ELSEVIER

Resource and Energy Economics 24 (2002) 33–51

RESOURCE and ENERGY ECONOMICS

www.elsevier.com/locate/econbase

Housing price responses to newspaper publicity of hazardous waste sites

Ted Gayer [a,*], W. Kip Viscusi [b]

[a] *3600 N Street NW, Suit 200, Georgetown University, Washington, DC 20007, USA*
[b] *Hanser 302, Harvard Law School, Cambridge, MA 02138, USA*

Received 30 December 2000; received in revised form 24 May 2001; accepted 24 May 2001

Abstract

This paper uses housing market data to examine the relationship between newspaper coverage of local hazardous waste sites and housing prices. We explore a range of measures of newspaper publicity, including the number of Superfund-related articles, the number of such articles that focus on the risk levels at the sites, and the number of such articles that appear on page one or section A. We restrict our sample to those houses sold more than once in order to eliminate confounding timE−invariant determinants of housing price. Our findings indicate a price increase of approximately US$ 100–200 per article, which could suggest that the publicity either led residents to lower their perceptions of risk or led them to increase their expectations of a clean-up (or both).

JEL classification: D62; R21

Keywords: Hedonic property model; Risk perceptions

1. Introduction

According to opinion polls, the public views hazardous waste sites as perhaps the top environmental concern. [1] This prominence was evident in the 1996 national election, where all of the Presidential and Vice-Presidential debates raised hazardous waste clean-up as a pressing environmental concern. The primary mechanism for providing the information that generates this public concern is media coverage. Coverage of hazardous waste sites evokes images of Love Canal and Hollywood dramatizations of hazardous wastes problems. Indeed, the concern has been so great that the publicity may in some cases have generated

* Corresponding author. Tel.: +1-202-687-7059; fax: +1-202-687-5544.
E-mail address: gayert@gunet.georgetown.edu (T. Gayer).

[1] See US EPA (1987) and Hamilton and Viscusi (1999a).

0928-7655/02/$ – see front matter
PII: S0928-7655(01)00047-1

excessive alarm. Thus, a separate literature has now arisen on whether the government's responsibility is to address real risks or to alleviate public fears. [2]

In this paper we examine the role of media coverage by assessing newspaper articles that deal with neighborhood hazardous waste risks. Our study focuses on several hazardous waste sites in the greater Grand Rapids, Michigan area. We do not directly observe the effect of newspaper articles on risk beliefs. Indeed, stated risk beliefs may not be accurate because people may misrepresent their concerns in order to push for clean-ups at public expense. Our focus instead is on housing price market effects. If, for example, risk beliefs increase because of awareness of hazardous wastes, then one would expect housing prices to be reduced by this disamenity. Thus, we use price changes to make inferences about changes in risk perceptions.

As the work of George Tolley and other members of the Chicago School attests, individual preferences and beliefs are frequently manifested through market transactions. For example, the volume by Tolley et al. (1994) discusses many approaches to valuing health risks. The contributions to this volume by Kenkel et al. (1994) and Fabian and Tolley (1994) discuss the issues involved with using surveys in order to value health risks. This technique is especially useful when reliable market data are not available. As their analyses indicate, however, constructing surveys to yield reliable benefit estimates is often a non-trivial task. One potential shortcoming of surveys is that they may not always replicate decisions that would be made in a market. When reliable market data are available, use of such data to analyze individual valuations of risk is usually preferable. In this instance, we have excellent market data, permitting us to make assessments about how people respond to changes in risk information.

Whether housing prices rise or fall because of the hazardous waste publicity depends on the level of people's prior beliefs and whether this publicity conveys a risk level that is higher or lower than these prior risk levels. If people are unaware of any such risks posed in their neighborhood, then news of these hazards is likely to boost public risk perceptions, lowering housing prices. If, however, people already have some awareness of the risk, and the media coverage indicates that the risks are not great or that they will soon be reduced through clean-up efforts, then housing prices may rise as coverage increases. We test the relationship between media coverage and housing prices using housing market transactions from 1988 through 1993. The longitudinal nature of our dataset allows us to focus on houses sold more than once in order eliminate the confounding time-invariant effects on housing prices.

In earlier results, reported in Gayer et al. (2000a,b), we found a strong relationship between housing prices and the presence of hazardous waste sites. However, such relationships implicitly assume that there is some informational mechanism by which these risks become known to the public. This abstraction from informational mechanisms is typical of the hedonic wage and price literature generally, as risks are linked to market outcomes without exploring how the market participants learn about the risks. This paper has a different and new focus, as we examine how newspaper coverage of hazardous waste site risks relates to housing prices in the greater Grand Rapids area. Moreover, by focusing on a single housing market rather than a national market, we can better isolate the role of information, controlling for the structure of that market.

[2] See, for example, Breyer (1993) and Zeckhauser and Viscusi (1990).

In Section 2 we outline our hedonic property model, which uses repeat sales of houses to isolate the relationship between price and media coverage. Our media coverage variables are the subject of Section 3, and in Section 4 we examine the relationship between different measures of newspaper coverage and housing prices. Section 5 summarizes the findings, which is that hazardous waste site publicity is positively related to housing prices.

2. Empirical model

We rely on the hedonic property model in order to examine the relationship between housing prices and hazardous waste site information provided by the local newspaper. Such a linkage would imply that residents' perceptions of the sites change due to the publicity. The hedonic model postulates that the sale price of a house is a function of its structural characteristics, neighborhood characteristics, and the perceived environmental health risks associated with living in the house.

Our focus is on the perceived environmental health risks stemming from local hazardous waste sites that are listed on the Environmental Protection Agency's (EPA) National Priorities List (NPL). The NPL is the government's roster of the most dangerous hazardous waste sites, and placement on this list qualifies the site for federal remediation funds under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Such sites are commonly referred to as Superfund sites. We assume that the perceived risks of these Superfund sites are a function of, among other things, local newspaper publicity about the sites.

