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The Economic Impact of a Transient Hazard on Property Values: The 1988 PEPCON Explosion in Henderson, Nevada

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Abstract

This article investigates the effect of the May 1988 explosion of a chemical plant in Henderson, Nevada on residential property values (1) before the explosion (anticipation), (2) between the time of the explosion and an announcement of relocation, and (3) subsequent to an announcement in July 1988 that the plant would be rebuilt 100 miles away in Cedar City, Utah. This article uses the conventional hedonic model wherein the real prices of residential houses are related to the characteristics of the property (age, size, and amenities); the timing of the sale; and distance from the site of the explosion, rounded to the nearest mile. A quadratic specification of the model showed that the model was sensitive to the mean distance from the hazard. In a sample of properties throughout the Las Vegas Valley, property values decreased with distance from the explosion, indicating the presence of other hazards. The quadratic specification was stable only for properties within six miles of the explosion site, which included the communities of old Henderson (to the east) and the master planned community of Green Valley (to the west). A discontinuous specification of the model, in which distance was measured by a set of dummy variables (i.e., within two miles, within three miles, etc.) proved to be much more stable. Property within two miles of the hazard were depressed both before and after the explosion, although after the relocation announcement, property values rebounded to reflect the reduction in the number of hazardous plants. This article lends weight to the accumulating body of evidence that real estate markets do behave efficiently.

Key Words: hedonic, hazard, housing, market efficiency

1. Introduction

On May 4, 1988, a welder's torch set off an explosion of a vat of ammonium perchlorate, a volatile ingredient in solid rocket fuel. Within minutes the Pepcon plant in Henderson, NV, disappeared. The explosion, which rocked the Las Vegas valley, killed two employees, leveled an adjacent marshmallow manufacturing factory, and caused extensive but repairable damage to residential and commercial property. The blast did not harm the Kerr-McGee facility two-thirds of a mile away, the only other manufacturer of ammonium perchlorate in the U.S.A. Two areas most affected: the residential neighborhoods of old Henderson, an industrial town about 15 miles from the Las Vegas strip, and the rapidly growing master planned community of Green Valley, which had been annexed by the city of Henderson in the early 1980s. Figure 1 shows the location of the Pepcon plant (triangle) in the southeast corner of the Las Vegal valley between Green Valley (to the west) and Henderson (to the east). Figure 2 magnifies the map of the Green Valley and Henderson, showing the Pepcon plant site midway between zip code 89014 (Green Valley) and zip code 89015 (Henderson).

As homeowners replaced broken windows and garage doors and filed insurance claims, Pepcon's parent corporation negotiated with community leaders about the rebuilding. On July 27, 1988, 84 days after the explosion, corporate officials announced that the Pepcon plant would not be rebuilt in heavily populated southern Nevada, but would be relocated in Cedar City, Utah, approximately 100 miles to the northeast.

The events of May through July of 1988 present a unique opportunity to investigate the impact of a transient hazard on property values in a rapidly growing community. The city of Henderson is the fastest growing city in Nevada, the fastest growing state in the U.S.A. Using an extensive record of residential housing sales, this article explores both the spatial and temporal impacts of the explosion on the Henderson and Green Valley residential housing markets. Analyzing nearly 8,000 housing sales, we relate housing prices to the distance between each house and the Pepcon plant, and link significant changes in this relation, before and after the explosion, and after the relocation announcement. Our large sample size (in comparison to other studies) allows us to test the hypothesis of market efficiency by looking at daily, as opposed to monthly or annual, housing transactions. Our investigation shows that home buyers in Henderson appeared to be better informed about the hazard both before and after the explosion, perhaps because of the older, settled nature of that community. Before the explosion, property values significantly increased as distance from the plants increased in both old Henderson and Green Valley. After the plant explosion, the impact of distance from the plant on housing prices increased. After the relocation announcement, the price-distance relation returned to pre-explosion levels in Henderson, but disappeared in Green Valley.

In the next section, we present a review of the literature, followed by a discussion of the incident and a description of the hypotheses to be tested. The fourth and fifth sections present the model and data, respectively. The sixth section contains the empirical results, followed by a concluding section.

2. The literature

2.1. Do nuisances affect property values?

There is an emerging consensus in the literature on the effect of neighborhood nuisances on residential property values: to varying degrees, the existence of such nuisances *does* significantly reduce property prices. Colwell (1979) established that overhead electrical power transmission lines reduced property prices up to 200 feet away, but such lines had no discernible impact farther away. Later he (1990) also demonstrated that the price-reducing effect of overhead power transmission lines declined with time; Colwell cited the growth

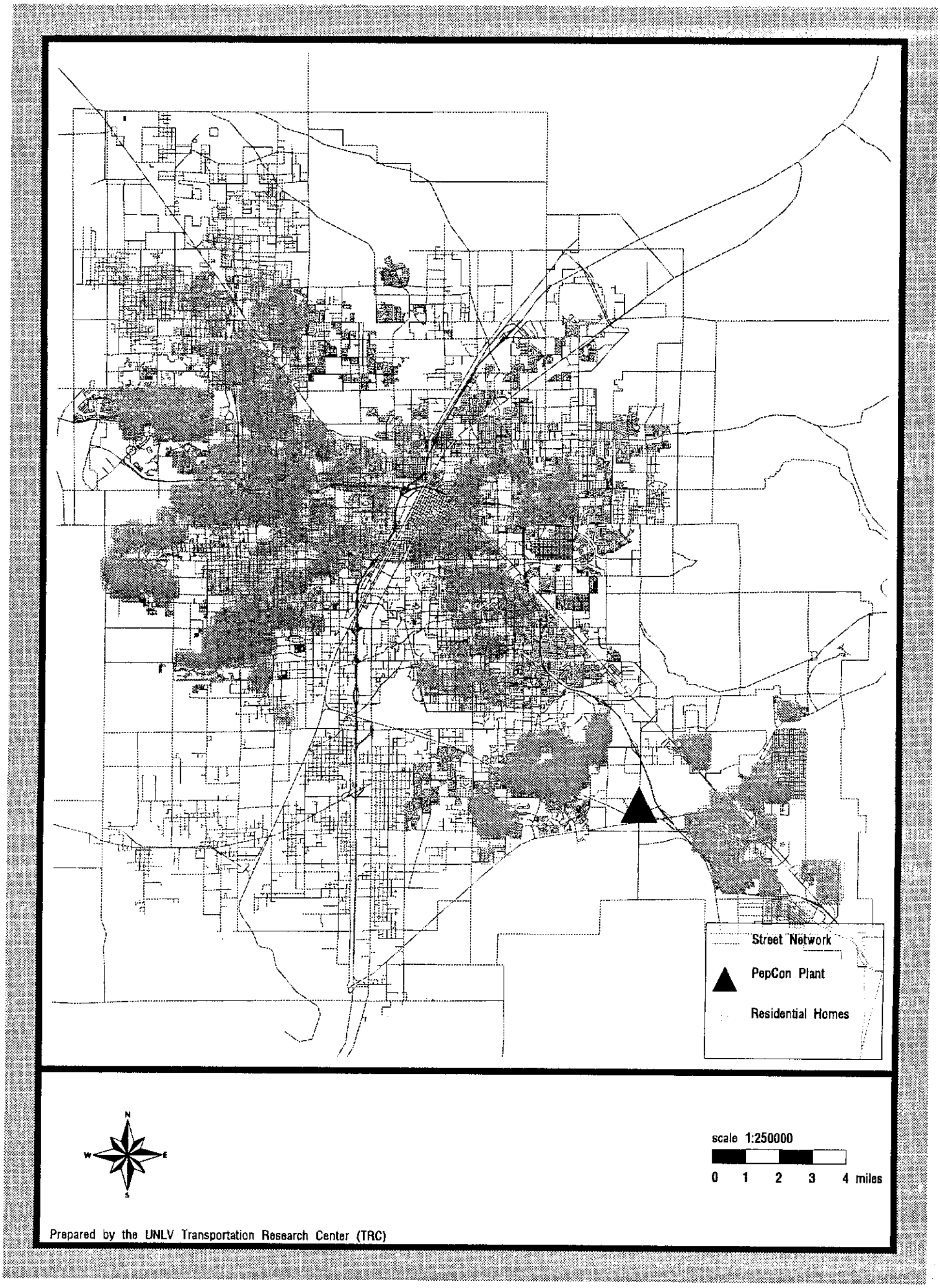

Figure 1. Location of residential homes and the Pepcon plant in Las Vegas, Nevada.

