these judgments are reflected in property values. The research presented here suggests quite the opposite. This section documents many cases of expert error to help explain why expert opinion may play a limited role in explaining residents' risk beliefs, as the judgments of experts are only one component of the mix of news media stories and perceptual cues received by the typical citizen. As Fischhoff (1989) notes, the pronouncements of a few scientists are unlikely to change risk beliefs determined largely by media stories and perceptual cues. Finally, this section describes the characteristics of stigma, social amplification of risk and the heuristic of shunning.

Numerous well-known examples highlight the errors and misestimates of experts from academia, government, and industry:

Errors by scientific experts
- The false discovery of Cold Fusion
- The failures at Biosphere 2
- Birth defects from Thalidomide

Errors by government experts
- The near nuclear meltdown at Three Mile Island
- Soil contamination at Love Canal, Niagara, New York

Errors by industry experts
- The defective Dalkon Shield for birth control
- The Union Carbide Accident in Bhopal, India

Furthermore, news about human and environmental health is omnipresent, yet much of this information is contradictory. A cursory survey of two major national newspapers conducted over a three-month period in 1999, yielded a nearly a dozen articles that contested previously reported claims or presented evidence of expert misjudgment and error. Even when experts are in essential agreement, the news media often focuses on those aspects where experts disagree (Wilkins and Patterson 1990), lowering the perceived credibility of experts. In a study examining news coverage of Three Mile Island and Chernobyl, Rubin (1987) found that news stories tended to dichotomize events rather than blend a continuum of information to recipients. While undoubtedly errors are a crucial part of scientific progress, for residents living near Superfund sites, the prospect of scientific error is not unacceptable. If expert opinion is not perceived to be infallible, then residents living near Superfund sites must also, in part, construct their own subjective risk beliefs, which are likely based on perceptual cues and media coverage.

Perceptual cues are physical aspects that are observed by local residents and are suggestive of risk. Examples of perceptual cues include odors emanating from landfills, unusual flavors in well water, unusual water coloration and high volumes of truck traffic around the site. Ironically, some actions taken by authorities to minimize public health risks tend to exacerbate risk beliefs and stigma by providing cues that some risk is present. Erecting chain link fences, posting 24-hour guards, placing warning signs, and conducting on-site tests with workers wearing protective clothing are all cues to residents that risk levels may be high. Such actions, which may be necessary, almost never lower risk beliefs. Furthermore, proximity to a site increases the frequency and duration of observation that yield perceptual cues.

The effects of strong perceptual cues are well illustrated for the OII landfill. According to McClelland et al. (1990), no credible evidence indicated that there was a significant long-term health risk to residents. However, concern about high volumes of truck traffic and odors from the landfill prompted local residents to organize and confront problems associated with the site. In their survey, McClelland et al. found a significant correlation between the awareness of perceptual cues and high risk beliefs of many residents living near the site. Furthermore, residents had a bimodal response, as many of the remaining residents believed the risk was trivial, while more than half believed that living near the site was as dangerous as smoking more than one pack of cigarettes per day (an incremental annual risk of death of approximately 1/100). Assuming typical values for statistical life and assuming three people per home, the discounted present value of the risk for the residents that assessed the risk as similar to smoking exceeded the price these residents paid for their homes! Residents who responded this way reported that they were desperate to sell and sought immediate cleanup. Note that hedonic property value analysis does not consider the effect of corner solutions by potential or actual homeowners. This problem is addressed in the section below.

How a risk affects the community, society, and the economy will depend on individual and group perceptions of the risk (Slovic et al. 1991; Kunreuther and Slovic 2001). In situations like Superfund sites, where there are a large number of events connected to perceptual cues and media attention, there can be a compounding or ''rippling'' effect as more people become concerned about the risk (Kasperson et al. 1988). As Kunreuther and Slovic (2001) describe it, interactions among individuals can produce a ''social amplification of the original risk concern.'' The greater the population living near a site, the greater is the potential for compounding or social amplifying the risk concern. When residents or potential buyers are extraordinarily fearful of a site, they may respond by shunning the neighboring communities consistent with the corner solution problem mentioned above. This behavioral response is call stigmatization and has been explored in a number of experiments that suggest that if risks are perceived as being excessive, an individual's calculations of risk versus benefit is replaced by a simple heuristic of shunning or avoiding the stigmatized object. Note that we cannot distinguish between large risk perceptions causing people to withdraw from a market and stigma, since both are behaviorally the same. However, this may constitute a distinction without a difference since perceptual cues drive both phenomena.

According to Rozin (2001), stigma has been shown to have a number of key properties. Laboratory experiments testing these properties have included examples where a dead sterilized cockroach is dipped into glasses of juice then subjects' willingness to drink the juice is gauged (Rozin 2001). While the full range of reactions to residents living next to Superfund sites cannot be precisely compared to a subject's reaction to a cockroach in juice, there are a number of properties of stigma that appear to be similar and are worth noting. First, stigma shares many of the psychological characteristics of contagion, where contagion is associated with touch or physical contact. For example, subjects refused to drink the juice if the sterilized cockroach was dipped into the glass. However, they would drink the juice if the cockroach was just placed near it. Second, stigma appears to be permanent in that it does not decay over time by itself. Subjects refused to drink the juice even if it had been in the freezer for one year. Third, stigma appeared to be insensitive to dose. Reductions in the duration of contact between juice and cockroach appear to have little effect. Any contact by the cockroach was sufficient for subjects to shun the juice. Fourth, the source of contagion giving rise to the stigma is usually unknown. Finally, subjects tend to medicalize the risk, describing that the stigmatization was the result of a fear of health effects. Rozin concludes that while shunning may be an adaptive response to avoid contaminated food, it can be triggered in inappropriate circumstances.

The possibility that Superfund sites might be stigmatized could have a major impact on the prospects for successful cleanup of contaminated sites. In principle, future improvements should be capitalized into home values. However, if such sites are permanently shunned because they are viewed as permanently stigmatized, property values may not recover quickly once cleanup is initiated or even when cleanup is completed.