Economic theory does not suggest a functional form for the hedonic price function. [3] For this analysis, we assume that a unit change in a characteristic leads to a percent change in price. We also assume that price increases by a real estate price index that varies by year. Thus, the hedonic price function can be expressed as follows:

$$\text{price}_{it} = B_t \, e^{\alpha_1 S_i} \, e^{\alpha_2 Z_i} \, e^{\alpha_3 \text{news}_t} \, e^{u_{it}} \tag{1}$$

where B_t is the true (but unknown) real estate price index that varies by year, S_i a vector of structural characteristics, Z_i a vector of neighborhood characteristics, news_t the amount of newspaper publicity concerning the local Superfund sites, and u_{it} is a vector of unobservable characteristics that vary by time and house. Thus, Eq. (1) is equivalent to formulating the log of housing prices as a linear function of a constant term that reflects the overall real estate price index in year t, a set of house structural characteristics, a set of neighborhood characteristics, and the media coverage variables. Taking logs of Eq. (1), one has the following

$$\ln \text{price}_{it} = \ln B_t + \alpha_1 S_i + \alpha_2 Z_i + \alpha_3 \text{news}_t + u_{it} \tag{2}$$

The variable of interest is newspaper publicity, which specifically measures the amount of Superfund-related newspaper coverage that has occurred previous to the sale of the house. We will discuss this variable in detail in the next section.

[3] Most empirical hedonic studies assume a semi-log or a Box–Cox specification (Harrison and Stock, 1984; Bartik and Smith, 1987; Cropper et al., 1988; Michaels and Smith, 1990; Kiel and McClain, 1995).

Notice that we assume that the structural and neighborhood characteristics are time-invariant. This is a reasonable assumption for our analysis, because, as best as can be determined, there were no major changes in the neighborhood's infrastructure in the housing market we examine. We also dropped any observations for which there was a change in structural characteristics between sales. Also notice that the publicity variable varies by time (specifically, by day), but not by house. This is because a single local newspaper serves the entire greater Grand Rapids community, which is the sample for this study. The variable measures the amount of coverage that occurred before the sale of the house. Two houses sold on the exact same day will therefore have experienced the same level of newspaper publicity about the local sites. In a supplemental analysis, we relax this assumption by weighting newspaper publicity by the distance of the house from the Superfund site mentioned in each article. This allows the publicity measure to vary over both time and location.

One of the difficulties with estimating the hedonic price function is that it requires information on a large number of characteristics of the houses in the sample, including their neighborhood characteristics. Such comprehensive data are seldom available. However, as first done by Bailey et al. (1963), focusing on houses that sold more than once can eliminate all the time-invariant characteristics of the analysis. [4] In this case, given that the time-variant effects are controlled for, or that they are not correlated with changes in the variable of interest, then one is left with an unbiased estimate of the relationship between newspaper publicity and housing prices. [5]

For a house sold more than once, Eq. (1) can be re-written for the later period t'. Taking the ratio of repeat sales, and then taking the logarithm of both sides, results in the following equation:

$$\ln\frac{\text{price}_{it'}}{\text{price}_{it}} = \ln B_{t'} - \ln B_t + \alpha_3(\text{news}_{t'} - \text{news}_t) + u_{it'} - u_{it} \tag{3}$$

For houses sold three times, we form two ratios. For these observations, however, the resulting error terms may be correlated. While this autocorrelation does not lead to biased estimates, it could lead to inefficient estimates and an underestimation of the standard errors of the coefficients. However, given that there are only 64 houses in the sample that were sold three times, the problem is not an acute one. While we do not report the results in this paper, controlling for the autocorrelation using GLS leads to point estimates and standard errors that are virtually identical to the OLS results that we do report in this paper. [6]

Eq. (3) indicates that the log of the price ratio over time is a simple linear regression in which the independent variables are the change in newspaper information and the change in the log of the relative real estate price indexes. [7] Bailey et al. (1963) shows that the log

[4] The time-invariant characteristics drop out even if the coefficients for these variables enter non-linearly into the equation, given the assumption that the characteristics enter the equation additively. This places fewer restrictions on the functional form of the hedonic price equation.

[5] Palmquist (1982) used this line of analysis in his repeat sales method for estimating the price effects of highway noise.

[6] We do, however, provide heteroskedastic-consistent standard errors for our OLS results.

[7] Given the specification in Eq. (3), the real estate price indexes are conflated with the depreciation values for the houses. Palmquist (1979) demonstrates a way for controlling for depreciation, but failing to control for depreciation does not affect the coefficients of the variables of interest.

of the price indexes can be treated by creating a variable, x_j, that equals +1 if period j is the period of the final sale, −1 if period j is the period of the initial sale, and 0 otherwise. The index is normalized by letting $\ln B_{1988} = 0$. Thus, the repeat sales equation we estimate is as follows:

$$\ln \frac{\text{price}_{it'}}{\text{price}_{it}} = \sum_{j=1989}^{1993} x_j + \alpha_3(\text{news}_{t'} - \text{news}_t) + u_{it'} - u_{it} \tag{4}$$

One potential source of bias in Eq. (4) occurs if the change in the error term over time is correlated with the change in publicity. That is, if there are other characteristics changing over time that are correlated with changes in the newspaper information, then the estimate for α_3 will in part capture this effect. The most likely confounding factor is other information about the Superfund sites provided by the EPA. There is ostensibly good reason to suspect that the newspaper coverage will be influenced by EPAs information about the sites, so that the publicity measure may capture both governmental risk information as well as other sources of information about the sites.

We control for this confounding information using two variables: one that controls for whether the EPA released their detailed study (discussed in the next section) for the closest site, and the other that controls for the change in risk information derived from the EPAs report on the closest site. We discuss these variables in greater detail in the next section. It should be noted that we do not, however, control for other sources of changes in information, such as information received from local television and radio stations. One must therefore keep in mind that, to the extent that we find a significant relationship between newspaper publicity and housing prices, this relationship could be drawing on the effects from omitted sources of information. We also control for seasonal effects on housing sales by including quarterly seasonal indicators as additional covariates. These indicators are also differenced in the repeat sales framework.