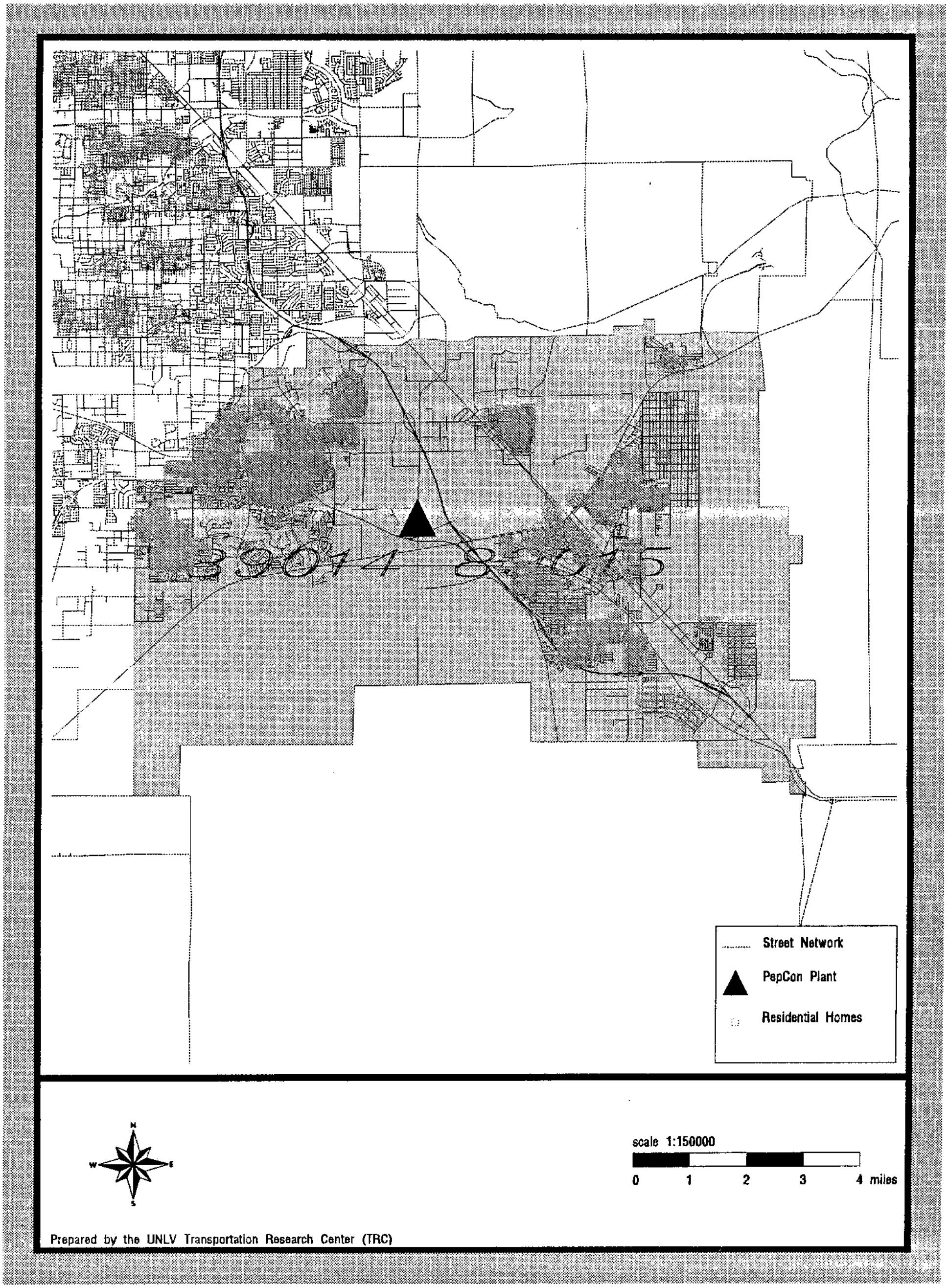

Figure 2. Location of residential homes and the Pepcon plant in Green Valley (zip 89014) and old Henderson (zip 89015).

of trees as one explanation. Delaney (1992) surveyed 219 appraisers and found that they believed that there was a 10% discount on property values in proximity to overhead power lines. The most cited reason for the discount was the unsighly nature of the lines (93.9%), but concern for health was also an important reason given (59.9%). Kung and Seagle (1992) concluded that the most serious impact on property values would result from knowledge by the public of the possible health effects.

Thibodeau (1990) examined the effects of a high-rise office building in neighboring residential properties. He found that nearby houses decreased in value by 15%. However, there was a 5% premium on houses located over 1,000 meters from the structure. Frankel (1992) investigated the effects of aircraft noise on property values. Through a survey of 2,000 realtors and 70 appraisers, he found a significant discount for noise levels above 65–70 Ldn.[1] While discounts approximating 5% occur in the 65–70 Ldn range, those discounts reach 15% when Ldns reach the 75–80 range.

Carter (1989) found evidence that nonhazardous landfills depress property prices. Reichert et al. (1992) found the negative effect to be between 5.5% and 7.3%, depending on the distance from the site. In older, less expensive neighborhoods, the effect was smaller—between 3 and 4%. Thayer et al. (1992) estimated the effect of nonhazardous landfills in dollars. They concluded that housing prices in the Baltimore area rose by $1,300 to $1,700 for each mile distant from a waste disposal site. On the other hand, Bleich et al. (1991) employed a sample of 1,628 transactions over a ten-year period to show that if a landfill was well-designed and well-managed, the effect on property prices would be minimal. Do et al. (1994) measured the effect of neighborhood churches on residential property values in Chula Vista, California. They document a $4,000 price reduction for houses 50 feet from a church, relative to the value of a similar house 850 feet away.

Gamble and Downing (1982) study two effects of nuclear power plant proximity on residential properties before and after the Three Mile Island incident in 1979. They found that before the accident property values increased by $163 for each mile distant from the plant. They found no change in values subsequent to the accident. Galster (1986) studied the appreciation of prices for houses located near the Three Mile Island plant. He found that houses located within five miles of the plant rose more slowly in value than those located five to 25 miles away.

Hazardous waste facilities seem to depress property values by a greater magnitude. Smolen et al. (1992) found that in Toledo, Ohio there was a $12,000 premium for each mile distant from a toxic chemical waste dump, up to 5.75 miles, with no effect beyond that range. McClelland et al. (1990) used a hedonic regression model to determine the effect of risk perception of a hazardous waste landfill on house values in the Los Angeles area. They discovered that a 10% increase in respondents' indicating a high risk lowered property prices by $2,084. Closing the landfill reduced the number of respondents who thought there was a high level of risk by 25%, leading to a $5,000 increase in property values. Kohlhase (1991) looked at the effect of an EPA announcement that a site contained hazardous waste material. She discovered a premium for distance from the site of $3,310 per mile. The premium disappeared after the site was cleaned up and pronounced safe by the EPA.

On the high end of the risk perception spectrum, residents appear to be unhappy with the prospect of nuclear respositories. Hoyt et al. (1992) found a statistically significant difference in the level of concern between those who were knowledgeable about the facility and those who were initially ignorant, but informed of the facility. Hoyt et al. found that those with more knowledge of the facility tended to be less concerned. Smolen et al. (1992) found that the announcement of a low-level radioactive landfill near Toledo caused property prices to drop quickly near the proposed site. After the announcement that the facility would not be located in that area, property values rebounded "quickly." When one uses annual data, as did Smolen, it is difficult to determine precisely how quickly property values rebound, and, consequently, how efficient the housing market is. Indeed, few studies investigate how quickly property values react to the commencement or the termination of a neighborhood nuisance. This stems from the general reliance on annual or quarterly data with small sample sizes, making it difficult to track the timing of nuisance changes on property values. But this is precisely the question that should most interest economists and real estate specialists: do markets respond efficiently to the presence and removal of neighborhood hazards? To answer this question a large sample size with numerous daily sales is required.

2.2. *Should the housing market be considered efficient?*

Gau (1985) tested the weak form version of market efficiency using data from apartment and commercial property sales from Vancouver, British Columbia. He found support for the hypothesis that real estate markets are weak-form efficient. Gau also tested the semi-strong version of the hypothesis by analyzing the effect of new publicly available information on real estate asset prices. Here, too, he found support for market efficiency. Jones et al. (1981) also found support for the hypothesis that housing markets function efficiently, by demonstrating that housing prices reflected energy use as measured by annual fuel bills. On the other hand, Krantz et al. (1982) argued that housing markets are inefficient because only about 60% of property tax changes are capitalized in property prices. However, their finding does not necessarily contradict the efficiency hypothesis. If approximately 40% of property taxes were used to fund local public services (e.g., parks, schools, fire and police stations), whose positive value to residents would also be capitalized in property values, then housing markets would indeed be efficient.