4. Stigma and Property Values

The possibility that stigma may cause large losses in property values has been noted by other researchers (e.g., Dale et al. 1999; Adams and Cantor 2001) and the EPA (Harris 2004). In contrast to the hedonic approach (Rosen 1974; Harrison and Stock 1984; and for application to hazardous sites see Bartik 1988; Michaels and Smith 1990; Kolhase 1991; Ketkar 1992; Mendelsohn et al. 1992; Harris 2004 etc.) where risk is treated as one of many attributes that contribute to a determination of sale price, stigma is likely to affect property values in a rather different and more direct manner. Upon learning of the contamination potentially affecting their community, some current homeowners may simply be unwilling to continue living in their homes, and likewise, potential buyers will be unwilling to consider buying a home in that community. If some owners and buyers have lexicographic preferences, the standard hedonic model fails since it relies on a continuous tradeoff between risk and home prices. Shunning by both current owners and potential home buyers will reduce the total demand for housing for a neighborhood near a site as shown in Figure 1. Imagine that the total demand for homes in a fully built-out neighborhood with H existing homes is $Q(P)$ where Q is the number of desired homes, P is the sale price, and quantity demanded falls with price, $Q' < 0$. If, for example, homes were sold in a competitive uniform price auction, the equilibrium price, P_e, is obtained by solving $H = Q(P)$, so $P_e = Q^{-1}(H)$. Now consider the case where a fraction f of home buyers and owners shun a neighborhood because of a nearby Superfund site. The usual hedonic model cannot handle this phenomenon because the hedonic price adjustment for these individuals – either through very high subjective risk beliefs (assuming conventional values of statistical life) or shunning – would give homes an implied cost of risk greater than or equal to the value of the home. In either case, the perceived costs of staying in the home are greater than the entire value of the home and the observed behavior would be identical. This implies that fraction f of current owners

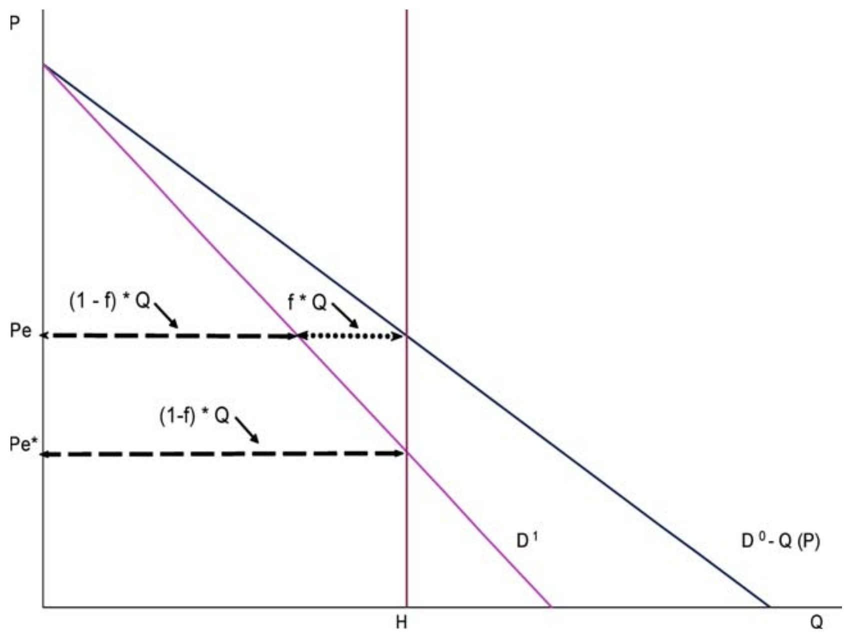

Figure 1. Effect of stigma on equilibrium housing prices.

will sell their home and that the number of potential buyers will be reduced by fraction f as well. As shown in Figure 1, since total demand for the neighborhood has been defined to include current owners, the equilibrium price will now be determined by solving $H = (1 - f)Q(P)$, so $P_e{}^* = Q^{-1}(H/(1 - f))$ and $P_e{}^* < P_e$ for $f > 0$. If f falls with distance from the site, as is likely since perceptual cues decline with distance, then property values will rise with distance, *ceteris paribus*.

Since hedonic analysis is used to incorporate typical attributes for predicting property prices, how can a downward sloping demand be incorporated into the analysis? The answer proposed here is that hedonic models predict an average price based on home and community attributes, but do not take into account individual buyer characteristics, including bidding errors, which will affect the willingness to pay for homes in a particular area. So, for example, relative to a predicted hedonic price, P_h, one particular individual will be willing to pay more (or less) because grandmother happens to live in the neighborhood and another particular individual will be willing to pay less because of a random error in bidding strategy. Clearly no hedonic market can exist for such attributes since they are buyer-specific, and these sale price deviations will appear as part of the error term in the estimated hedonic equation. Thus, for homes with a particular set of hedonic attributes in a homogenous neighborhood with a mean sale price of P_h, there exists an array of values for homes among potential buyers, V, with a cumulative distribution function of $Q(V)$. Presumably, the H buyers with the highest individual values will own homes in the area.

To further understand the property value market, the market is modeled as a discriminative auction to account for the fact that identical homes in the same neighborhood can, in fact, sell for different prices depending on unobserved individual buyer errors and other attributes (see Cox et al. 1984, for a discussion of the relevant theory and an experimental test of this auction). Approximating the property value market with an appropriate auction, where multiple buyers compete for available homes, solves the potential problem associated with modeling real estate sales as bilateral negotiations where some sellers potentially have no value. In a discriminative auction, other potential buyers provide competition that maintains the price at a higher level than that which would be predicted by bilateral negotiation. The properties of a discriminative auction are well understood, and this auction provides a reasonable approximation to the real estate market under the special circumstances where homes near a site are stigmatized.