By estimating Eq. (4), we test the relationship between housing prices and local newspaper publicity about the neighborhood Superfund sites. Unfortunately, we cannot identify empirically the mechanism by which publicity affects the housing market. However, our conjecture is that any effect of publicity on housing prices can be attributable to two different mechanisms. The publicity could lead residents to reassess their perceptions of the risks associated with the nearby hazardous waste sites. If the newspaper publicity provides information that leads to an increase in the perceptions of risks, then one would expect housing prices to drop. If the newspaper provides information that leads to a decrease in risk perceptions (i.e. the publicity informs residents that the risks are not as bad as they originally thought), then one would expect prices to increase. The other possible mechanism is that the publicity may change the residents' expectations of an imminent remediation of a neighborhood site. To the extent that the publicity leads residents to expect a shorter (longer) time until remediation, then one would expect housing prices to rise (decrease).

Residents use the newspaper information to continually update their perceptions of the risks of the sites. Before receiving information from the local newspaper and from the EPA, we believe that residents base their prior risk beliefs on their general knowledge of Superfund hazardous waste sites. In order to determine a rough measure of these priors, we compared the risk levels at the local sites to the national average of cancer risk from 150

sites located throughout the country.[8] Using a standardized measure of on-site risk levels for groundwater and soil (discussed in the next section), we found that the average national level of Superfund risk is much greater than the average risk from the sites in greater Grand Rapids. Our conjecture, therefore, is that the updating information provided by the local newspaper leads to a lowering of risk perceptions away from the national and state averages, and thus an increase in housing prices.

3. Data description

In a previous paper (Gayer et al., 2000a), we assembled a dataset consisting of 16,928 observations on sales of houses in greater Grand Rapids, Michigan. The greater Grand Rapids area consists of the cities of Grand Rapids, Walker, Wyoming, Kentwood, and Grandville. The housing sales occurred between 1 January 1988 and 31 December 1993. During this period, there were seven hazardous waste sites in the greater Grand Rapids area listed on the NPL. We obtained the housing data on the time of sale and the price of sale from the multiple listing service of the Grand Rapids Society of Realtors. For this paper, we restrict the sample to include only those houses that were sold more than once. This restricted dataset consists of 3,702 housing sales observations: 64 houses that were sold three times and 1,755 houses that were sold twice.

For the newspaper data, we did a full-text search of all articles printed from 1988 through 1993 in the Grand Rapids Press. The Grand Rapids Press serves the entire greater Grand Rapids area.[9] The search was for articles that contained information on any of the local Superfund hazardous waste sites. Articles printed after 1990 were available in electronic format, and those printed before 1990 were obtained in photocopy format directly from the newspaper's offices.

Our goal is to assess the relationship between newspaper publicity about local hazardous waste sites and housing values. We linked the date of the housing sale to the newspaper data in order to obtain measures of the amount of publicity that occurred before the sale of each house. We use various measures of newspaper publicity. The two broad categories of newspaper publicity are the number of articles in the newspaper pertaining to the local sites that were printed before the sale of the house and the number of words in such articles. We also use different subcategories of these measures of publicity. These include the number of Superfund-related articles that appear in section A of the paper and the number of words in such articles; the number of Superfund-related articles that appear in page one of a section of the paper and the number of words in such articles; and the number of Superfund-related articles that emphasize the environmental health risks of the sites and the number of words in such articles.

Table 1 contains the raw data of the articles used to compute the publicity measures. As indicated in the table, there were 41 Superfund-related articles that appeared in the Grand Rapids Press during the relevant period. On average, there were 546 words per article. Six

[8] See Hamilton and Viscusi (1999b) for a complete analysis of the risks from these 150 Superfund sites.

[9] As of February 2000, the Grand Rapids Press had a Sunday circulation of 193,829 and a daily circulation of 141,693.

Table 1
Raw data of Superfund-related articles appearing in the Grand Rapids (1988–1993)

Date of publication	Article title	Number of words	Section A	Page one	Risk emphasis
16 April 1988	Toxic waste hunters begin digs in Butterworth dump	607	Yes	No	Yes
2 May 1988	Landfill probe yields barrels of toxins	508	No	Yes	Yes
19 July 1988	Toxins at Butterworth dump might pose threat	868	No	Yes	Yes
26 July 1988	Residents warned to avoid toxic Butterworth dump	669	No	Yes	Yes
2 August 1988	EPA calls for patrols at old dump site	603	No	Yes	Yes
4 October 1988	Butterworth dump's toxic 'hot spot' to be fenced	556	No	No	Yes
7 March 1989	EPA studies Folkertsma dump site	262	No	No	Yes
5 April 1989	Contaminants found in groundwater near old Kentwood dump	398	No	Yes	Yes
10 May 1989	Landfill warnings sought on subdivision's papers	487	No	Yes	Yes
24 May 1989	Evidence of contamination is found at toxic waste site	556	No	No	Yes
14 June 1989	City, EPA may help pay for study of Butterworth dump	631	No	No	No
5 September 1989	EPA allocates US$ 54710 to monitor dump's toxins	201	No	No	No
11 October 1989	Butterworth dump PCB site gets top clean-up priority	383	No	No	Yes
22 December 1989	Old dump's soil, water are tainted, report says	667	Yes	Yes	Yes
4 June 1990	EPA schedules Tuesday meeting on pollution study	457	No	No	Yes
11 June 1990	Fencing helps make Butterworth dump safer, report finds	704	Yes	No	Yes
15 June 1990	Independent advisers challenge Butterworth dump study	1004	No	Yes	Yes
20 June 1990	Editorial	721	Yes	No	Yes
17 August 1990	Levin says he will push federal officials for better study of Butterworth dump	400	No	Yes	Yes
28 November 1990	EPA wants landfill site 'Capped' to cut risk of exposure to toxins	794	No	Yes	Yes
30 November 1990	Plain-field water no longer top woe	570	No	Yes	Yes
19 February 1991	EPA plan to clean dump site labeled excessive	436	No	No	No
20 February 1991	Super delay at Superfund site	513	Yes	No	No
26 March 1991	US$ 1.5 million clean-up urged for dump site	148	No	No	No
10 April 1991	EPA hopes more tests patch up holes in Butterworth landfill study	439	No	No	Yes
23 July 1991	Butterworth dump must be cleaned-up, EPA concludes	708	No	No	Yes
1 August 1991	Deal near on Kentwood dump clean-up	466	No	Yes	No
7 August 1991	City will pay 20% of clean-up at landfill; Kent will pay balance	353	No	No	No
27 November 1991	Leaky tanks account for rise in contaminated sites	541	No	No	Yes
26 March 1992	EPA demands force Kent officials to ok extra landfill clean-up costs	585	No	No	No
27 March 1992	EPA clutters Kent clean-up	556	Yes	No	No
27 May 1992	DNR rips EPA clean-up plan for old Butterworth landfill	848	No	Yes	Yes
30 May 1992	EPA reaches agreement on walker toxic waste site	278	Yes	No	No
12 June 1992	EPAs plan for old dump is opposed by the DNR	487	No	No	Yes
11 July 1992	Over 1200 firms, individuals face landfill clean-up bills	640	Yes	No	No
31 July 1992	Businesses protest penalty payments for site clean-up	716	Yes	Yes	No
9 October 1992	US$ 15 million 'Clean-up' of landfill is ordered	573	Yes	No	Yes
10 November 1992	Leaking fuel tanks add to list of pollution sites	522	No	No	Yes
18 December 1992	Residents recall toxic chemical pools at Spartan	547	No	Yes	Yes
20 January 1993	Landfill clean-up cost hits US$ 11.6 million	376	No	Yes	No
4 May 1993	State evaluating health effects of waste at Folkertsma landfill	589	No	No	Yes