3. The incident

American Pacific Corporation operated the Pepcon plant that manufactured ammonium perchlorate, a highly volatile ingredient in solid rocket fuel. The plant was located in Henderson, Nevada, an industrial town of 50,000 approximately 15 miles from the city of Las Vegas. Residential property in old Henderson (zip code 89015) sold between 1986 and 1990 (the span of our sample) averaged 3.51 miles from the Pepcon plant, with a range from 2 miles to 7 miles from the plant. Residential property in Green Valley (zip code 89014) is located at an average distance of 3.2 miles from the Pepcon plant, with a range of 2 to 15 miles. Green Valley accounts for about 64% of property sales in the two zip code areas between 1986 and 1990. On July 27, 1988, the American Pacific Corporation announced that the Pepcon plant would not be rebuilt on the original site, but would instead be relocated in Cedar City, Utah, about 100 miles northeast of Las Vegas.

Thus, we have the existence of a hazardous activity upon which a thriving residential community is growing; that is, moving to the nuisance. The hazard dramatically erupts, and then, within three months, is lessened from two to one, reducing the probability of a future explosion by 50%. If the housing market operates efficiently, several factors should be revealed:

1. Property values should have been depressed prior to the explosion, relative to what they would have been had the hazard not existed. That is, as distance from the hazard increased, property values should have increased, ceteris paribus.
2. If the market had underestimated the hazard, property values should have responded quickly and significantly to the explosion as market agents reevaluated the probability of a chemical explosion. The rate of increase of property values with respect to the distance from the hazard should have increased after the explosion.
3. Property values should have responded to the removal of the hazard, also quickly and significantly. After the announcement that the hazard was removed, property values should have increased slightly, due to the reduction from two hazardous chemical plants to one.

4. The model

We use a hedonic model of housing prices, employing several housing characteristics and a time trend to represent the rate of appreciation of housing values. Dummy variables are introduced to indicate (a) the explosion ($P = 0$ before May 4, 1988, $P = 1$ on and after May 4, 1988, and (b) the announcement that the plant would be relocated ($C = 0$ before July 27, 1988, and $C = 1$ on and after July 27, 1988).[2]

Since the explosion caused no injuries to people in their homes, but only damaged property, we take potential losses by property owners to be proportional to the value of their house.[3] The appropriate functional form to test this specification is a double-log form, wherein coefficients measure the percentage change in the real price due to a 1% change in (continuous) regressors. We expect that the elasticity of value with respect to size should be positive, but smaller than one, for both building size (B^2) and lot size (L^2). The smaller than unitary elasticity with respect to building size reflects economies of scale in construction. Doubling the square footage of a house would increase its perimeter by only 50%. Holding the size of the building constant, a larger lot means more yard work and higher irrigation costs, so that diminishing returns prevail. Also, since block walls are ubiquitous in the Las Vegas Valley, the cost of enclosing a lot is a function of perimeter, rather than area, so the contribution of lot size to residential value should be inelastic. We hypothesize that the value of a house will vary with age and distance from the hazard in quadratic form; hence, age (A) and distance (d) are entered as a quadratic function.[4]

$$\ln p_{idt} = \ln \beta_0 + \beta_1 A_i + \beta_2 A^2 + \beta_3 \ln(B^2) + \beta_4 \ln(L^2) + \beta_5 t + \beta_6 Pl + \beta_7 FP + \beta_8 d + \beta_9 d^2 + \ln \epsilon_{it} \quad (1)$$

where:

$\ln p_{idt}$ = the natural logarithm of property real price of property i at time t (January 1, 1986 = 0), and distance d from hazard. The reported selling price was deflated by the monthly consumer price index for housing (1982–1984 = 100).
A = age of house at the time of sale in years[5]
$\ln(B^2)$ = natural logarithm of square feet of house
$\ln(L^2)$ = natural logarithm of lot size (in square feet)
t = time trend (number of months after 1/1/86)
Pl = 1 if house has a pool; 0 if there is no pool
FP = 1 if house has at least one fireplace; 0 if the house has no fireplace[6]
d = distance between house and the site of the Pepcon plant in miles[7]
$\ln \epsilon_{it}$ is the natural logarithm of the random disturbance term (mean 1, constant variance σ^2)

If the market is efficient, the coefficient on d should be positive, and the coefficient on d^2 should be negative, with $|\beta_8| > 4\beta_9$. That is, as distance from the plant(s) increases, housing prices should increase at a decreasing rate, with the effect falling to zero when $d^* = |\beta_8|/2\beta_9$.[8] Note that the efficient market hypothesis is the *alternative* hypothesis.[9] If any of the following three outcomes occur, we should accept the *null* hypothesis that the market is not efficient.

1. $\beta_8 \leq 0$. That is, property values do not increase significantly as distance from the Pepcon/Kerr-McGee plants increases.
2. $\beta_9 \geq 0$. That is, property values continue to increase as distance from the hazard increases, implying either irrational behavior on the part of home buyers, or the influence of another, potentially stronger hazard further removed from this hazard site.
3. $|\beta^8| \leq 4\beta_9$. That is, property values achieve their maximum value less than two miles from the chemical plants, which is irrelevant to our data, since the minimum distance between residential property and the plants is two miles.[10]

Otherwise, we expect the usual hedonic results. Property values should increase with the size of the home ($\beta_3 > 0$) and with lot size ($\beta_4 > 0$), and should decline with the age of the home ($\beta_1 < 0$), while increasing with the square of age ($\beta_2 > 0$).[11] Both the presence of a pool ($\beta^6 > 0$) and the presence of a fireplace ($\beta_7 > 0$) should increase the price of the house.

To test the timing of property value responses to both the explosion and the removal of one of the hazards, additional indicator variables are introduced:

P = dummy variable for Pepcon explosion; $P = 1$ after May 4, 1988 and 0 before May 4, 1988.

C = dummy variable for relocation of plant to Cedar City, Utah. $C = 1$ after July 27, 1988 and 0 before July 27, 1988.

Introduction of these terms allows us to test whether the market responds quickly to each event. We also introduce interaction terms between the two events and the distance between each house and the plant:

Pd = a slope shifter to detect change in parameter β_8 due to the Pepcon explosion. If the actual explosion increases risk perception, we would expect that the (absolute value) of the percent change in value due to an extra mile of distance should increase in the wake of the explosion.

Cd = a slope shifter to identify change in parameter β_8 due to the relocation announcement. By reducing the number of plants from two to one, parameter β_8 should have fallen in absolute value after the relocation decision.

We introduce similar slope dummies for squared distance:

Pd^2 = a slope shifter to measure change in parameter β_9 due to the Pepcon explosion. If the actual explosion increases risk perception, we would expect that the optimal distance from the plant should increase, which may imply that β_9 decreases.

Cd^2 = a slope shifter to measure the change in parameter β_9 to to the relocation announcement.

This yields the second test equation:

$$\ln p_{idt} = (\beta_0 + \beta_{10}P + \beta_{11}C) + \beta_1 A_i + \beta_2 A^2 + \beta_3 \ln(B^2) + \beta_4 \ln(L^2) + \beta_5 t + \beta_6 Pl + \beta_7 FP + (\beta_8 + \beta_{12}P + \beta_{13}C)d + (\beta_9 + \beta_{14}P + \beta_{15}C)d^2 + \ln \epsilon_{it}. \quad (2)$$

Note that the six intercept and slope shifter variables are likely to be collinear, given the brief time period between the explosion and the relocation announcement. Accordingly, an *F*-test is used to measure the joint significance of all six indicators.

Despite the fact that quadratic functions are ubiquitous in real estate econometrics literature, there is some concern that such functions may create phony results as the function strains to return to the data beyond the distance of any effects. Accordingly, we estimate a more generalized value-distance function which allows for discontinuous results. This discontinuous distance specification allows for abrupt changes in the relation between residential property values and the distance from the hazard. We define an *MI2* as the dummy variable set equal to 1 for all houses with two miles[12] of the plant site; *MI2* = 0 for all other properties in the sample. The variable *MI3* is coded as 1 for all properties within three miles of the plant site; *MI3* is coded as zero for all remaining properties. Note that all properties for which *MI2* = 1, *MI3* = 1. We coded properties up to ten miles from the plant site in the Las Vegas Valley sample; the reference group for this sample is all properties more than ten miles from the hazard. Nearly all properties in Green Valley and Henderson are within six miles of the plant site. Our distance indicators are restricted to *MI2*, *MI3*, *MI4*, and *MI5*. The reference group for Green Valley and Henderson includes properties more than five miles from the plant site.