As previously discussed, sellers in this model have essentially no value for the homes they are selling since they shun the site. Thus, any positive price they can get for the home is acceptable. This corresponds to an auction situation where buyers bid on H homes put up for sale, and the H bidders with highest bids obtain the homes for the prices bid. Figure 2 shows this market in the context of total demand where all homes in a neighborhood are potentially up for sale. Note that the bids in a discriminative auction (shown as the lower step function) fall below the true values (upper step function). Note also that compared to the price that would be obtained in a uniform price auction giving a price, P_e, in a discriminative auction there is a distribution of bids and sale prices around the equilibrium price, since buyers pay accepted bid prices. In a discriminative auction, it is well known that if buyers are risk-neutral, the average of the accepted bids will equal the uniform price, so revenue-neutrality exists in theory between uniform price and discriminative auctions. Note also that risk aversion will increase bids in a discriminative auction and bring them closer to true values because buyers trade off the gain in consumer surplus of a lower accepted bid against the reduced probability of having their lower bid accepted. The lower bid curve shown in Figure 2 assumes risk-neutrality and plausibly provides a lower bound for bids in a real estate market.

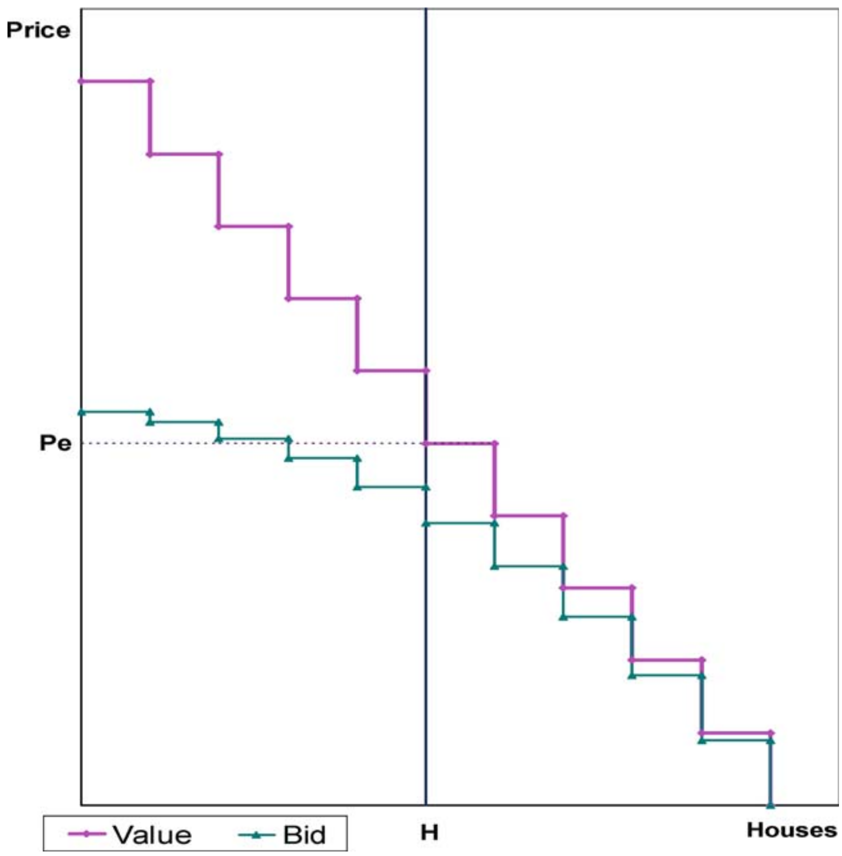

Figure 2. Discriminative auction market.

With these concepts in mind, we can turn to the hedonic model used to estimate property values at each of the study sites. The hedonic model estimated to explain property values uses a logarithmic specification and takes the form:

$$\mathrm{SPRICE}_{\mathrm{it}} = P_t \mathrm{DIST}_{\mathrm{it}}^{b_{1t}} e^{b_2 A_{iT}} e^{b_e S_{\mathrm{it}}} e^{b_4 D_{iT}} e^{\varepsilon_{\mathrm{it}}} \qquad (1)$$

Here, P_{t} is an area-wide price index for owner-occupied housing in year t, $\mathrm{DIST}_{\mathrm{it}}$ is the distance of each dwelling from the Superfund site in question. The coefficient associated with this variable will be allowed to differ across years by interacting the constant distance measure with yearly dummy variables. The vector A_{iT} is property attributes and S_{it} is a vector of (interpolated) time-varying characteristics of the Census tract in which the dwelling is located, and D_{iT} is a vector of the logarithms of the distances from the dwelling to a potentially relevant set of other spatially differentiated local amenities or disamenities, calculated at time T, the end of the sample period, rather than contemporaneously.

Taking the logarithms of both sides of the equation yields a version of this model that is appropriate for estimation:

$$\mathrm{LSPRICE}_{\mathrm{it}} = lnP_{\mathrm{t}} + b_{1t}\mathrm{LDIST}_{\mathrm{it}} + b_{2t}A_{iT} + b_{3t}S_{\mathrm{it}} + b_{4t}D_{iT} + \varepsilon_{\mathrm{it}} \qquad (2)$$

where $\mathrm{LSPRICE}_{\mathrm{it}}$ denotes the logarithm of the observed selling price, lnP_{t} will be captured as an intercept for the first year in the sample and a set of intercept shifters activated by yearly dummy variables. The variables of key interest are the $\mathrm{LDIST}_{\mathrm{it}}$, which consist of a vector of logged distances from the dwelling to the Superfund site interacted with yearly dummies in order to permit year-varying elasticities of housing prices with respect to distance to the site. Geographic Information Systems (GIS) techniques were used to measure distances from the homes to the closest Superfund site and the distances to other local amenities or disamenities as they existed in year T.

An ideal sample of data would consist of transactions data and housing structural characteristics, neighborhood characteristics, distances to all relevant amenities and disamenities, all collected contemporaneously with the time of sale. This ideal data would also include analogous information (except for selling price) about houses that did not sell in these periods, either because they were not for sale, or they did not find a buyer. This would allow the researcher to control for non-random selection in the pool of dwellings actually observed to be transacted.