of the articles were printed in 1988, eight in 1989, seven in 1990, eight in 1991, ten in 1992, and two in 1993. Ten of the articles appeared in section A of the paper, and these averaged 598 words in length. Sixteen of the articles appeared on page one of a section, and these averaged 620 words in length. Twenty-eight of the articles emphasized the risks of the sites, and these averaged 588 words in length. The content of the articles vary widely, including among other things, the following: information about neighborhood groups critiquing the EPA for not pursuing a strong enough remediation action for a site, information pertaining to the 1200 parties that are potentially financially responsible for leaving car batteries at a dump site, cost estimates charged for remediation of a site, and general information about the release of EPA reports on the sites.

In the repeat sales analysis, each of the publicity variables is differenced in order to obtain changes in publicity between housing sales. We are therefore estimating the relationship between the amount of publicity that occurred since the previous sale of the house and the change in price since the previous sale of the house. For each of the publicity variables, the change since the previous housing sale has a unique value for each observation unless two houses were sold twice on the same day.

We also conduct a supplemental analysis in which the newspaper publicity variable is weighted by the inverse of the distance of the house to the Superfund site discussed in each article. Allowing the change in publicity to vary for each house in this manner assumes that publicity has a diminishing influence on housing values as the distance from the pertinent site increases.

As mentioned previously, the repeat sales method is valid only if one controls for other changes that occurred between the sales of each house. If such changes are omitted, and if they are correlated with the change in the variable(s) of interest, then the coefficient(s) of interest will be biased. The main possibilities for such an omission are changes in the information about the Superfund sites deriving from the EPA. To the extent that the newspaper coverage is correlated with the EPA information (which seems highly plausible), then the estimated newspaper coefficient will capture this EPA effect. In such a case, media coverage of EPA studies would serve as the risk communication mechanism.

We use two variables to capture changes in EPA information. The first is a dummy variable that has a value of 1 if the day of the house's sale occurred after the release of the EPAs Remedial Investigation and Feasibility Study (RI/FS) for the closest Superfund site, and has a value of 0 otherwise. The RI/FS is part of the site characterization process that the EPA conducts at sites on the NPL. The RI/FS contains a baseline risk assessment and provides regional EPA decision-makers with a quantitative assessment of human health risk at a site, a description of remedial action objectives, and an analysis of the alternatives proposed to reach these objectives. After evaluating an RI/FS, the EPA selects a remedial action and then documents the reasons for its selection in the Record of Decision. Because Eq. (4) is a difference equation, the resulting RI/FS measure is for whether or not the RI/FS report was released between the two sales of the house.

The other information variable measures the risk information available to the residents at the time of the sale of the house. For houses sold after the EPA releases its risk assessment contained in the RI/FS, we base the risk information variable on the information contained in this report. That is, the risk information variable is set equal to the objectively measured lifetime excess cancer risk for each household, which is computed by combining

EPAs on-site cancer risk estimate with distance dilution estimates. For each chemical, the on-site risk estimate is the product of chemical concentration, ingestion rate, exposure duration, exposure frequency, inverse of the body weight, inverse of the averaging time, and the chemical's slope factor (a measure of toxicity). We draw on EPA guidelines for the distance dilution factor for soil risks. For groundwater dilution estimates, we use a Geographic Information System program to map the location of each of the houses and to map the groundwater plumes (which are the underground reservoirs). We then compute the proportion of houses in the census block group residing above a plume and multiply this by the proportion of houses that draw their water from groundwater plumes (which is obtained through census data). Combining the on-site risk estimates with the dilution factors yields point estimates of the risk that each chemical poses to each household, which is acquired from the information presented by the EPA in the RI/FS for each site. We then sum the risk estimates for each chemical and for a standardized set of exposure pathways. This yields an objective measure of the lifetime excess cancer risk to each household in the sample from each of the local sites. [10]

Since many of the houses are sold before the release of the RI/FS for the closest site, we need to postulate how residents form their perceptions of the risks from the sites given that they have yet to receive the site-specific risk information from the EPA. We do not assume that the residents have no awareness of the local sites. Instead, we assume that before the release of the RI/FS for the closest site, residents are aware of the site and base their perceptions on their general knowledge of Superfund hazardous waste sites. That is, for houses sold before the release of the RI/FS, we assume that residents form their priors based on their general knowledge of nationwide Superfund sites. Specifically, we set the risk information variable equal to the national on-site average risk level of Superfund sites, again adjusted by the distance dilution estimates. [11]

Additionally, we control for seasonal effects on housing values by including quarterly seasonal indicators. Since the newspaper articles about the local Superfund sites appear not to be distributed randomly throughout the year, omitting the seasonal effects could lead to biased estimates of the publicity coefficients. [12]

To offer motivation for the regression estimation, Table 2 presents some descriptive information on changes in publicity and changes in housing prices. The table analyzes only those houses that were sold in 1989 and sold again in 1992. In 1989, there were eight articles pertaining to the local sites. These articles provided information on the contaminants at the Kentwood, Butterworth, and Folkertsma landfills, as well as the costs of cleaning up the Butterworth site. In 1992 there were 10 articles that were primarily concerned with the costs of cleaning up the Kentwood, Butterworth, Folkertsma, and H. Brown sites. The intervening years of 1990 and 1991 featured 15 articles on risks, delays, and clean-up options for several of these sites.