With this specification, the new version of (1) becomes:

$$lp_{idt} = \beta_0 + \beta_1 A_i + \beta_2 A^2 + \beta_3 \ln(B^2) + \beta_4 \ln(L^2) + \beta_5 t + \beta_6 Pl + \beta_7 FP + \sum_{d=3}^{d_{\max}} \gamma_d MI_d + \ln \epsilon_{it}. \quad (1a)$$

Coefficient γ_d measures the effect of being d miles from the hazard, as compared to being $d - 1$ miles from the hazard. Accordingly, we expect γ_2 to be negative, since two miles is the closest proximity to the plant site. The coefficient γ_3 should be *positive*, indicating an increase in property values with distance from the hazard. The plant has no further effect on property values at distance j where

$$\sum_{d=3}^{j} \gamma_d MI_d = 0.$$

Interaction terms between distance indicators and the date of the Pepcon explosion (P) and the relocation announcement (C) measure temporal changes on the property value-distance relation:

$$-lp_{idt} = (\beta_0 + \beta_{10}P + \beta_{11}C) + \beta_1 A_i + \beta_2 A^2 + \beta_3 lB^2 + \beta_4 lL^2 + \beta_5 t + \beta_6 Pl + \beta_7 FP + \sum_{d=2}^{n} (\gamma_{1d} + \gamma_{2d}P + \gamma_{3d}C)MI_d + \ln \epsilon_{it}. \quad (2a)$$

A negative size on γ_{22} (on interaction term *PMI2*) either implies an increase in the perceived hazard two miles from the explosion site or perhaps the effect of transitory damage on home prices between May 8 and July 27, 1988. Negative coefficients on other γ_2 terms imply a diminished recovery of property values with distance from the explosion. We expect positive signs for γ_3 (on interaction term CMI_d), as home buyers absorb the information that the number of hazardous plants has decreased by one.

5. The data set

The data used to test market efficiency were taken from a computerized database (*Metroscan*) of the files of the Tax Assessor's office of Clark County, Nevada. The database consists of 319,451 properties including 196,000 single family residences. For each residence, the files contain information on approximately 30 physical characteristics, in addition to the location (street address and zip code), sales date, and sales price. From the database, we selected a sample of 3,084 properties located within zip code 89014 (Green Valley), 1,764 properties located in zip code 89015 (old Henderson), and a random sample of 2,922 properties located to the north and west of Green Valley.[13] All sales occurred between January 1, 1986 and December 31, 1990.[14] Descriptive statistics for the variables selected are shown in Table 1. Note that for each variable selected, there are significant differences in the mean among the three subsamples. The greatest difference rests with the distance from the chemical plant complex. The mean distance from Green Valley homes is 3.2 miles; the mean distance from Henderson homes is 3.5 miles; while the mean distance from the rest of the valley is 14 miles. Another notable difference is in the age of homes: average age in Green Valley is only 1.6 years as compared to 9.5 years for Henderson, and 6.5 years for the rest of the Vegas Valley. As such, we would expect buyers of older houses to be better

Table 1. Descriptive statistics.

Entire Sample

	RPRICE	AGE	SQFTL	SQFTB	MONTH	FP	POOL	MILES	P	C	Z89014	Z89015
Mean	84190.99	6.46	7769.50	1720.22	37.69	0.78	0.21	7.34	0.04	0.67	0.40	0.23
Median	79307.18	1.00	6630.00	1612.00	41.80	1.00	0.00	4.00	0.00	1.00	0.00	0.00
Maximum	220458.55	57.00	162000.00	7571.00	60.83	1.00	1.00	22.00	1.00	1.00	1.00	1.00
Minimum	30400.63	0.00	2304.00	380.00	0.07	0.00	0.00	2.00	0.00	0.00	0.00	0.00
Standard deviation	28206.18	9.84	5122.05	562.72	16.48	0.42	0.40	5.68	0.20	0.47	0.49	0.42
Observations	7780	7780	7780	7780	7780	7780	7780	7780	7780	7780	7780	7780

Henderson

	RPRICE	YAGE	SQFTL	SQFTB	MONTH	FP	POOL	MILES	P	C
Mean	66123.23	9.49	8884.59	1483.17	34.09	0.59	0.11	3.51	0.04	0.58
Median	64232.04	6.00	6863.00	1415.00	35.63	1.00	0.00	4.00	0.00	1.00
Maximum	157853.81	55.00	162000.00	4591.00	58.77	1.00	1.00	7.00	1.00	1.00
Minimum	30400.63	0.00	3468.00	384.00	0.17	0.00	0.00	2.00	0.00	0.00
Standard deviation	18851.89	11.52	7130.29	477.99	17.04	0.49	0.31	1.12	0.19	0.49
Observations	1764	1764	1764	1764	1764	1764	1764	1764	1764	1764

Green Valley

	RPRICE	AGE	SQFTL	SQFTB	MONTH	FP	POOL	MILES	P	C
Mean	94980.87	1.62	7025.15	1888.22	40.59	0.92	0.25	3.20	0.03	0.75
Median	89067.85	1.00	6537.00	1788.00	45.10	1.00	0.00	3.00	0.00	1.00
Maximum	220458.55	16.00	66066.00	7571.00	58.77	1.00	1.00	15.00	1.00	1.00
Minimum	32992.93	0.00	3200.00	888.00	0.40	0.00	0.00	2.00	0.00	0.00
Standard deviation	25243.35	2.52	2969.89	552.31	14.97	0.27	0.43	1.17	0.18	0.43
Observations	3084	3084	3084	3084	3084	3084	3084	3084	3084	3084

Rest of Las Vegas Valley

	RPRICE	AGE	SQFTL	SQFTB	MONTH	FP	POOL	MILES	P	C
Mean	83675.02	9.73	7884.15	1685.54	36.79	0.74	0.22	14.02	0.05	0.63
Median	77047.85	4.00	6600.00	1593.00	40.33	1.00	0.00	15.00	0.00	1.00
Maximum	214776.63	57.00	54886.00	5222.00	60.83	1.00	1.00	22.00	1.00	1.00
Minimum	33990.15	0.00	2304.00	380.00	0.07	0.00	0.00	5.00	0.00	0.00
Standard deviation	30140.22	11.40	5337.13	563.33	17.13	0.44	0.42	3.44	0.22	0.48
Observations	2932	2932	2932	2932	2932	2932	2932	2932	2932	2932
F-stat	694.55	736.55	76.67	324.90	97.07	417.25	73.13	19831.81	6.36	82.32

RPRICE real price of house (1982–1984 = 100)
AGE age of house in years (year purchased minus year built)
SQFTL square feet of lot
SQFTB square feet of building
MONTH month sold (January 1, 1986 = 0)

FP dummy variable for presence of fire place
PL dummy variable for presence of pool
D distance from house to PEPCON plant, in miles
P dummy variable for PEPCON explosion (0 before 5/4/88, 1 after 5/4/88)

C dummy variable for relocation announcement (0 before 7/27/88, 1 after 7/27/88) informed, typically because new home buyers rely on builder warrantees and have less of an incentive to investigate potential defects with properties. This moral hazard is likely to carry over into knowledge of environmental hazards.

Table 2 presents the correlation coefficients for the entire sample of 7,780 properties, as well as the correlation coefficients for the three subsamples. In each case, all regressors tend to be positively correlated with the real price of the house except age (in all cases), and distance (in the case of Green Valley). However, the correlation between value and age is weakest for Green Valley, which also has the youngest housing stock. Correlations between regressors tend to be weak (below 0.5) in all cases except between the six indicators of the explosion and relocation announcement dates, portending a multicollinearity problem.

6. The results

For completeness, we estimated eight regressions, relating real housing prices (deflated by the monthly CPI for housing) to age, building size, time, amenities, and distance from the hazard, with and without regard to the explosion and relocation announcement dates for the entire sample, for the combined samples from Henderson and Green Valley, and for the samples from Henderson and Green Valley alone. Results are reported for a cubic relation between price and age for the Green Valley properties and for the combined Green Valley–Henderson sample. These results are reported in Table 3.

In all cases, real housing price is positively related to building and lot size, indicators for fireplace(s) and a pool, and with respect to time. Housing prices in the Las Vegas area consistently increase faster than the consumer price index for housing, indicative of a booming economy. For the entire sample, houses in Henderson (Z89015 = 1) have significantly lower prices than houses in the rest of the Las Vegas Valley. However, there is no significant difference between homes in the Las Vegas Valley sample and the Green Valley sample. In the combined sample for Green Valley and Henderson, housing prices decreased with age and the square of age, and increased with the cube of age, implying that housing prices decrease to approximately 40 years. The quadratic model implies that Green Valley housing prices increase with age up to about 4.5 years, then begin to decrease in value to 40 years. The cubic model implies that Green Valley housing prices increase with age until they are 3.5 years old, then decline in value until 12.5 years of age.