When a researcher has data like these data over a number of years, it is possible to control for many unobserved housing and neighborhood characteristics that do not vary across time by using the so-called "repeat sales" method. When a house has sold more than once in the observed time period, the difference in the selling price can be explained in terms of differences in any explanatory variables that have also changed over time. This method for eliminating all the time-invariant characteristics from the analysis was first proposed by Bailey et al. (1963), and has recently been used to analyze the influence of news stories about Superfund sites on housing prices (Gayer and Viscusi 2002). One disadvantage of this method is that the sample of repeat-sales dwellings over-represents houses with greater turnover and excludes dwellings that have been sold only once during the window of time for which data are available. There is also a problem that any remodeling or updating of the property that is not captured by the quantity variables typically recorded in multiple listing service data will go unacknowledged in the process of dropping all structural characteristics by differencing over time.

In this study, we use a source of data that over-samples houses that have been sold only once over the time period in question. The data roughly reflect the current status of the dwellings. The data are provided, for the most part, by Experian, a company which provides information to direct mail marketers and others. These data are updated at fairly regular intervals, although not simultaneously. Anyone buying these records gets the most recent information available. For each street address in the sample, most records include information on the date when the house was purchased and the price that was paid at that time. For different localities, there are different quantities of structural information in the data set. From the same data supplier, all fields will be available for all localities, but for any given locality, blocks of fields will be blank. Blank fields differ across localities, possibly reflecting different public recording requirements.

An obvious disadvantage of this sample is that in all of the data sets we only observe selling prices for the most recent sale of a house. If a house is in an area where turnover is high, there will be more recent sales and fewer earlier sales. For analytical purposes, it would be preferable to have data on all sales in all years and selling price in those years, but such data do not exist.[1] Data could be purchased from Experian every year, if a future study could be anticipated, but retrospectively, the data are not available. The data are collected primarily for current marketing purposes and records are updated without saving their previous values. Historical modeling is not a use anticipated by the providers of the data. Consequently, there may be some systematic sampling. We observe earlier transaction prices only for houses which are still occupied by the owners who purchased them at that earlier date. We do not observe many early transaction prices for houses in neighborhoods where there has been a lot of turnover. It must be a maintained hypothesis that rates of turnover are uncorrelated with identification and cleanup of Superfund sites. This may be a strong assumption, but there are few alternatives. So it will be necessary to speculate upon the types of biases

Table I. Yearly distance coefficients and standard errors by site

Year	OII landfill		Montclair		Woburn	
	b_{1t}	(Std. error)	b_{1t}	(Std. error)	b_{1t}	(Std. error)
1970	−0.087	*(0.075)*				
1971	−0.168	*(0.070)*				
1972	−0.144	*(0.048)*				
1973	−0.131	*(0.040)*				
1974	−0.153	*(0.053)*				
1975	−0.123	*(0.028)*				
1976	−0.092	*(0.021)*				
1977	−0.093	*(0.025)*				
1978	−0.074	*(0.024)*			−0.118	*(0.044)*
1979	−0.017	*(0.044)*			−0.213	*(0.077)*
1980	−0.158	*(0.043)*			−0.072	*(0.065)*
1981	−0.120	*(0.135)*			−0.156	*(0.087)*
1982	0.118	*(0.089)*			−0.116	*(0.059)*
1983	−0.132	*(0.043)*			−0.199	*(0.056)*
1984	−0.031	*(0.051)*			−0.177	*(0.045)*
1985	−0.056	*(0.048)*			−0.084	*(0.047)*
1986	−0.006	*(0.036)*			−0.161	*(0.048)*
1987	−0.055	*(0.033)*	−0.062	*(0.026)*	−0.177	*(0.040)*
1988	−0.013	*(0.057)*	0.022	*(0.020)*	−0.133	*(0.036)*
1989	0.086	*(0.050)*	−0.026	*(0.011)*	−0.137	*(0.036)*
1990	−0.033	*(0.039)*	−0.001	*(0.013)*	−0.138	*(0.036)*
1991	0.111	*(0.069)*	0.019	*(0.012)*	−0.128	*(0.037)*
1992	−0.047	*(0.027)*	0.010	*(0.012)*	−0.098	*(0.039)*
1993	−0.018	*(0.028)*	0.015	*(0.009)*	−0.082	*(0.031)*
1994	−0.004	*(0.026)*	0.042	*(0.015)*	−0.153	*(0.032)*
1995	0.004	*(0.044)*	0.036	*(0.011)*	−0.081	*(0.033)*
1996	0.046	*(0.041)*	0.037	*(0.011)*	−0.092	*(0.029)*
1997	0.073	*(0.037)*	0.091	*(0.017)*	−0.145	*(0.041)*
1998	−0.004	*(0.020)*				
1999	0.010	*(0.021)*				
Observations						
	9279		11,940		12,444	
Distance from Site (km)						
Min	0.06		0.00		0.37	
Max	8.47		8.41		8.41	

this non-random selection is likely to produce in the effects of distance from a Superfund site on housing transactions prices.

However, a distinct advantage exists of only having one observation for each home in the sample. By only having one observation per house and controlling for area-wide price index with dummy variables, we ensure that each observation is independent. Therefore, the coefficient b_{1t} (the effect of distance from the Superfund site on property values) can be observed over time by looking at the hedonic estimates for each year over the 20–30 years of observations that have been obtained for each of the sites (Table I).

From Equation (1), we can derive a variable, R_t, by specifying a ratio that can answer the question of how do property values of homes close to the superfund site ($\mathrm{DIST_{min}}$) compare to prices that are sufficiently far away from the site as to not be negatively effected ($\mathrm{DIST_{max}}$) holding all other factors equal. In addition to this relative effect of distance, we can understand the time trends in property values by first averaging the b_{1t} coefficients derived from hedonic equations over 3-year intervals to dampen noise and then normalizing these coefficients by the initial 3-year period property value effect, $t=0$. Using algebra from Equation (1), the resulting specification is as follows:

$$R_t = \left(\frac{\mathrm{DIST_{min}}}{\mathrm{DIST_{max}}}\right)^{b_{1t}-b_{10}}. \qquad (3)$$

A key advantage of this specification is that it provides estimates that are relatively easy to interpret as the index for each site starts at 1.0 (or 100%) and either decreases or increases in successive 3-year periods.

