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Hazard Proximity or Risk Perception? Evaluating Effects of Natural and Technological Hazards on Housing Values

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Abstract

Despite the substantial literature on environmental hazards' effect on residential property value, the findings are inconsistent. Little attention has been given to the relationship between hazard proximity and risk perception and their distinct roles in affecting housing values. This research proposes a multistage causal model in which the influence of hazard proximity on property value is mediated by risk perception. The model was tested for three hazards (flood, hurricane, and toxic chemicals) using data from 321 households in Harris County, Texas. The results indicate that risk perception is a mediating factor between hazard proximity and property value, but there is some evidence that the mediation is partial rather than complete. Hazard proximity can be perceived as a potential risk and an environmental amenity at the same time for certain types of hazards. These two perceptions operate in opposite directions when affecting housing value. Implications for environmental hazards disclosure policies are discussed.

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Natural hazards such as floods and hurricanes cause enormous housing losses every year in the United States. Indeed, Hurricane Katrina alone damaged more than 300,000 housing units along the Gulf Coast region in 2005 (NLIHC, 2005). Technological hazards from polluting industries and toxic chemical sites also pose significant threats to the health and overall life quality of the residents in surrounding areas. The serious consequences of both natural and technological hazards have led to a series of consumer protection policies requiring disclosure of natural and technological hazards. For example, the National Flood Insurance Act of 1974 requires flood designation for all properties mortgaged through federally insured financial institutions. The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and the Pollution Prevention Act of 1990 makes disclosure of toxic chemical release locations mandatory for industrial facilities. In California, the Natural Hazard Disclosure Law (AB 1195) of 1998 requires disclosures of six types of natural hazards to property buyers. Along the coast of Texas, the state government has identified official risk areas that are susceptible to hurricane threat. The common assumption of these policies is that disclosing the geographic locations of hazards will increase people's risk perception (perceived personal risk) so they will take preventive measures to avoid risks. In the residential housing market, this means that residential properties in risk-prone areas would be less desirable and thus have lower values than equivalent units located elsewhere.

Hazardous area designation and disclosure policies have generated a considerable amount of research on the effects of natural and technological hazards on residential property value; such hazards include floods (e.g., Bin & Kruse, 2006; Eves, 2002; Harrison, Smersh & Schwartz, 2001; Shultz & Fridgen, 2001; Soule & Vaugha, 1973; Speyer & Ragas, 1991; Tobin & Montz, 1994), earthquakes (e.g., Beron, Murdoch, Thayer, & Vijverberg, 1997), hurricanes (e.g., Ewing, Kruse & Wang, 2007; Simmons, Kruse & Smith, 2002), nuclear wastes (e.g., Gawande & Jenkins-Smith, 2001), and toxic chemical releases (e.g., Adeola, 2000; Lee, Taylor & Hong, 2008). The findings, however, are not consistent. Many studies suggest that natural and technological hazards have a negative effect, but others suggest no effect, and still others suggest a positive effect on property value. One explanation for this inconsistency is that most research studies used property distance from hazard sources as the independent variable when evaluating hazard effects on property value. Much less attention has been given to the effect of prospective purchasers' perceived personal risk from these hazards. This is a critical relationship because it is the perceived personal risk, not the physical distance to the hazard source that affects the price people are willing to pay for a residence. There are many factors that can amplify or attenuate prospective purchasers' perceptions of the environmental risks associated with a given property (Kasperson et al., 1988; Lindell & Perry, 2004; Pidgeon, Kasperson, & Slovic, 2003).

Finally, most of the studies examining the effects of hazard proximity on property values examined only a single hazard. Little research has examined the effects of multiple hazards within a single study, which would test the generalizability of the findings across multiple natural and technological hazards and, moreover, assess the additivity of these effects.

To address these neglected issues, this article reviews previous research on hazard effects on residential property value and proposes a model that describes the causal relationship between hazard proximity and risk perception as well as its relationship to property value. Subsequent sections describe the sources of data collected in Harris County, Texas and procedures used to analyze these data. Finally, the last section examines the extent to which the results support the model and the practical implications for policy and theoretical implications for future research.

Literature Review and Conceptual Model

Residential properties are multidimensional commodities. When households choose among alternative residences, they not only compare housing structure characteristics, but also neighborhood quality, accessibility, and environmental amenities (Fujita, 1989). All these factors play a role when households decide how much to pay for a particular property (for a review, see Knaap, 1998). This implies that natural and technological hazards in the neighborhood could also influence residential property value. If environmental hazards are perceived as disamenities, property values in the proximity of hazard sources would be expected to be lower than those in the less vulnerable areas.