The first equation for each set treats the Pepcon/Kerr-McGee chemical complex as a "timeless" hazard. The Las Vegas Valley sample implies that property values *decrease* in value with distance up to 8.36 miles, then begin increasing. This result contradicts the hypothesis that the Pepcon plant was a hazard with a wide diameter and points up the problem in the quadratic functional form.[15]

For the combined sample from Henderson and Green Valley, and for the sample from Green Valley, property values are not significantly related to distance from the hazard in (1). For the Henderson sample, property values increase up to 4.55 miles from the hazard.[16] These results seem to imply that only in Henderson is the relation between property values stable with respect to the Pepcon explosion and the announcement of relocation to Cedar City.

For the entire Las Vegas Valley, introduction of terms for the Pepcon explosion (P) and the relocation announcement (C) render all distance coefficients statistically insignificant.[17]

Table 2. Correlation coefficients.

Entire Sample (n = 7780)

	LRPRICE	AGE	ln(L²)	ln(B²)	MONTH	FP	POOL	D	D²	P	PM	C	CM
LRPRICE	1.0000	-0.4793	0.3232	0.8115	0.1962	0.5258	0.3284	0.0542	0.0921	0.1599	0.1316	0.1672	0.1389
AGE	-0.4793	1.0000	0.1306	-0.2798	-0.0554	-0.4411	0.0115	0.0885	0.0214	-0.0420	0.0340	-0.0562	0.0211
ln(L²)	0.3232	0.1306	1.0000	0.3832	-0.0669	0.0476	0.2085	0.0000	-0.0128	-0.0581	-0.0321	-0.0613	-0.0369
ln(B²	0.8115	-0.2798	0.3832	1.0000	0.0970	0.4658	0.3254	-0.0083	0.0126	0.0863	0.0453	0.0882	0.0489
MONTH	0.1962	-0.0554	-0.0669	0.0970	1.0000	0.0497	-0.0477	-0.0061	0.0208	0.8604	0.4876	0.8707	0.5197
FP	0.5258	-0.4411	0.0476	0.4658	0.0497	1.0000	0.1297	0.0006	0.0223	0.0467	0.0239	0.0477	0.0253
POOL	0.3284	0.0115	0.2085	0.3254	-0.0477	0.1297	1.0000	0.0029	-0.0097	-0.0402	-0.0291	-0.0369	-0.0280
D	0.0542	0.0885	0.0000	-0.0083	-0.0061	0.0006	0.0029	1.0000	0.9828	-0.0098	0.7058	-0.0242	0.6650
D²	0.0921	0.0214	-0.0128	0.0126	0.0208	0.0223	-0.0097	1.0000	0.0139	0.7143	0.0024	0.6770	
P	0.1599	-0.0420	-0.0581	0.0863	0.8604	0.0467	-0.0402	-0.0098	0.0139	1.0000	0.5628	0.9099	0.5313
PM	0.1316	0.0340	-0.0321	0.0453	0.4876	0.0239	-0.0291	0.7058	0.7143	0.5628	1.0000	0.4974	0.9429
C	0.1672	-0.0562	-0.0613	0.0882	0.8707	0.0477	-0.0369	-0.0242	0.0024	0.9099	0.4974	1.0000	0.5839
CM	0.1389	0.0211	-0.0369	0.0489	0.5197	0.0253	-0.0280	0.6650	0.6770	0.5313	0.9429	0.5839	1.0000

Henderson (Zip = 89015; n = 1764)

	LRPRICE	AGE	ln(L²)	ln(B²)	MONTH	FP	POOL	D	D²	P	PM	C	CM
LRPRICE	1.0000	-0.4689	0.4986	0.7427	0.1548	0.5276	0.2949	0.4644	0.4634	0.1142	0.2796	0.1329	0.2828
AGE	-0.4689	1.0000	-0.0204	-0.2440	0.0583	-0.4278	-0.0115	-0.2839	-0.2774	0.0646	-0.0697	0.0511	-0.0705
ln(L²)	0.4986	-0.0204	1.0000	0.5178	0.0389	0.0944	0.1728	0.3869	0.4367	0.0187	0.1627	0.0305	0.1688
ln(B²	0.7427	-0.2440	0.5178	1.0000	0.0495	0.4253	0.2500	0.3890	0.3930	0.0413	0.1775	0.0517	0.1784
MONTH	0.1548	0.0583	0.0389	0.0495	1.0000	-0.0005	0.0020	0.0737	0.0728	0.8720	0.7779	0.8769	0.7880
FP	0.5276	-0.4278	0.0944	0.4253	-0.0005	1.0000	0.1003	0.3001	0.2866	-0.0116	0.1106	-0.0004	0.1132
POOL	0.2949	-0.0115	0.1728	0.2500	0.0020	0.1003	1.0000	0.1106	0.1111	-0.0098	0.0285	0.0131	0.0488
D	0.4644	-0.2839	0.3869	0.3890	0.0737	0.3001	0.1106	1.0000	0.9828	0.0723	0.4199	0.0704	0.3982
D²	0.4634	-0.2774	0.4367	0.3930	0.0728	0.2866	0.1111	0.9828	1.0000	0.0675	0.4129	0.0680	0.3949
P	0.1142	0.0646	0.0187	0.0413	0.8720	-0.0116	-0.0098	0.0723	0.0675	1.0000	0.8920	0.9237	0.8309
PM	0.2796	-0.0697	0.1627	0.1775	0.7779	0.1106	0.0285	0.4199	0.4129	0.8920	1.0000	0.8260	0.9356
C	0.1329	0.0511	0.0305	0.0517	0.8769	-0.0004	0.0131	0.0704	0.0680	0.9237	0.8260	1.0000	0.8995
CM	0.2828	-0.0705	0.1688	0.1784	0.7880	0.1132	0.0488	0.3982	0.3949	0.8309	0.9356	0.8995	1.0000

Table 2. Continued.

	Green Valley (Zip = 8901; n = 3094)												
	LRPRICE	AGE	$\ln(L^2)$	$\ln(B^2)$	MONTH	FP	POOL	D	D^2	P	PM	C	CM
LRPRICE	1.0000	-0.0717	0.5551	0.8602	0.0925	0.3278	0.3433	-0.0431	-0.0092	0.0676	0.0313	0.0703	0.0398
AGE	-0.0717	1.0000	0.0992	-0.1074	0.0057	-0.1044	0.0753	0.0183	0.0043	-0.0009	0.0243	-0.0070	0.0225
$\ln(L^2)$	0.5551	0.0992	1.0000	0.5102	-0.1062	0.1764	0.2990	0.1007	0.0835	-0.0965	-0.0198	-0.1026	-0.0343
$\ln(B^2$	0.8602	-0.1074	0.5102	1.0000	0.0004	0.3480	0.3154	-0.0594	-0.0160	0.0022	-0.0369	0.0009	-0.0340
MONTH	0.0925	0.0057	-0.1062	0.0004	1.0000	-0.0671	-0.0950	-0.1123	-0.0535	0.8499	0.6284	0.8628	0.6632
FP	0.3278	-0.1044	0.1764	0.3480	-0.0671	1.0000	0.0835	0.0330	0.0116	-0.0429	-0.0229	-0.0598	-0.0383
POOL	0.3433	0.0753	0.2990	0.3154	-0.0950	0.0835	1.0000	0.0107	0.0047	-0.0824	-0.0623	-0.0858	-0.0678
D	-0.0431	0.0183	0.1007	-0.0594	-0.1123	0.0330	0.0107	1.0000	0.8871	-0.1041	0.5000	-0.1206	0.4562
D^2	-0.0092	0.0043	0.0835	-0.0160	-0.0535	0.0116	0.0047	0.8871	1.0000	-0.0478	0.5076	-0.0565	0.4781
P	0.0676	-0.0009	-0.0965	0.0022	0.8499	-0.0429	-0.0824	-0.1041	-0.0478	1.0000	0.7721	0.9135	0.7215
PM	0.0313	0.0243	-0.0198	-0.0369	0.6284	-0.0229	-0.0623	0.5000	0.5076	0.7721	1.0000	0.6876	0.9267
C	0.0703	-0.0070	-0.1026	0.0009	0.8628	-0.0598	-0.0858	-0.1206	-0.0565	0.9135	0.6876	1.0000	0.7897
CM	0.0398	0.0225	-0.0343	-0.0340	0.6632	-0.0383	-0.0678	0.4562	0.4781	0.7215	0.9267	0.7897	1.0000