5. Results

As can be seen in Figures 3–5, relative property values of the three case studies tend to follow an overall declining trend consistent with the notion of progressive stigmatization of the site. This result is in contrast to a number of earlier studies that examined property values over shorter time periods (Kiel 1995; Carroll et al. 1996; Kiel and Zabel 2001). For the OII landfill (Figure 3), property values initially show an increase from the original time period of 1970–1972, perhaps as a response to the promise of the closure of the landfill and the development of a golf course on the site. However, property values begin to fall upon the discovery of potential problems. When the site is added to the NPL list in 1985, prices of neighboring homes appear to recover somewhat, however, with the onset of cleanup activities property values continue to decline or at least stay in a depressed state. By the end of the sample, relative property values of homes near the site appear to be just 60.5% of their original value after accounting for all other factors.

For Montclair (Figure 4), relative property values of neighboring communities experienced a steady decline throughout the decade of ongoing cleaning efforts, which included removing soil around houses and major reconstruction of roads, parks, and sidewalks. The result is that by the end of the sample period 1996–1997, relative property values are just 76.5% of their original value. Finally, for Woburn (Figure 5), relative home values decrease after initial discovery of the sites only to experience a significant rebound with the listing of both sites on the NPL in 1983. However, this recovery appears temporary as values begin to decline with the onset of cleanup activities. Nearly two decades after the original discovery of the problems, the relative property values of homes near the sites had decreased to just 86.0% of their original value.

To explain the long term downward trends observed in relative property values shown, we develop a psychological/economic model that hypothesizes that events drive perceived risk/stigma. If the trend is driven by f, the fraction of homeowners and potential buyers who shun homes near the site, a model

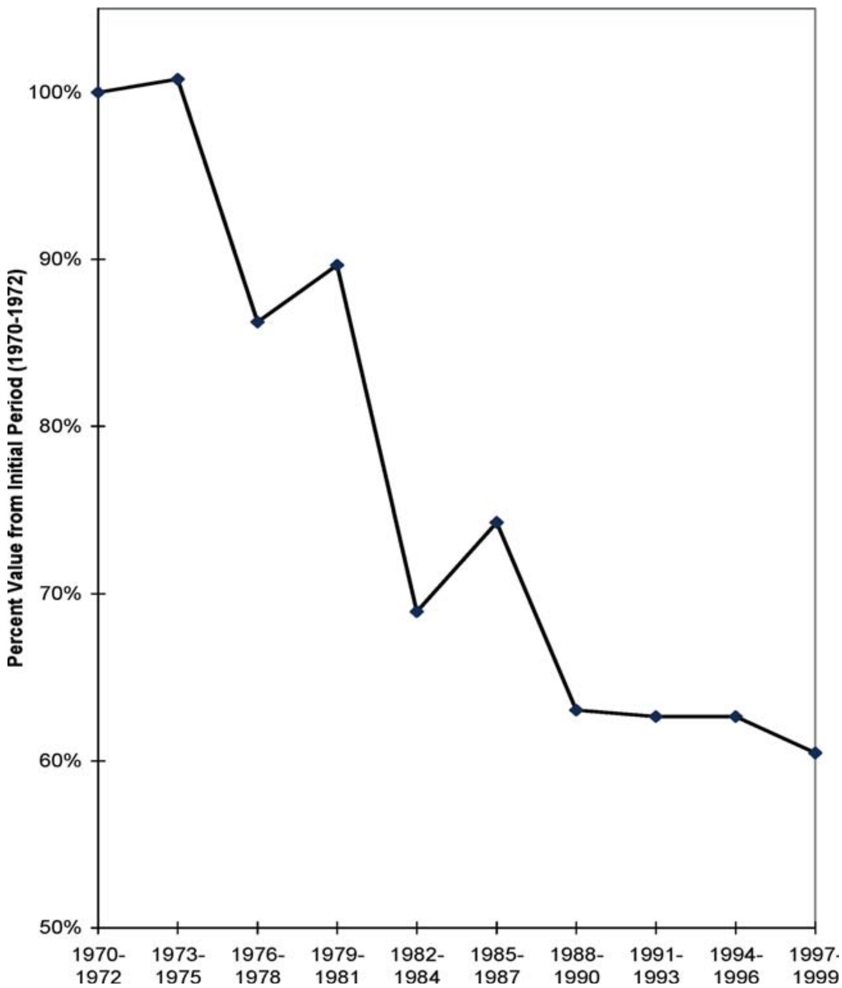

Figure 3. OII landfill, California.

of the determination of f over time is needed. From the discussion of the psychology of risk perception and stigma, the determination of the fraction of shunners will be driven by media attention and perceptual cues resulting from activity at the site, which are in turn driven by ''events'' such as EPA announcements, discovery, NPL-listing, and cleanup. Thus, it is plausible that the percentage change between periods in the fraction of the population who shun the site is a linear function of the number of events of type j occurring during the prior interval. We characterize these by $E_{j,t-1}$, which is either discrete dummy variables (for example, NPL listing) or an index summarizing the number of events of a certain type (for example, number of EPA announcements). Thus,