Effects of Environmental Hazards on Property Values

Researchers have examined the effect of flood hazards, both inland and coastal floods, on residential property values in many different areas across the United States and around the world. Most studies have reported that proximity to flood hazard has a significant negative effect on property value, indicating that properties susceptible to flood damage have lower values than equivalent ones located elsewhere. These findings imply that people perceive proximity to flood hazard as an environmental disamenity and thus demand discounted prices for properties vulnerable to flood threat. However, other studies found no significant differences between home values in and outside of flood zones (Babcock & Mitchell, 1980; Damianos & Shabman, 1979; Fried, Winter, & Gilless, 1999; Muckleston, 1983; Schaffer, 1990; Zimmerman, 1979). This latter finding suggests that the distance to flood hazards was considered as neither an amenity nor a disamenity when people purchased those properties. Finally, Shilling, Benjamin, and Sirmans (1985) and Montz (1993) found that prices of residential properties in flood risk areas were higher than prices of similar houses located elsewhere. This suggests that river proximity was perceived as environmental amenity, even though it was a source of flood hazard.

One likely explanation for these conflicting results is that the effect of proximity to flood hazard on property value is mediated by perceived personal risk of flooding, which refers to people's assessment of the likelihood that they will be personally affected by specific consequences such as death, injury, property damage, or disruption of daily activities (Lindell & Hwang, 2008). That is, proximity to flood hazard causes perceived personal risk, which in turn affects the price people are willing to pay for a residential property. The link between hazard proximity and perceived risk is imperfect because hazard prone areas can vary in the recency, frequency, and severity of the events they have experienced, all of which are characteristics that affect risk perception (Lindell & Perry, 2004). This reasoning explains why Graham and Hall's (2001, 2002) study of property values in the coastal region of North Carolina found an immediate decline in home sales prices with each successive hurricane. Similarly, Bin and Polasky (2004) found that whereas a house located within a floodplain had a lower market value than an equivalent house located outside the floodplain, the price discount for housing located within a floodplain was significantly larger after Hurricane Floyd than before.

Similarly, homeowners in hazard-prone areas can vary in the credibility of the information sources from which they have received risk information—authorities, news media, or peers (families, friends, neighbors, or coworkers; Arlikatti, Lindell, & Prater, 2007) as well as in their ability to interpret the risk messages they have received. For example, many people cannot accurately identify their home's location on a risk-area map (Arlikatti, Lindell, Prater & Zhang, 2006; Zhang, Prater & Lindell, 2004). Indeed, Troy and Romm (2004) found that flood zone designations were better disclosed under

California's Natural Hazard Disclosure Law of 1998 (AB 1195) than under the National Flood Insurance Program (NFIP), which was the primary policy regarding flood disclosure in California prior to passage of AB 1195. Consequently, the magnitude of housing price reductions in flood hazard areas increased after AB 1195 was implemented.

Another reason for the inconsistent relationship between hazard proximity and property values is that the causal path from hazard proximity to property values via risk perception can be offset by another causal path from hazard proximity to property values via environmental amenities. That is, proximity to rivers and coastlines can provide ready access to recreational opportunities and the aesthetic value of riverfront or coastal views. There is evidence that such amenities can be capitalized in property values. For example, Smith and Palmquist (1994) found that ocean-front properties along the outer banks of North Carolina had significant higher rental prices than other properties, especially during the peak season when people can enjoy more outdoor ocean-front recreational activities.

Inconsistent results are not limited to research on the effects of flood hazards on property values. Research on the effects of hazardous materials proximity on property value has examined radiological risk (Gamble & Downing, 1982; Gamble, Downing & Sauerlender 1978; Gawande & Jenkins-Smith, 2001; Metz & Clark, 1997; Nelson, 1981), noxious facilities (Clark & Nieves, 1994; Dale, Murdoch, Thayer, & Waddell, 1999; Folland & Hough, 1991; Lee et al. 2008; McClelland, Schulze, & Hurd, 1990; McCluskey & Rausser, 2001), fuel pipelines (Broxall, Chan, & McMillan, 2005; Hansen, Benson, & Hagen 2006), air pollution (Freeman, 1979; Harrison & Rubinfeld, 1978; Nelson 1978), and water contamination (Leggett & Bockstael, 2000; Page & Robinowitz, 1993). Although most studies found negative correlations between property value and proximity to hazardous materials, some reported no relationship. Gamble et al. (1978), Gamble and Downing (1982), and Nelson (1981) studied housing prices in areas surrounding the Three Mile Island nuclear power plant and concluded that distance to the plant was unrelated to home sale prices. Similarly, Metz and Clark (1997) studied two nuclear power facilities in California and found no evidence that property values were influenced by their proximity to the plants.