	Random Sample of Las Vegas and Unincorporated Clark County (n = 2931)												
	LRPRICE	AGE	$\ln(L^2)$	$\ln(B^2)$	MONTH	FP	POOL	D	D^2	P	PM	C	CM
LRPRICE	1.0000	-0.5026	0.3358	0.7741	0.1798	0.4996	0.2882	0.3135	0.3501	0.1469	0.2537	0.1536	0.2524
AGE	-0.5026	1.0000	0.1846	-0.2367	-0.0341	-0.4096	0.0832	-0.5259	-0.5469	-0.0208	-0.2123	-0.0335	-0.2071
$\ln(L^2)$	00.3358	0.1846	1.0000	0.3841	-0.0631	0.0605	0.2275	-0.0723	-0.0443	-0.0430	-0.0684	-0.0536	-0.0745
$\ln(B^2$	0.7741	-0.2367	0.3841	1.0000	0.0982	0.4577	0.3231	0.1545	0.1769	0.0884	0.1400	0.0870	0.1357
MONTH	0.1798	-0.0341	-0.0631	0.0982	1.0000	0.0412	-0.0742	0.1719	0.1833	0.8549	0.8044	0.8671	0.8190
FP	0.4996	-0.4096	0.0605	0.4577	0.0412	1.0000	0.1198	0.2400	0.2517	0.0416	0.1172	0.0439	0.1100
POOL	0.2882	0.0832	0.2275	0.3231	-0.0742	0.1198	1.0000	-0.1239	-0.1210	-0.0572	-0.0947	-0.0537	-0.0872
D	0.3135	-0.5259	-0.0723	0.1545	0.1719	0.2400	-0.1239	1.0000	0.9892	0.1528	0.4615	0.1557	0.4368
D^2	0.3501	-0.5469	-0.0443	0.1769	0.1833	0.2517	-0.1210	0.9892	1.0000	0.1622	0.4733	0.1677	0.4512
P	0.1469	-0.0208	-0.0430	0.0884	0.8549	0.0416	-0.0572	0.1528	0.1622	1.0000	0.9209	0.8938	0.8316
PM	0.2537	-0.2123	-0.0684	0.1400	0.8044	0.1172	-0.0947	0.4615	0.4733	0.9209	1.0000	0.8322	0.9125
C	0.1536	-0.0335	-0.0536	0.0870	0.8671	0.0439	-0.0537	0.1557	0.1677	0.8938	0.8322	1.0000	0.9304
CM	0.2524	-0.2071	-0.0745	0.1357	0.8190	0.1100	-0.0872	0.4368	0.4512	0.8316	0.9125	0.9304	1.0000

Table 3. Regression results (dependent variable: log of real price): quadratic distance specification.

	Las Vegas Valley	Las Vegas Valley	Henderson Green Valley	Henderson Green Valley	Henderson	Henderson	Green Valley	Green Valley
Log Intercept	5.91[1] 113.85	5.89[1] 112.18	5.91[1] 99.32	5.74[1] 85.15	6.68[1] 60.31	6.61[1] 57.39	5.16[1] 69.68	5.03[1] 59.41
AGE	-0.0128[1] -22.04	-0.0128[1] -21.97	-0.0020 -1.66	-0.0020 -1.68	-0.0088[1] -8.34	-0.0088[1] -8.37	0.0350[1] 7.87	0.0363[1] 8.14
AGE^2	0.000119[1] 8.17	0.000119[1] 8.17	-0.0003[1] -3.94	-0.0003[1] -4.09	0.000054[1] 2.27	0.000056[2] 2.34	-0.0064[1] -6.29	-0.0068[1] -6.69
AGE^3			5.35E-06[1] 3.91	5.59E-06[1] 4.10			0.000266[1] 4.27	0.0003[1] 4.68
$\ln(L^2)$	0.1287[1] 26.66	0.1294[1] 26.86	0.1176[1] 19.02	0.1214[1] 19.60	0.1322[1] 13.54	0.1307[1] 13.42	0.1607[1] 16.37	0.1352[1] 16.50
$\ln(B^2)$	0.5704[1] 79.59	0.5679[1] 79.22	0.5747[1] 67.49	0.5709[1] 66.95	0.4096[1] 26.08	0.4094[1] 26.16	0.6585[1] 68.42	0.6523[1] 67.52
MONTH	0.0022[1] 21.08	0.0028[1] 12.98	0.0021[1] 17.50	0.0027[1] 10.68	0.0022[1] 11.06	0.0030[1] 6.73	0.0020[1] 13.83	0.0026[1] 8.75
FP	0.0577[1] 11.67	0.0591[1] 11.96	0.0722[1] 12.00	0.0736[1] 12.29	0.0912[1] 10.34	0.0921[1] 10.48	0.0347[1] 4.09	0.0362[1] 4.29
PL	0.0793[1] 17.93	0.0796[1] 18.04	0.0654[1] 12.79	0.0642[1] 12.62	0.1127[1] 9.79	0.1144[1] 9.95	0.0425[1] 8.09	0.0416[1] 7.97
D	-0.0117[1] -4.88	-0.0006 -0.17	0.0045 1.16	0.1110[1] 5.45	0.0773[1] 4.48	0.1296[1] 4.66	0.0008 0.20	0.1141[1] 3.42
D^2	0.0007[1] 6.71	0.000010 0.06	-0.0004 -1.06	-0.0166[1] -5.82	-0.0085[1] -3.63	-0.0164[1] -4.31	-0.0002 -0.48	-0.0181[1] -3.74
Z89014	-0.0067[1] -0.58	-0.0032[1] -0.28						
Z89015	-0.1321[1] -12.39	-0.1294[1] -12.07	-0.1541[1] -29.61	-0.1535[1] -29.57				

Table 3. Continued.

	Las Vegas Valley	Las Vegas Valley	Henderson Green Valley	Henderson Green Valley	Henderson	Henderson	Green Valley	Green Valley
Pog		-0.0031 -0.10		-0.1940 -1.51		-0.2519 -1.20		-0.0931 -0.59
C		0.0095 0.32		0.3231 2.60		0.3592 1.73		0.2179 1.48
PD		-0.0070 -0.80		0.0954 1.24		0.0753 0.59		0.0623 0.67
PD^2		0.0004 0.94		-0.0127 -1.16		-0.0030 -0.16		-0.0117 -0.89
CD		-0.0075 -0.88		-0.2018[1] -2.71		-0.1637 -1.29		-0.1723[2] -1.98
CD^2		0.0004 1.01		0.0291[1] 2.75		0.0158 0.86		0.0296[2] 2.41
Observations	7780	7780	4848	4848	1764	1764	3084	3084
Adjusted R^2	0.7962	0.7972	0.8249	0.8267	0.7317	0.7341	0.7813	0.7838
Durbin-Watson	1.77	1.78	1.97	1.98	1.98	1.99	1.93	1.94
Multiple *F*	2763.5[1]	1799.3[1]	2081.5[1]	1363.8[1]	535.3	325.5	1106.0	701.9
F-to-include		7.22[1]		9.24[1]		3.63[1]		6.95[1]
SSE	164.60	163.68	83.46	82.51	35.57	35.13	41.89	41.33

In the combined sample for Henderson and Green Valley, introduction of the event indicators renders the coefficients on distance and distance squared both statistically significant, implying that property values increased at a decreasing rate with distance from the plant site *before* the explosion ($P = C = 0$). The explosion itself decreased property values in the combined sample by 17.6%, a result that is significant at the 10% level for a *one-tail* test. After the explosion, property values rebounded by 38%, implying some discount in value prior to the incident. Between the time of the explosion and the relocation announcement, the change in value with respect to distance is given by: $\partial \ln(p)/\partial d = 0.206 - 0.0293d$. This implies a maximum value at a distance of 3.5 miles. After the relocation announcement, the value-distance relation becomes: $\partial \ln(p)/\partial d = 0.0046 - 0.0002d$, which, for all intents and purposes, is no relationship at all.[18]

In the Henderson sample, introduction of the interaction terms between the explosion (P), the relocation announcement (C), and distance (D) increases the absolute value on both distance and distance squared. Before the explosion, property values were maximized approximately four miles from the plant site. Although none of the interacttion terms are significant,[19] the picture which they paint indicates a decline in property values by 22.3% in the wake of the explosion, and a recovery by 43.2% after the relocation announcement. After the relocation announcement, the property value reaction function becomes: $\partial \ln p/\partial D = 0.412 - 0.0036D$, implying no effect from the remaining chemical plant at 5.7 miles.