$$f_t - f_{t-1} = \alpha + \sum_j \beta_j E_{j,t-1} \tag{4}$$

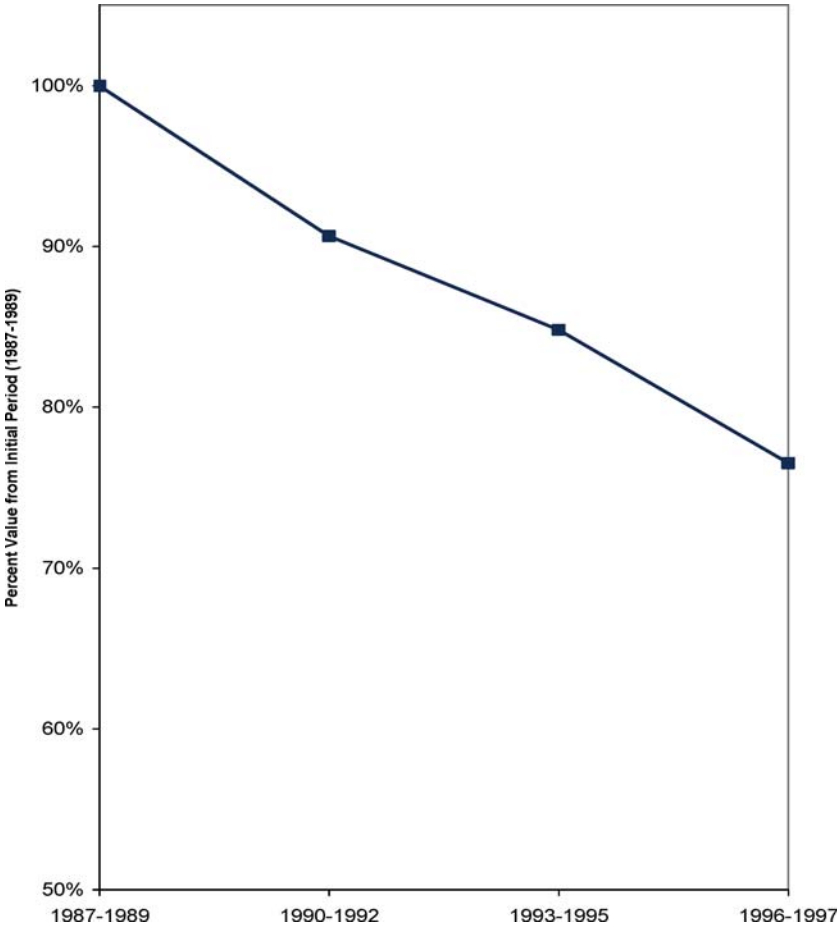

Figure 4. Montclair, New Jersey.

So, in a period with no events, $E_{j,t-1} = 0 \; \forall \; j$, we hypothesize that α is negative and f will decline, thereby raising home values, because some people who know about the site will leave the area (perhaps because of job opportunities elsewhere) and some new potential buyers will move into the area who will have no awareness of the site. Other events, such as cleanup activities, might, (a) raise awareness and thereby increase the fraction of the population who shun the site, or alternatively, (b) reduce the fraction of shunners in the population by convincing people who know about the site that it is now safe. This latter possibility is unlikely given the psychology of stigmatization and social amplification. Note also that changes in perceived risk for those who may not shun the site will likely follow a similar model.

There are no available data on f, so the model specified above cannot be estimated directly. However, if one assumes a constant elasticity of demand,

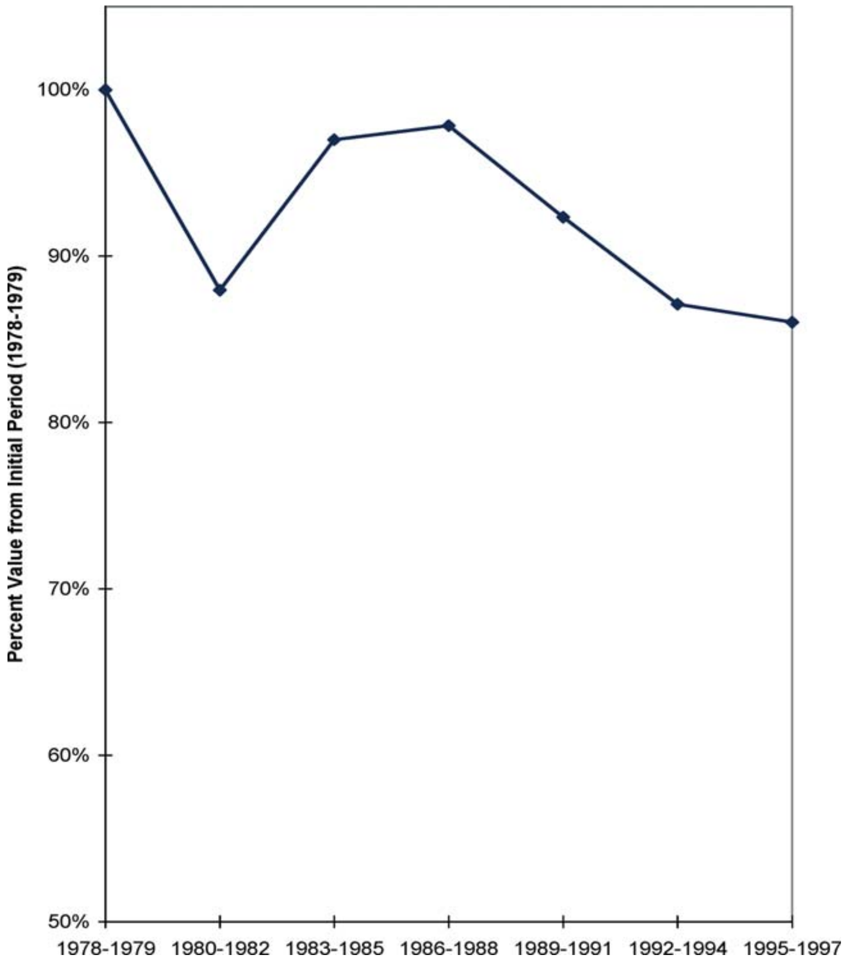

Figure 5. Woburn, Massachusetts.

$\eta < 0$, and risk-neutrality, a simple transformation exists between f_t and R_t as defined above: $f_t = 1 - R_t^{-\eta}$. Thus, the equation describing movement in f_t can be rewritten as:

$$R_t^{-\eta} - R_{t-1}^{-\eta} = -\left(\alpha + \sum_j \beta_i E_{j,t-1}\right) \tag{5}$$

To employ this transformation we need to know the relevant elasticities of demand that depend on the error distribution in bids. Since we do not know the distribution of individual unobserved buyer-specific attributions and bidding errors that constitute the demand curve in the discriminative auction, we assume that the elasticities are all −1.0, consistent with a linear approximation of the relationship between f and the change in R over time.