[10] This method of computing Superfund risk was used in Hamilton and Viscusi (1999a,b) and in Gayer et al. (2000a,b).

[11] The national on-site average risk comes from a sample of 150 Superfund sites used in Hamilton and Viscusi (1999a). For more details concerning this measure of prior risk, and the assumptions underlying this measure as a proxy for prior risk perceptions, see Gayer et al. (2000b).

[12] In actuality, omitting the seasonal indicators does not significantly alter the coefficient estimates for the variables of interest.

Table 2
Changes in price and Superfund publicity for houses sold in 1989 and sold again in 1992[a]

	Mean changes for all houses sold both in 1989 and 1992 ($N = 196$)	Mean changes for houses with largest increase in articles between sales ($N = 44$)	Mean changes for houses with smallest increase in articles between sales ($N = 49$)	Mean changes for houses with largest increase in words between sales ($N = 49$)	Mean changes for houses with smallest increase in words between sales ($N = 53$)
Change in price	6252 (425)	6365 (801)	5855 (1224)	6559 (741)	6004 (1147)
Change in number of articles	23.89 (0.30)	29.91 (0.22)	18.53 (0.26)		
Change in number of words	12912 (162)			15947 (123)	10140 (135)
Housing characteristics					
Bedrooms	2.93 (0.05)	2.91 (0.10)	3.08 (0.13)	2.92 (0.09)	3.02 (0.12)
Bathrooms	1.50 (0.04)	1.49 (0.08)	1.51 (0.08)	1.50 (0.07)	1.47 (0.08)
Fireplaces	0.38 (0.05)	0.39 (0.09)	0.45 (0.09)	0.37 (0.09)	0.43 (0.09)
Basement	0.84 (0.03)	0.82 (0.06)	0.84 (0.05)	0.82 (0.06)	0.85 (0.05)
Lot size	9176 (463)	8326 (479)	8864 (692)	8163 (441)	8811 (652)
Garage	0.91 (0.02)	0.86 (0.05)	0.96 (0.03)	0.88 (0.05)	0.94 (0.03)

[a] Standard errors are in parentheses. Houses sold in 1989 and then again in 1992 represent the modal years of the repeat sales sample.

The first column in Table 2 lists some descriptive statistics for this subsample. For these 196 houses, the mean increase in price was US$ 6,252, and during this time there were 23.89 more Superfund-related articles and 12,912 more words in these articles. The second and third columns focus on publicity as measured as the number of articles, focusing on the houses with the largest number of articles between sales and the smallest number of articles between sales. The fourth and fifth columns focus on publicity as measured as the number of words in articles, where once again the focus is on the largest and smallest values for publicity. Keep in mind that for this table publicity varies only by time (i.e. by day), and not by house. So the houses in this subsample have all experienced similar changes in publicity (because they were sold in the same years), with the only differences occurring because their sales occurred on different days in these years. Comparing the structural characteristics in column two to those in column three, and comparing the structural characteristics in column four to those in column five, indicates that there is no statistically significant difference between the structural characteristics of houses with the largest amount of change in publicity and those with the smallest amount of change in publicity.

The 44 houses described in column two are those that experienced the greatest increase in articles between sales (i.e. the top quartile), and the 49 houses in column three are those that experienced the smallest increase in articles between sales (i.e. the bottom quartile). The houses that experienced the largest increase in publicity were associated with an increase in price of US$ 6,365, while those that experienced small increases in publicity were associated with an increase in price of only US$ 5,855. Columns four and five have similar implications: houses that experienced a large increase in words of publicity increased in price by US$ 6,559, and houses that experienced a small increase in words of publicity increased in price by US$ 6,004. Thus, there is some prima facie evidence that the publicity, as reflected in these articles, increases housing prices. Yet the high standard errors for the price changes result in statistically insignificant difference-in-difference estimates of prices. The estimates in this table also do not control for all the other characteristics. For this we turn to the repeat sales regression analysis.

4. Results

4.1. Estimation of equations with publicity measured by the number of articles

Table 3 contains the semi-log regression results in which the left-hand side variable is the change in the log of prices. The media variable for publicity is measured as the change in the number of Superfund-related articles between housing sales. Each equation specification uses a different measure of these articles based on the different breakdown of articles in Table 1. The media variable for Eq. (1a) is the change in the number of Superfund-related articles. The media variable for Eq. (2a) is the change in the number of Superfund-related articles that emphasize the environmental health risks associated with the site. The media variable for Eq. (3a) is the change in the number of Superfund-related articles that appeared in section A of the newspaper. The media variable for Eq. (4a) is the change in the number of Superfund-related articles that appeared on page one of the newspaper section.

Table 3
Repeat sales regression results of relationship between Superfund-related articles and housing prices (with and without distance weights)*

Variables	Eq. (1a)		Eq. (2a)		Eq. (3a)		Eq. (4a)	
	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted
Intercept	0.059 (0.006) a	0.060 (0.006) a	0.059 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a
Year 1989	0.043 (0.008) a	0.059 (0.005) a	0.031 (0.009) a	0.056 (0.005) a	0.062 (0.005) a	0.062 (0.005) a	0.038 (0.009) a	0.059 (0.005) a
Year 1990	0.066 (0.014) a	0.096 (0.007) a	0.044 (0.015) a	0.091 (0.007) a	0.103 (0.007) a	0.101 (0.006) a	0.061 (0.014) a	0.098 (0.007) a
Year 1991	0.055 (0.022) b	0.105 (0.010) a	0.028 (0.023)	0.096 (0.010) a	0.116 (0.012) a	0.114 (0.009) a	0.050 (0.022) b	0.107 (0.010) a
Year 1992	0.031 (0.030)	0.099 (0.012) a	0.009 (0.027)	0.089 (0.012) a	0.114 (0.016) a	0.109 (0.011) a	0.037 (0.026)	0.103 (0.012) a
Year 1993	0.022 (0.037)	0.106 (0.014) a	−0.002 (0.032)	0.094 (0.014) a	0.124 (0.022) a	0.118 (0.013) a	0.027 (0.032)	0.111 (0.014) a
Change in number of articles	0.003 (9.459E−04) a	0.002 (7.737E−04) b						
Change in number of risk articles			0.005 (0.001) a	0.004 (0.001) a				
Change in number of section A articles					9.19E−05 (0.002)	0.003 (0.003)		
Change in number of page one articles							0.007 (0.002) a	0.003 (0.002) c