The situation in Green Valley is somewhat different. If the timing of the explosion is ignored, property values in Green Valley appear independent of the distance from the plant site. Introducing the date of the explosion indicates that, prior to the explosion, property values increase at the rate of 4.17% at a distance of two miles from the chemical plant. After the explosion, but prior to the relocation announcement, property values increase at a rate of 12% at a distance of two miles from the plant site(s).[20] After the relocation announcement, property values increase by 0.33% per mile two miles from the hazard. Two explanations suggest themselves: (1) that new home buyers in Green Valley are unaware that some hazard still exists after the relocation announcement; (2) that the "bandwagon effect" of the growth in Green Valley is nearly as strong as the fear of the remaining hazard, causing the two to cancel.

7. Discontinuous distance function

For reasons mentioned above, there are reasons to question the validity of the quadratic relation between property values and distance from the hazard. Assuming a continuous relation means that the function can be pulled out of shape by the existence of other hazards some distance away from the hazard in question. Table 3a presents the results of the discontinuous distance specification introduced as (1a) and (2a) above. Variable MI_d is coded as one for all properties within d miles of the plant site, and coded as zero for all properties more than d miles away. The reference group for each equation consists of properties $d_{max} + 1$ miles removed. For the Las Vegas Valley, we include indicators for $MI2$ through $MI10$; the reference group consists of properties more than ten miles distant from the plant.

First, we note that the coefficients on $MI2$ are consistent across the eight regression results. Properties within two miles of the Pepcon plant are depressed 6.3% for the Las Vegas Valley

Table 3a. Regression results (dependent variable: log of real price): discrete distance specification.

	Las Vegas Valley	Las Vegas Valley	Henderson Green Valley	Henderson Green Valley	Henderson	Henderson	Green Valley	Green Valley
Log intercept	5.98[1]	5.97[1]	5.99[1]	5.98[1]	6.95[1]	6.93[1]	5.41[1]	5.43[1]
	117.25	116.85	91.20	90.20	60.32	60.13	63.07	62.35
AGE	-0.0151[1]	-0.0151[1]	-0.0013	-0.0012	-0.0088[1]	-0.0089[1]	0.0363[1]	0.0367[1]
	-27.17	-27.07	-1.08	-1.05	-8.32	-8.36	8.36	8.43
AGE^2	0.000162[1]	0.000161[1]	-0.000436[1]	-0.000435[1]	0.000046[1]	0.000049[2]	-0.006727[1]	-0.006817[1]
	11.15	11.09	-5.42	-5.41	1.93	2.04	-6.75	-6.83
AGE^3			7.31E-06[1]	7.92E-06[1]			0.00028[1]	0.00028[1]
			5.40	5.39			4.62	4.68
$\ln(L^2)$	0.1329[1]	0.1327[1]	0.1224[1]	0.1215[1]	0.1281[1]	0.1259[1]	0.1328[1]	0.1324[1]
	27.10	27.07	19.32	19.18	13.04	12.80	16.47	16.38
$\ln(B^2)$	0.5551[1]	0.5549[1]	0.5564[1]	0.5566[1]	0.3985[1]	0.3991[1]	0.6351[1]	0.6342[1]
	77.24	77.15	65.54	65.44	25.18	25.29	66.82	66.74
MONTH	0.0024[1]	0.0030[1]	0.0022[1]	0.0027[1]	0.0023[1]	0.0030[1]	0.0020[1]	0.0025[1]
	23.14	13.96	18.28	10.85	11.46	6.95	13.99	8.82
FP	0.0503[1]	0.0507[1]	0.0693[1]	0.0699[1]	0.0899[1]	0.0904[1]	0.0276[1]	0.0283[1]
	10.25	10.32	11.70	11.79	10.24	10.32	3.33	3.40
POOL	0.0746[1]	0.0745[1]	0.0618[1]	0.0616[1]	0.1105[1]	0.1113[1]	0.0398[1]	0.0401[1]
	17.03	17.04	12.26	12.24	9.64	9.71	7.78	7.87
MI2	-0.0649[1]	-0.0792[1]	-0.0649[1]	-0.0816[1]	-0.0627[1]	-0.0748[1]	-0.0675[1]	-0.0922[1]
	-11.38	-7.05	-12.41	-8.01	-5.91	-4.74	-12.39	-7.22
MI3	0.0497[1]	0.0629[1]	0.0494[1]	0.0651[1]	0.0161	0.0172	0.0608[1]	0.0915[1]
	8.84	6.18	9.60	7.07	1.65	1.16	10.90	8.31
MI4	0.0125	0.0167	0.0092	0.0147	-0.0445[1]	-0.0080	0.0136	-0.0075
	1.66	1.69	1.34	1.28	-3.19	-0.41	1.82	-0.55
MI5	0.0249	0.0252	0.0124	0.0128	0.0525[1]	0.0516[1]	-0.0792[2]	-0.0818[2]
	1.66	1.68	0.86	0.89	2.80	2.72	-2.15	-2.21
MI6	-0.0155	-0.0160						
	-0.69	-0.72						

Table 3a. Continued.

	Las Vegas Valley	Las Vegas Valley	Henderson Green Valley	Henderson Green Valley	Henderson	Henderson	Green Valley	Green Valley
MI7	0.0150	0.0153						
	0.68	0.70						
MI8	0.1121[1]	0.1120[1]						
	5.54	5.54						
MI9	0.0070	0.0076						
	0.42	0.45						
M10	-0.0747[1]	-0.0747[1]						
	-6.10	-6.11						
Z89014	-0.1083[1]	-0.1081[1]						
	-5.71	-5.71						
Z89015	-0.2307[1]	-0.2313[1]	-0.1524[1]	-0.1524[1]				
	-12.35	-12.38	-29.47	-29.41				
P		-0.0176		-0.0148		0.0527		-0.0780[2]
		-1.46		-0.57		1.14		-2.65
C		-0.0038		0.0037		-0.0394		0.0432
		-0.32		0.15		-0.87		1.53
PMI2		-0.0442		-0.0471		-0.0877		-0.0056
		-1.25		1.49		-1.60		-0.15
PMI3		0.0231		0.0147		-0.0223		0.0202
		0.78		0.55		-0.47		0.68
PMI4		-0.0131		-0.0141		-0.0641		0.0409
		-0.57		-0.45		-1.19		1.15
CMI2		0.0665		0.0725[2]		0.1144[2]		0.0383
		1.95		2.37		2.11		1.10
CMI3		-0.0433		-0.0382		0.0195		-0.0632[2]
		-1.52		-1.49		0.42		-2.23

Table 3a. Continued.

	Las Vegas Valley	Las Vegas Valley	Henderson Green Valley	Henderson Green Valley	Henderson	Henderson	Green Valley	Green Valley
CMI4		0.0064		0.0053		0.0081		−0.0138
		0.29		0.17		0.15		−0.40
Observations	7780	7780	4848	4848	1764	1764	3084	3084
Adjusted R^2	0.8009	0.8014	0.8310	0.8315	0.7345	0.7365	0.7945	0.7959
Durbin-Watson	1.87	1.88	1.88	1.95	1.93	1.93	1.92	1.93
Multiple F	1739.9[1]	1208.0[1]	1833.9[1]	1139.8[1]	444.4[1]	260.3[1]	994.2[1]	602.0[1]
F-to-include		3.05[1]		2.84[1]		2.64[1]		3.60[1]
SSE	164.5979	163.684	83.45809	82.51262	35.56699	35.13274	41.8905	41.33016

and the combined sample of Henderson and Green *before* the explosion. The consistency of this result is heartening, since the only properties within two miles of the Pepcon plant site are within Green Valley and Henderson. Prior to the explosion, Henderson properties prices were depressed by 6%, while Green Valley properties were depressed 6.5%. Introducing the event interaction terms consistently increases the coefficient on *MI2*, indicating that property values were depressed by a greater amount before the explosion then afterwards. Only in Green Valley was the coefficient on *P* significantly negative; in no case was the coefficient on *C* significantly positive.

The coefficient on *PM2*, while consistently negative, is never significant. The coefficient on *CM12* is significantly positive in the Henderson-Green Valley combined sample, and for Henderson.

The coefficient on *MI3* is consistently positive in all eight regressions, and consistently smaller than the coefficient on *MI2*. This implies that houses between 2.5 and 3.5 miles from the hazard typically sell for more than houses within 2.5 miles of the site. The sample of Green Valley properties shows coefficients equal in absolute value, indicating that the adverse effects of the hazard are neutralized at three miles. Henderson properties show only minor recovery at three miles and a significant decrease at four miles. Introduction of the indicators for the explosion and the relocation announcement render the coefficient on *MI4* insignificant. The coefficient on *MI5* is positive and significant for the Henderson sample, implying that the effect of the hazard was felt over a larger distance in Henderson than in the rest of the valley (effectively, Green Valley).