Table II presents a psychological/economic model using the data shown in Table I for the three case studies. Since all of the home sale observations are independent, a simple linear regression can be used with the observations of changes in relative property value, $b_{1t} - b_{10}$, over the three-year periods. The estimating equation is weighted by the varying precision from which the dependent variables are estimated (Saxonhouse 1976). The model includes site-specific fixed effects and dummy variables for discovery, NPL listing, and the beginning of major phases of cleanup. The variable "events" is derived by summing the number of major announcements and actions described in EPA published reports for the relevant three-year interval for each of the three case studies (Table III). To facilitate interpretation, the signs of the coefficients are reversed, such that a negative coefficient means a loss of relative property value and a positive coefficient means a gain in relative property value.

The analysis shows that discovery, beginning of cleanup, and the number of events, all negatively affect property values by drawing attention to the

Table II. Psychological/economic model, dependent variable $b_{1t} - b_{10}$

	Estimated coefficient
Discovery	−2.252* *(0.788)*
NPL-listing	2.037** *(0.568)*
Clean-up begins	−2.151** *(0.518)*
Number of events	−0.332** *(0.057)*
OII landfill	2.064** *(0.509)*
Montclair	0.291 *(0.721)*
Woburn	2.391** *(0.507)*

Notes: $R^2 = 0.911$; $N = 18$. Standard errors are listed in parentheses.
*Significant at the 5% level or less.
**Significant at the 1% level or less.

Table III. Number and description of events from EPA reports

Event type	Number of events			
	OII landfill	Montclair	Woburn	Total
EPA action	11	3	14	28
State government action	6	1	4	11
Local government action	10	1	0	11
Public action	2	1	9	12
Potentially responsible party action	7	0	0	7
Remediation action	6	4	3	13
EPA announcement	12	3	8	23
Site incident	5	2	12	19
Total	59	15	50	124

Definitions:
EPA action – Includes site investigations, orders, notifications/decisions, remediation, legal actions, and regulations by the EPA.
State government action – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by state agencies.
Local government action – Includes site investigations, orders, resolutions, remediation, lawsuits, reports, and regulations by local cities, counties, and school districts.
Public action – Includes the creation of public interest groups, major public meetings and protests, lawsuits by the residents, and the hiring of technical advisors for the community.
Potentially responsible parties action – Includes site operation and closure committees formed, and lawsuits.
Remediation action – Includes containment of contaminations, remediation efforts, and site improvements.
EPA announcement – Includes official Consent Decrees, Record of Decisions, and announcements of settlements with the Potentially Responsible Parties.
Site incident – Includes general site facts, reports, and studies regarding the contaminants and occurrences at the site.

site (Table II). Thus, the effect of any event, publicity or site information, good or bad, appears to increase the fraction of current homeowners and potential buyers who stigmatize and shun the communities neighboring the sites. In other words, at least within the observed period of the studies, all news is bad news and causes relatively permanent property value losses as an increasing fraction of original owners leave and more potential buyers shun the site. The only good news in the study is that property values did significantly recover for a short period after sites were listed on the NPL. But, it is likely that as soon as homeowners and potential buyers realized that EPA could not immediately clean up the sites, the process of stigmatization began resulting in property value reductions. All of these coefficients are significant at better than the 5% level.

Rather than property losses reversing immediately once cleanup has begun, we see no permanent recovery in property values within the time period of the data and speculate that recovery will only occur as the local population gradually moves away, events cease, and perceptual cues and media attention disappear, so more buyers are uninformed. Note that McClelland et al. (1990) found that most buyers were uninformed in spite of reporting requirements. The site specific fixed effects are all positive and the coefficients for OII and Woburn are significant at better than the 1% level. This indicates that property values will increase if no actions are taken and no news is generated by the site. For example, at OII one could expect a complete recovery in about a decade if no news is generated from the site and recovery might occur in about half that time for the other sites.

Combining the estimated coefficients from Table II with the history of the OII and the corresponding dates and events in a simple simulation, potential beneficial policies become evident (Table IV). To facilitate the interpretation, the coefficients were transformed into R_t as described by Equation (3) using the average standard error from the OII hedonic regression as shown in Table I. These simulations consider four different scenarios and include a 3-year extrapolation of a recovery in property values after cleanup is complete where there are no further events. As shown in Table IV and Figure 6, Simulation A is the baseline history for OII where the dates for discovery, NPL listing, beginning of major cleanup activities, and the number of events are included. These estimated results are very close to the pattern observed in Figure 3 as property values drop to 68.1% of their original value by the time cleanup activities cease. Simulation B uses the same historic baseline but reduces the number of events by 20%, thereby lowering a key factor driving the property loss. The reduction in the number of events results in a 16.6% increase in the value of the homes after the completion of the cleanup. Simulation C again reduces the number of events by 20%, but also shortens the timetable from 30 years to 21 years primarily by speeding up the NPL listing process and the corresponding periods of cleanup. With this scenario, property values still decrease, but the process of recovery begins nearly a decade earlier, which is critical from a discounted present value perspective. Finally, Simulation D expedites the listing and cleanup process even further while still keeping the number of events 20% lower. The results are a reduction of the process to 15 years, thus reducing the process by half.

Given the legislative history of Superfund, some of these scenarios are clearly fanciful, but the results are nevertheless suggestive as to what potential benefits could be obtained by expediting the cleanup process and reducing the number of events that drive perceptual cues and media attention. These results support several of the suggestions made by Kunreuther and Slovic (2001, Chapter 21) for reducing stigma and social amplification.