As is the case with proximity to flood hazard, the conflicting results might be attributable to the mediating effects of risk perception in the causal chain between proximity to hazardous materials and property value. It is notable that chemical facilities display daily perceptual cues of risk such as odors, noise, and visible polluting fumes (Preston, Taylor & Hedge, 1983). In addition, it has been shown that residents who were exposed to toxic chemical facilities were likely to develop psychological illnesses as well as physical health problems (Bevc, Marshall & Picou, 2007). Both the chronic annoyances and reported health problems in the vicinity of chemical facilities would reinforce people's perceived personal risk associated with hazardous materials. As a result, increasing concerns over the adverse consequences of living close to toxic chemicals would be expected to depress property values in the area. McClelland, et al. (1990), Gawande and Jenkins-Smith (2001), and McCluskey and Rausser (2001), all reported that intense media coverage of health problems associated with toxic chemical releases raised residents' risk perceptions. The heightened risk perception, in turn, caused significant property value reduction in the vicinity of noxious facilities. However, proximity to potential toxic risk does not always elicit high risk perception if it is not paired with undesirable environmental cues (e.g. noise, smoke, odor), adverse experiences, or other conditions (e.g. media coverage). For instance, Hansen et al. (2006) estimated the effect of a fuel pipeline on property values. They found no significant differences in housing prices regarding properties' proximity to the pipeline. After an accident, however, property values dropped sharply in the neighborhoods close to the pipeline. This study also reported that property value reduction diminished with increasing distance from the pipeline. These findings imply that the accident changed people's risk perception, which in turn drove down property values. On rare occasions, proximity to chemical facilities can be perceived as desirable, especially for those who work there (Napton & Day, 1992), but this would not likely be the case for the rest of the population.

Conceptual Model: Hazard Proximity, Risk Perception, and Property Value

As the literature review suggested, despite substantial research on natural and technological hazard effects on housing values, the findings were very inconsistent. Most studies treated hazard proximity as a direct influence on housing values, but there was evidence that the effect of hazard proximity is mediated by perceived personal risk. Nonetheless, the foregoing discussion of the literature leads to a hypothetical conceptual model (Figure 1), which depicts the causal relationship between hazard proximity, risk perception, and housing value. In the model, the effect of hazard proximity on housing value is mediated by perceived personal risk. This mediation implies two conditions. First, hazard proximity should be significantly related to risk perception. Second, mediation also implies a direct effect of risk perception on property value.

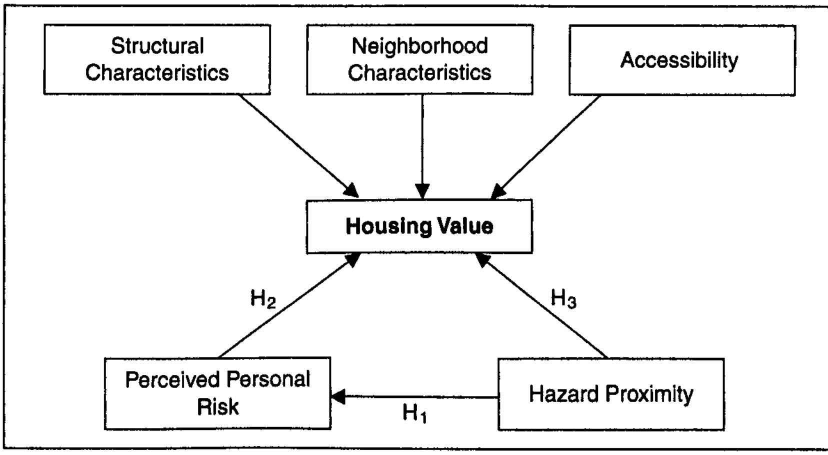

Figure 1. Hypothesized Model Between Hazard Proximity, Risk Perception, and Housing Value
Note: The path is identified by the number of the hypothesis with which it is associated.

Hypothesis 1: Risk perception of environmental (flood, hurricane, and toxic chemicals) hazards will be positively related to hazard proximity.

Hypothesis 2: Risk perception of environmental (flood, hurricane, and toxic chemicals) hazard will have a negative effect on housing value.

As noted previously, it is possible that this mediation is partial rather than complete because proximity to rivers and the coast (i.e., hurricane risk) can provide amenity in the form of access to recreational opportunities. However, the mediation of risk perception is expected to be complete for toxic chemicals facilities because an amenity effect would not be expected for these hazard sources.

Hypothesis 3a: Proximity to flood hazard and hurricane hazard will have a direct positive effect on housing value that is independent of risk perception.