* Each observation is a repeat sale of a house. The dependent variable is the log of the ratio of prices. Each regression controls for changes in the status of the Remedial Investigation for the closest site between sales and for changes in risk information between sales. Each regression also includes quarterly seasonal indicator variables. The "distance weighted" regressions weight the publicity variable by the inverse of the distance between the house and the relevant Superfund site. Heteroskedastic-consistent standard errors are reported in parentheses. The letters "a", "b", and "c" indicate statistical significance at the 1, 5, and 10% levels, respectively. All tests of significance are two-tailed. Each regression is based on 1883 observations. The mean change in the number of articles was 21.6, the mean change in the number of risk articles was 14.01, the mean change in the number of section A articles was 5.39, and the mean change in the number of page one articles was 7.76.

For each specification, we estimate one equation in which publicity is the variable of interest and one equation in which the variable of interest is publicity weighted by the inverse of distance of the house to the relevant Superfund site. In each equation listed in this table, we control for the change in risk information and the change in the RI/FS status for the closest site. We also control for seasonal effects of the time of each sale. The standard errors listed in the regression results are corrected to provide heteroskedastic-consistent estimates.

To account for general price changes, each equation includes separate annual dummy variables, which capture time-specific housing price trends. The coefficient estimates for the first few year indicators are statistically significant for all the equations that include the non-distance weighted publicity measures. The coefficient estimates for all the year indicators are statistically significant for the equations that include the distance weighted publicity measures. This implies increased housing prices relative to 1988. For the most part, the annual coefficient estimates suggest that housing prices were about 3–10% higher in 1989 through 1993 than they were in 1988.[13] The coefficient results also indicate that there was a slight decline in housing prices in 1991 through 1993.[14]

The regression results for Eq. (1a) suggest that housing prices are positively correlated with the number of articles about the neighborhood Superfund sites. For the specification that includes the non-weighted measure of publicity, housing prices are 0.3% (roughly US$ 200) higher given each additional article. For the specification that includes the distance weighted publicity measure, housing prices are 0.2% (roughly US$ 130) higher given each additional article.[15] The former is statistically significant at the 1% level, and the latter is statistically significant at the 5% level.

The regression results for Eq. (2a) suggest that the number of articles that discuss the environmental health risks associated with the neighborhood Superfund sites is positively correlated with the housing price. That is, for the specification that includes the non-weighted measure of publicity, housing prices are approximately 0.5% (roughly US$ 370) higher given an additional article about the risks at the sites. For the specification that includes the distance weighted publicity measure, housing prices are 0.4% (roughly US$ 280) higher given an additional article about the risks at the sites. Both of these results are statistically significant at the 1% level.

The regression results for Eq. (3a) suggest that housing prices do not respond to the number of articles in section A of the paper. However, Eq. (4a) indicates that prices are positively correlated with the number of articles on page one of a section. For the specification that includes the non-weighted measure of publicity, housing prices are approximately 0.7% (roughly US$ 500) higher given an additional page one article about the sites. For the specification that includes the distance weighted measure of publicity, housing prices are approximately 0.3% (roughly US$ 250) higher given an additional page one article.

[13] All tests of significance in this paper are two-tailed tests. The omitted dummy variable is for 1988.

[14] Note that all of the equations estimated in Tables 3 and 4 yield significant estimates for the intercepts. This does not accord with the repeat sales model, since it suggests that a house immediately resold will appreciate significantly. Nonetheless, suppressing the intercept in the estimation does not change the implications of the results.

[15] We compute the price changes at the mean housing price. Throughout this section, for the distance weighted specifications, we compute predicted price changes for houses located one mile from the relevant site.

The former result is statistically significant at the 1% level, and the latter is statistically significant at the 10% level.

The results in Table 3 indicate that housing prices in greater Grand Rapids are positively correlated with newspaper publicity about the local Superfund sites. For the non-distance weighted specification, a mean change in the number of articles corresponds to a total housing price increase of approximately US$ 4,400; a mean change in the number of articles that focus on risk corresponds to a total housing price increase of approximately US$ 5,200; a mean change in the number of page one articles corresponds to a total housing price increase of approximately US$ 3,900. For the specifications that weight newspaper publicity by the inverse of distance from the site to the house, a mean change in the number of articles corresponds to a total housing price increase of approximately US$ 2,800 for a house one mile from the relevant sites; a mean change in the number of articles that focus on risk corresponds to a total housing price increase of approximately US$ 3,900 for a house one mile from the relevant sites; a mean change in the number of page one articles corresponds to a total housing price increase of approximately US$ 1,900 for a house one mile from the relevant sites. [16]

These price increases suggest that the newspapers were communicating good news about the sites. The publicity could have either led people to lower their perceptions of the risks from the sites, or it could have led them to increase their expectations that remediation of the sites was imminent (or both). Comparing across equations indicates that different types of articles are related to price changes by different magnitudes. For example, page one articles are correlated with an increase in housing prices that are about two times as high as the increase from any Superfund-related article.

4.2. Estimation of equations with publicity measured by the number of words

Table 4 contains the semi-log regression results for the equations analogous to those in Table 3, except that the publicity variables are measured as the number of words in Superfund-related articles in the Grand Rapids Press. Each specification uses a different measure of publicity. In Eq. (1b), publicity is measured as the change in the total number of words appearing in articles about the neighborhood Superfund sites. In Eq. (2b), publicity is measured as the change in the number of words in Superfund-related articles that emphasize the environmental health risks of the sites. In Eq. (3b), publicity is measured as the change in the number of words in Superfund-related articles that appear in section A of the paper. In Eq. (4b), publicity is measured as the change in the number of words in Superfund-related articles that appear on page one of a section.