Table 4 presents evidence that the discontinuous distance specification is consistently better, as measured by the sum of the squared errors (SSE). The sum of the squared errors of the quadratic specification is broken down into two components, the sum of squared pure error (SSPE), which is equal to the sum of squared errors for the discontinuous specification, and the sum of squares due to lack of fit (SSLF), equal to the difference between the sum of squares of the two specifications. By construction, the discontinuous model will result in a smaller sum of squares, because the fit is not forced to follow a continuous curve. Because a set of discrete distance dummy variables is required, the question is whether the smaller sum of squares gained by the discontinuous specification is worth the loss of degrees of freedom. The mean squared errors due to lack of fit (MSLF) equal the SSLF divided by the difference in the number of regressors. This is then divided by the mean square pure error (MSPE) to yield the *F*-statistic. In each case, we reject the null hypothesis that the discontinuous specification is not superior to the continuous (quadratic) one.

8. Conclusion

The dramatic explosion of the Pepcon chemical plant in Henderson, Nevada, on May 4, 1988 and the announcement of the removal of the hazard on July 27, 1988 provide a unique opportunity to investigate the dynamic effect of a transient hazard on residential property values. This article has shown that, prior to the explosion, property values in both older Henderson (zip = 89015) and booming Green Valley (zip = 89014) varied significantly with distance from the hazard. After the explosion, property values became more sensitive (although insignificantly so) to the distance from the site of the explosion. This could be

Table 4. Lack of fit test: Quadratic vs. general surface estimate.

	Entire Sample		Henderson Green Valley		Henderson		Green Valley	
	Without Event Indicators	With Event Indicators	Without Event Indicators	With Event Indicators	Without Event Indicators	With Event Indicators	Without Event Indicators	With Event Indicators
	Quadratic Distance Specification							
SSE	164.5979	1673.6838	83.45809	82.51262	35.5699	35.13274	41.8905	41.33016
dfn	11	19	11	17	9	15	10	16
dfd	7768	7760	4846	4840	1754	1748	3083	3077
	Discontinuous Distance Specification							
SSE	160.6085	160.1045	80.55949	80.17327	35.16172	34.74175	39.41269	39.03247
dfn	18	26	13	21	11	19	12	20
dfd	7761	7761	4844	4836	1752	1744	3081	3073
MSLF	0.569914	0.511329	1.4493	0.584837	0.20409	0.097748	1.238905	0.574423
MSPE	0.020694	0.020629	0.016631	0.016578	0.020069	0.019921	0.012792	0.012702
F	27.53967	24.78644	87.14565	35.27702	10.16917	4.906824	96.84866	45.2239
Probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

explained by residents underestimating the probability of the hazard, or because of adverse selection: buyers might feel that property sold soon after the explosion had unrepaired damage. After the announcement that the plant was not to be rebuilt in southern Nevada, property prices in old Henderson and Green Valley became less sensitive to the distance from the remaining producer of ammonium perchlorate.

We contrasted a continuous and discontinuous specification of the relation between real housing prices and distance from the hazard and found the latter model to be consistently superior. The discontinuous model showed a suppression of housing prices within two miles of the hazard and was insensitive to the mean distance from the hazard in the sample. This is a feature not shared by the quadratic specification. We also found that property values were higher for properties between 2.5 and 3.5 miles of the hazard, relative to properties that are closer. Only in Henderson were property values depressed as far as 5.5 miles from the plant site. We highly recommend that future articles on the impact of hazardous locations on residential property values at least consider the discontinous specification attempted here.[21]

Most importantly, our results support the emerging consensus that real-estate markets are informationally efficient. There is clear evidence that home buyers discounted properties close to the hazard site *prior to* the explosion. Property values generally declined after the explosion, perhaps reflecting price concessions by sellers hoping to close in a market suddenly vulnerable to price renegotiation and higher search costs. After the announcement that one of the hazards would be relocated, rather than rebuilt, property values rebounded. So, even in a market where prices were contracted some time before the close of the deal, we have shown that such prices were sensitive to dramatic information about a hazard, in the form of an explosion, and to the reassurance that the hazard had been removed.

Notes

1. Ldn is a decibel measure whose weighting contains a penalty for nighttime noise.
2. Although exchange prices on a transaction day are generally set several weeks earlier, events such as the Pepcon explosion, which might have caused even superficial damage, will provide the buyer with an opportunity to force a renegotiation of price. For instance, buyers may refuse to close on the scheduled date without price concessions. Rather than voiding the sales contract and searching for a new buyer in a now troubled market, the seller may acquiesce to the lower price. Thus, although institutional rigidities should lead one to expect little price reaction within a day or so of the event, we nonetheless test the model as though the market were so efficient as to allow quick renegotation of contractually agreed-upon prices.
3. Even if homeowners feared personal injury, the greatest loss would be income loss, which would also be proportional to the value of the home.
4. A set of variables measuring the condition fo the housing market (varying monthly) were also tried. These variables included the log of the mortgage interest rate (*LMORT*), the change in the housing stock (*DH*), the county unemployment rate (*CCUE*), and the percent change in population (DPOP). Since these variables were uniformly insignificant, the results of the regressions are suppressed here, but will be provided upon request.
5. Several observations were dropped because the year sold preceded the year built (e.g., the owner built a custom home), so that the transfer price reflected only the price of the land, and not the structure.
6. An indicator variable for the presence of one or more fireplaces was used instead of the number of fireplaces, because the latter variable was more highly correlated with the size of the building.
7. The distance measure in feet was computed in feet by the Transportation Research Center at UNLV. Because of the proximity of the Pepcon plant to the Kerr-McGee plant, which also manufactures ammonium perchlorate (they are approximately 2/3 of a mile apart), the distance variable was divided by 5,280 feet and rounded to the nearest mile.

8. Taking the partial derivative of the equation with respect to d and setting the result equal to zero, we have: $\beta_8 + 2\beta_9 d = 0 \rightarrow d^* = -(\beta_8/2\beta_9)$.
9. It is typical in the literature for the efficient market hypothesis to be the *null* hypothesis. The investigator hypothesizes that current price cannot be predicted from past prices, then "proves" this hypothesis by showing the lack of a significant relation between current and past prices. Appropriate use of the scientific method requires that the hypothesis which one wishes to support should bear the burden of proof, and therefore should be the *alternative* hypothesis.
10. As explained below, we also estimate a model that uses dummy variables for discrete distances from the hazard. This model fit the data significantly better than the quadratic model discussed here. This finding has implications for future hazard models.
11. For very new homes, value may actually increase with age due to an adverse selection. Buyers would infer that resales of nearly new homes indicate a seller trying to unload a lemon. With time, the probability that defects had been repaired would increase and, accordingly, the house's value. For this reason, a cubic model of price and the age of the house was fit for Green Valley, whose median age at the time of sale was one year. We also employ a cubuc age specification for the combined sample of Green Valley and Henderson.
12. Actually, this is 2.5 miles, due to rounding.
13. The random sample was selected by picking sellers whose last names began with the letters A, B, and Ca.
14. *Metroscan* reports data on the most recent sale of each home in the data set. This rules out the investigation of repeat sales for the same property, so we are unable to investigate arbitrage activity on individual properties.
15. A *cubic* distance specification is a positive sign on miles (significant at 5% level), a negative sign on miles squared, (significant at .01 level), and a positive sign on distance cubed (also significant at the .01 level). This specification implies that property values increase up to 2.7 miles from the hazard, then decrease up to 12.3 miles, which is the approximate distance from the plant site to downtown Las Vegas, Nellis Air Force Base, and about one mile west of the Las Vegas Strip.
16. $\frac{\partial lP}{\partial d} = 0.0773 - 2(.0085)d = 0 \rightarrow d* = \frac{0.0773}{0.017} = 4.547.$
17. The same thing happens in the cubic distance specification.
18. There is a 36% probability that neither distance nor distance squared has any impact on real price on observations restricted to after the relocation announcement.
19. The F-statistic for inclusion of the set of interaction variables is significant at the 1% level for each sample. However, the F-statistic for Henderson is the smallest of the four samples.
20. Restricting the regression to the 101 observations on Green Valley when $P = 1$ yields the equation:

$$\frac{\partial lp}{\partial d} = .166 - .058d \rightarrow d* = \frac{.166}{0.058} = 2.86.$$

21. The only drawback to the discontinuous model is that it requires breaking distance into discrete units. It was natural for this study to specify distance in integer miles, given the proximity of a continuing hazard (the Kerr-McGee plant) and a transient one (the Pepcon plant). Other investigators may have to experiment with the optimal discrete distance units.

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