Hypothesis 3b: Proximity to toxic chemical facilities will have no direct effect on housing value that is independent of risk perception.

As suggested in the residential property value literature (for a review, see Knaap, 1998), housing structural characteristics (e.g., size, number of bedrooms, number of bathrooms), neighborhood contextual variables (e.g., household income, demographic composition), and accessibility to public facilities (e.g., airports, central business district, municipal parks) are all important determinants of property value. These three groups of factors are also included in the model and serve as control variables in the analysis.

Method

Data

The hypotheses were tested using data from Harris County, Texas, which is located in a low-lying coastal area exposed to hurricanes and floods. Moreover, there are also hundreds of petrochemical manufacturing and distribution facilities across the county that pose toxic chemical hazards. Data were collected from five sources, the first of which was geographic data on households' proximity to floods, hurricanes, and toxic chemical releases. The second data source was a mail survey on households' perceived personal risks of flood, hurricane, and toxic chemical hazards. The third source was 2000 US Census data on neighborhood income level and demographic composition. The fourth source was Harris County tax appraisal data on property values in 2002 and building structural characteristics. The fifth and final source was geographic data on households' accessibility to the George Bush International Airport, Houston central business district, and parks.

Sample

Data were collected from owner-occupied single-family dwellings in Harris County. The sample was restricted to owner-occupied dwellings because housing is the biggest investment made by most households. Consequently, homeowners are likely to be sensitive to surrounding environmental risks when they decide where to purchase homes. To randomly sample the required number of households, a sample frame was constructed by obtaining a countywide list of single-family residential property records from the Harris County Appraisal District. Stratified random sampling was employed to select households from the sample frame. Four stratification variables were defined by the three environmental hazards (flood, hurricane, and chemical releases) and a low-risk area. Two hundred households were selected that were vulnerable to each hazard. In the cases selected for flood hazard, the Federal Emergency Management Agency flood insurance rate map for Harris County was used to randomly select 100 households within the 100-year

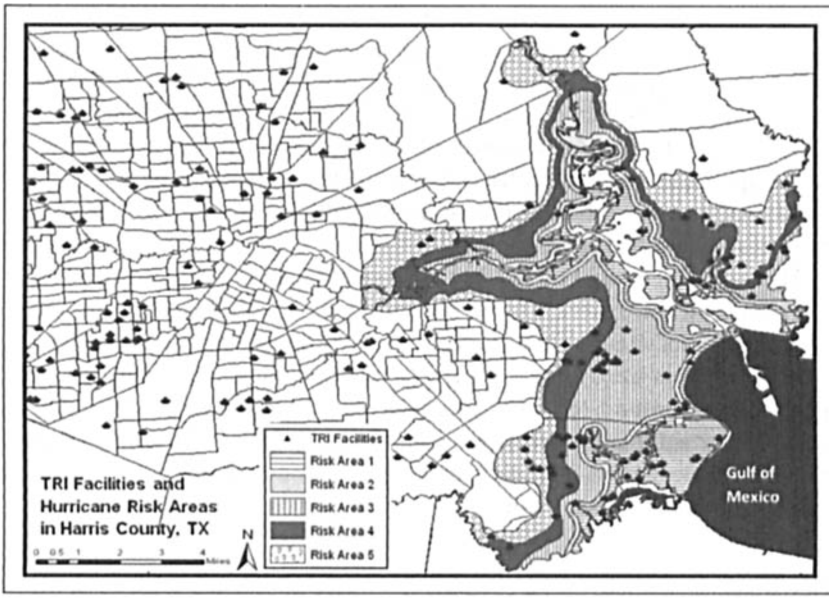

Figure 2. Map of the Five Hurricane Risk Areas and TRI Facilities

flood plain and 100 households in the 500-year flood plain. In the cases selected for hurricane hazard, 40 cases were selected from households located in each of the five hurricane-risk areas defined by the Texas Governor's Division of Emergency Management (see Preparedness and Planning at www.txdps.state.tx.us/dem). In the cases selected for chemical hazard, 40 cases were randomly selected at increments of 0.5 mile from 0 to 2.5 miles from the nearest hazardous material facility (see Figure 2). The remaining 200 households were randomly selected from outside the areas defined by these three environmental hazards (the low-risk areas).