For each specification, we estimate one equation in which the variable of interest is publicity and one equation in which the variable of interest is publicity weighted by the inverse of the distance between the house and the relevant Superfund site. As in the previous subsection, we control for changes in the level of risk information and for changes in the RI/FS status of the nearest site. We also include quarterly seasonal indicators to control

[16] For the distance weighted specifications, we compute these predicted price changes for houses one mile from the relevant sites. By construction, as distance increases, the predicted price changes would decrease.

Table 4
Repeat sales regression results of relationship between words in Superfund-related articles and housing prices (with and without distance weights)*

Variable	Eq. (1b)		Eq. (2b)		Eq. (3b)		Eq. (4b)	
	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted	Not distance weighted	Distance weighted
Intercept	0.059 (0.006) a	0.060 (0.006) a	0.059 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a	0.060 (0.006) a
Year 1989	0.047 (0.008) a	0.059 (0.005) a	0.039 (0.008) a	0.057 (0.005) a	0.062 (0.005) a	0.062 (0.005) a	0.045 (0.008) a	0.059 (0.005) a
Year 1990	0.071 (0.013) a	0.096 (0.007) a	0.058 (0.014) a	0.092 (0.007) a	0.102 (0.008) a	0.101 (0.006) a	0.071 (0.013) a	0.096 (0.007) a
Year 1991	0.064 (0.022) a	0.105 (0.010) a	0.045 (0.022) b	0.098 (0.010) a	0.115 (0.012) a	0.113 (0.009) a	0.064 (0.021) a	0.105 (0.010) a
Year 1992	0.043 (0.029)	0.099 (0.012) a	0.028 (0.026)	0.092 (0.012) a	0.111 (0.017) a	0.108 (0.011) a	0.053 (0.024) b	0.100 (0.012) a
Year 1993	0.036 (0.036)	0.105 (0.014) a	0.022 (0.031)	0.098 (0.014) a	0.120 (0.022) a	0.116 (0.013) a	0.049 (0.030) c	0.107 (0.014) a
Change in number of words	4.58E−06 (1.69E−06) a	3.39E−06 (1.35E−06) a						
Change in number of words in risk articles			7.33E−06 (2.01E−06) a	6.03E−06 (1.67E−06) a				
Change in number of words in section A articles					8.65E−07 (3.56E−06)	5.88E−06 (4.02E−06)		
Change in number of words in page one articles							8.98E−06 (3.15E−06) a	6.82E−06 (2.78E−06) b

* Each observation is a repeat sale of a house. The dependent variable is the log of the ratio of prices. Each regression controls for changes in the status of the Remedial Investigation for the closest site between sales and for changes in risk information between sales. Each regression also includes quarterly seasonal indicator variables. The "distance weighted" regressions weight the publicity variable by the inverse of the distance between the house and the relevant Superfund site. Heteroskedastic-consistent standard errors are reported in parentheses. The letters "a", "b", and "c" indicate statistical significance at the 1, 5, and 10% levels, respectively. All tests of significance are two-tailed. Each regression is based on 1883 observations. The mean change in the number of words was 11,657, the mean change in the number of words in risk articles was 8288, the mean change in the number of words in section A articles was 3249, and the mean change in the number of words in page one articles was 4870.

for seasonal trends in housing prices. We provide estimates of heteroskedastic-consistent standard errors.

As in the previous subsection, the equations include variables for each year so as to distinguish media-related effects from general time trends in housing prices. The coefficients on the years indicate that the prices were higher in the later years relative to prices in 1988. These results also suggest that prices declined slightly beginning in 1991.

The regression results for Eq. (1b) suggest that housing prices are positively correlated with the number of words printed in the newspaper concerning the neighborhood Superfund sites. For the specification that includes the non-weighted measure of publicity, each additional word is associated with a 32 Cent increase in housing price (evaluated at the mean housing price). Multiplying this by the average number of words per article yields a price increase of approximately US$ 175 per article. For the specification that includes the distance weighted publicity measure, each additional word is associated with a 24 Cent increase in housing price (evaluated at the mean housing price). Multiplying this by the average number of words per article yields a price increase of approximately US$ 130 per article. [17] Both results are statistically significant at the 1% level.

The regression results for Eq. (2b) suggest that housing prices are positively correlated with the number of words in articles that emphasize the environmental health risks of the sites. For the specification that includes the non-weighted publicity measure, an additional risk-related word in an article is associated with a 52 Cent increase in housing price. Multiplying this per word effect by the average number of words per article yields a price increase of approximately US$ 280 per article. For the specification that includes the distance weighted publicity measure, each additional word in a risk-related article is associated with a 43 Cent increase in housing price. Multiplying this by the average number of words per article yields a price increase of approximately US$ 230 per article. Both results are statistically significant at the 1% level.

The regression results for Eq. (3b) suggest no statistically significant correlation between housing prices and the number of words in Superfund articles in section A of the newspaper. However, the results of Eq. (4b) suggest that housing prices are positively correlated with the number of words in Superfund articles appearing on page one of a section of the paper. For the specification that includes the non-weighted publicity measure, an additional word in a page one article is associated with a 63 Cent increase in housing price. Multiplying this by the average number of words per article yields a price increase of approximately US$ 350 per article. For the specification that includes the distance weighted publicity measure, an additional word in a page one article is associated with a 48 Cent increase in housing price. Multiplying this by the average number of words per article yields a price increase of approximately US$ 260 per article.

The results in Table 4 have similar implications as the results in Table 3. That is, the housing prices in greater Grand Rapids are positively correlated with the level of newspaper publicity concerning the local Superfund sites. For the specifications that include the non-distance weighted publicity measures, a mean change in the number of words corresponds to a total housing price increase of approximately US$ 3,800; a mean change in

[17] As in the previous subsection, for the distance weighted specifications, we compute predicted price changes assuming that the house is one mile from the relevant site.

the number of words that focus on risk corresponds to a total housing price increase of approximately US$ 4,300; a mean change in the number of page one words corresponds to a total housing price increase of approximately US$ 3,100. For the specifications that weight newspaper publicity by the inverse of distance from the site to the house, a mean change in the number of words corresponds to a total housing price increase of approximately US$ 2,800 for a house one mile from the relevant sites; a mean change in the number of words in articles that focus on risk corresponds to a total housing price increase of approximately US$ 3,500 for a house one mile from the relevant sites; a mean change in the number of words in page one articles corresponds to a total housing price increase of approximately US$ 2,300 for a house one mile from the relevant sites. This positive correlation suggests that residents perceived the information from the newspaper as good news about the sites. Either they lowered their prior perceptions of the risks or they increased their expectation that the sites will soon be cleaned up (or both).