Table IV. Simulation results for four different cleanup scenarios

	Time horizon	Events	Discovery	NPL listing	Cleanup time period	Recovery time period	% of initial value after cleanup
Scenario A	30 years	All	1979	1986	1988–1990 1997–1999	2000–2002	68.1
Scenario B	30 years	20% Fewer	1979	1986	1988–1990 1997–1999	2000–2002	86.7
Scenario C	21 years	20% Fewer	1979	1982	1985–1987 1988–1990	1991–1993	86.9
Scenario D	15 years	20% Fewer	1979	1982	1982–1984	1985–1987	94.4

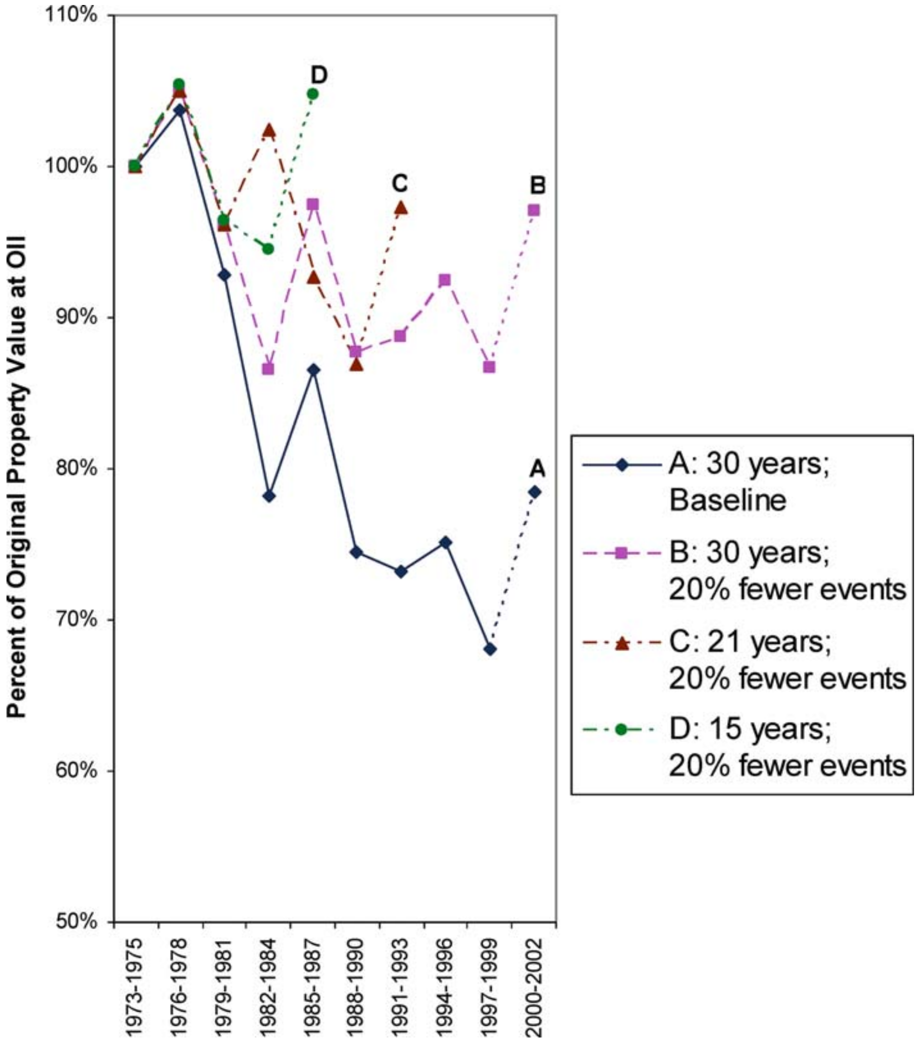

Figure 6. Policy simulations, OII landfill cast study.

6. Conclusion

Since economic benefits are based on discounted present value, the benefits of delayed cleanup for homes surrounding sites are likely to be negligible where cleanup takes up to 20 years. Another five to ten years may be needed after cleanup is complete for property values to recover. The principal policy conclusion becomes evident from the results of the psychological/economic model, which suggest that the promise of a prompt cleanup raises property values, while an increase in the number of events, which are the root cause of perceptual cues and media attention, decreases property values. Thus, cleanup should occur as quickly as possible after a site has been determined to be hazardous and this cleanup should be conducted in a way that does not arouse excessive attention. Otherwise the neighborhoods surrounding the site will also likely be stigmatized resulting in quasi-permanent economic damages.

Note that these results contrast with those of Gayer et al. (2000) and Gayer and Viscusi (2002) who argue that media attention supports learning that leads to a lowering of public risk perceptions more consistent with scientific evidence. Recall, no credible evidence supports a significant long-term health risk to residents living near OII (McClelland et al. 1990), yet the actual property value losses are enormous. One difference is that this study focuses on prominent sites while the two studies cited above focused on smaller, less prominent sites. Note, however, that most potential benefits from cleanup are likely to come from prominent sites. Also, both Woburn and Montclair are associated with demonstrable long-term health risks, yet property losses are much smaller than at OII. Finally, property value losses seem to be greatest when cleanup is completed, when risks should be at their lowest.

Carol Browner did in fact institute reforms to EPA policy in 1995 in part as an attempt to avoid the pattern shown in this study. EPA began to work with Potentially Responsible Parties in an attempt to negotiate sufficient cleanup at potential Superfund sites to avoid having sites listed on the NPL. These reforms may, in fact, have represented an optimal response given the difficulty stigma presents for neighborhoods surrounding Superfund sites. The enormously costly process of litigation and delayed cleanup that has occurred under the Superfund program has provided strong incentives for industry to avoid creating new hazardous waste sites. However, for residents living near Superfund sites, as they have often stated, the program has failed in spite of EPA's best efforts. When CERCLA was passed, little or none of the work in psychology necessary to understand the phenomena described here had yet been completed. In fact, much of the relevant work was motivated by Superfund.

This study raises several questions for future research. First, do residents truly respond more rationally to smaller, less prominent sites, as the work by Gayer, Hamilton, and Viscusi suggests? Second, although the psychological/economic model developed here produces coefficients that are statistically significant, it is based on data from just three case studies. Additional work to incorporate larger sites, as well as smaller sites, and additional explanatory variables would be worthwhile. Finally, more research to understand and prevent stigmatization is warranted.

Note

1. An area for further study would be the cross-validation of the sales prices for each year from other sources of data, such as the census.

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