The risk information provided by the EPA does indeed suggest good news about the risk levels at the sites. On average, the cancer risks at the local Superfund sites are less than the national average. Since we assumed that residents base their prior beliefs on their knowledge of the national sites, this result suggests that risk perceptions decrease after the release of the EPA risk reports. Though not reported in the tables, the results suggest a negative correlation between housing prices and the objectively measured cancer risk information stemming from the EPAs risk assessment report. Given a mean change in the risk level between sales (which is equal to a risk reduction of 7.80E−06), housing prices increase on average by US$ 60–90. Thus, housing prices increase given the EPAs information and increase by even more given the information provided by the local newspaper.

As before, comparing across equations indicates that the magnitude of the relationship between publicity and housing prices varies by the different types of publicity. A word in a page one article about a site is correlated with a price increase that is about two times as large as the price increase associated with a change in a word in any Superfund article. [18]

5. Conclusion

Conceptually, risk information provision could serve in an alarmist capacity by arousing public fears, or it could quell these fears, particularly if the public envisions worst-case scenarios. For the newspaper coverage of Superfund sites in the greater Grand Rapids area from 1988 through 1993, there was a positive relationship between publicity and housing prices, which is consistent with a calming media effect. Because the sites in this area are not as risky as the average national site, this effect is consistent with what one would expect if residents used the newspaper information to update their prior perceptions. The discussion of treatment remedies and EPA involvement also may have served to reduce perceived risk levels.

[18] For all the equations estimated in Tables 3 and 4, we also ran separate regressions omitting either the control variable for the change in RI/FS, or the control variable for the change in risk information, or both. The results are extremely robust for each of these specifications. This suggests that these controls are not highly correlated with the newspaper publicity variables. The results are also robust given specifications that omit the seasonal indicator variables.

The estimates suggest that the magnitude of the housing price change was approximately US$ 100–200 per article. We also find that a mean change in risk information is correlated with a US$ 60–90 increase in housing prices. We explored a range of sensitivity tests for the dependent variable and for different characterizations of media coverage. The results were quite robust and reflected plausible differences, such as a page one article having a greater magnitude than other articles that are featured less prominently. Overall, these finding are consistent with a public response to risk information that is manifested in market transactions.

Acknowledgements

Ted Gayer conducted much of this research while at the University of California at Berkeley, where he was a Robert Wood Johnson Scholar. He also received research support from a Georgetown University summer grant. W. Kip Viscusi received research support from the Olin Center for Law, Economics, and Business and the Sheldon Seevak Research Fund. Richard Bishop provided suggestions that led to this paper. We also received helpful comments from Glenn Blomquist and two anonymous referees.

References

Bailey, M.J., Muth, R.F., Nourse, H.O., 1963. A regression method for real estate price index construction. J. Am. Stat. Assoc. 58, 933–942.

Bartik, T.J., Smith, V.K., 1987. Urban amenities and public policy. In: Mills, E.S. (Ed.), Handbook on Urban Economics. North-Holland, Amsterdam.

Breyer, S.J., 1993. Breaking the vicious circle: toward effective risk regulation. Harvard University Press, Cambridge, MA.

Cropper, M.L., Deck, L.B., McConnell, K.E., 1988. On the choice of functional form for hedonic price functions. Rev. Econ. Stat. 70 (4), 668–675.

Fabian, R., Tolley, G., 1994. Issues in questionnaire design. In: Tolley, G., Kenkel, D., Fabian, R. (Eds.), Valuing Health for Policy: An Economic Approach. University of Chicago Press, Chicago.

Gayer, T., Hamilton, J.T., Viscusi, W.K., 2000a. Private values of risk tradeoffs at Superfund sites: housing market evidence on learning about risk. Rev. Econ. Stat. 82 (3), 439–451.

Gayer, T., Hamilton, J.T., Viscusi, W.K., 2000b. The Market Value of Reducing Cancer Risk: Hedonic Housing Prices with Changing Information, Working Paper. Georgetown Public Policy Institute.

Hamilton, J.T., Viscusi, W.K., 1999a. Calculating Risks? The Spatial and Political Dimensions of Hazardous Waste Policy. MIT Press, Cambridge, MA.

Hamilton, J.T., Viscusi, W.K., 1999b. How costly is “clean”? An analysis of the benefits and costs of Superfund site remediations. J. Policy Anal. Manage. 18 (1), 2–27.

Harrison, D., Stock, J.H., 1984. Hedonic Housing Value, Local Public Goods, and the Benefits of Hazardous Waste Clean-up. Energy and Environmental Policy Center, John F. Kennedy School of Government, Harvard University.

Kenkel, D., Berger, M., Blomquist, G., 1994. Contingent valuation of health. In: Tolley, G., Kenkel, D., Fabian, R. (Eds.), Valuing Health For Policy: An Economic Approach. University of Chicago Press, Chicago.

Kiel, K., McClain, K.T., 1995. House prices during siting decision stages: the case of an incinerator from rumor through operation. J. Environ. Econ. Manage. 28, 241–255.

Michaels, R.G., Smith, V.K., 1990. Market segmentation and valuing amenities with hedonic models: the case of hazardous waste sites. J. Urban Econ. 28, 223–242.

Palmquist, R.B., 1979. Hedonic price and depreciation indexes for residential housing: a comment. J. Urban Econ. 6, 267–271.
Palmquist, R.B., 1982. Measuring environmental effects on property values without hedonic regressions. J. Urban Econ. 11, 333–347.
Tolley, G., Kenkel, D., Fabian, R. (Eds.), 1994. Valuing Health For Policy: An Economic Approach. University of Chicago Press, Chicago.
US Environmental Protection Agency, 1987. Unfinished Business: A Comparative Assessment of Environmental Problems. Government Printing Office, Washington, DC.
Zeckhauser, R.J., Viscusi, W.K., 1990. Risk within reason. Science 248 (4955), 559–564.