In Fall 2002, a mail survey was conducted following Dillman's (1999) procedures. An initial packet containing a cover letter, a questionnaire, and a prestamped return envelope was sent to the 800 selected households. A reminder postcard was sent to each household after 1 week; those who did not return a questionnaire within 2 weeks were sent a second packet. The third packet was sent to nonrespondents 1 month after the second packet. A total of 321 out of the 800 single-family homeowners returned questionnaires for a gross response rate of 40.1%. One household was no longer at its original address and two households lived outside the study area. These three households were not replaced, yielding an adjusted response rate of 40.4%. This is a relatively typical response rate compared to other mail surveys of environmental hazards (Lindell & Prater, 2000; Mileti & Fitzpatrick, 1992). Moreover, recent research by Curtin, Presser, and Singer (2000) and Keeter, Miller, Kohut, Groves, and Presser (2000) reported that low response rates do not appear to bias central tendency estimates such as means and proportions. Furthermore, Newman (2008) explained how low response rates will not necessarily affect correlations.

The respondents slightly overrepresented older, married, highly educated, and higher-income males but are not substantially different from the 2000 Census data for Harris County. Moreover, although the sample does not exactly represent the county's general population, the degree to which sample means and proportions are representative of the Harris County population is less important than that there is enough demographic diversity to provide an adequate test of the relationships in the proposed causal model (see Lindell, 2008, for a discussion of sample credibility).

Measures

Table 1 provides a list of variables and their measures. Property value was measured using the appraised market value for 2002 obtained from the Harris County Appraisal District, which estimates market values of all residential properties annually based on the selling price of comparable units. The Texas property tax code also has an appeal and adjustment process if homeowners believe there is a discrepancy between the appraised value and the actual condition of the house. Therefore, the tax-based market value provides a good approximation of the price that survey respondents were willing to pay for their homes.

Measurement of proximity to hazard sources began with a geographic information system (GIS)–based parcel map that identified each household's latitude/longitude coordinates. Next, the analyst overlaid locations of rivers and streams to identify inland (freshwater) flood sources, the shoreline of Galveston Bay to identify hurricane source, and Toxic Release Inventory facility locations to identify sources of chronic low-level emissions and potentially catastrophic toxic chemical releases (www.epa.gov/tri/index.htm). GIS was used to calculate the distance from each household to the nearest flood, hurricane, and chemical hazard source. These horizontal distances are satisfactory measures of flood and hurricane exposure because the coast is extremely flat in this part of Texas. Consequently, risk-area boundaries are nearly parallel to the water bodies. As a result, these distances are better

Table 1. List of Variables and Descriptions

Concept	Variable	Description	Data Source
Housing price	Housing price	Assessed home value (dollars)	Harris county property tax appraisal office
Structural characteristics	Home age	Home age in years	Same as above
	Living area	Living area square footage	Same as above
	Fire place	Number of fire places	Same as above
	Bedroom	Number of bedrooms	Same as above
	Bathroom	Number of bathrooms (half bath is counted as 0.5 bathroom)	Same as above
Accessibility characteristics	Distance to airport	Distance to the George Bush International Airport (mile)	Generated in GIS
	Distance to CBD	Distance to Houston CBD (mile)	Generated in GIS
	Distance to park	Distance to the nearest park (mile)	Generated in GIS
Neighborhood characteristics	Household income	Median household income (thousand dollars)	2000 Census SF3
	Percentage White	Percentage of White	2000 Census SF3
Hazard proximity	Flood risk	Distance to rivers (mile)	Generated in GIS
	Hurricane risk	Distance to Galveston Bay (mile)	Generated in GIS
	Hazardous materials risk	Distance to the EPA TRI sites (mile)	U.S. EPA,
Risk perception	Flood risk perception	Perceived threats of floods	Survey
	Hurricane risk perception	Perceived threats of hurricane	Survey
	Hazardous materials risk perception	Perceived threats of hazardous materials	Survey

measures than risk areas for two reasons. First, using distances for flood and hurricane risk makes them more compatible with the measure for chemical risk. Second, using a continuous variable (distance) is psychometrically superior to using a coarsely categorized discrete transformation of that variable (five categories for hurricane risk and three categories for flood risk).

The mail survey data included respondents' self-reports of their perceived risks associated with floods, hurricane, and chemical materials. Respondents were asked to indicate their perceived risk by judging the likelihood of three types of consequences—major damage to their homes, injury to themselves or members of their household, and health problems to themselves or family members—for each type of hazard within the next 10 years. This operationalization is consistent with previous studies on seismic hazard perception (see Lindell & Perry, 2000; Lindell & Prater, 2000) and toxic chemical risk perception (Gawande & Jenkins-Smith, 2001; McClelland et al. 1990). The response scale for the perceived personal risk items was anchored by 1 to 5 scale (1 = *not at all likely* to 5 = *almost a certainty*). The reliabilities of the perceived personal risk scales were $\alpha = 0.83$, 0.84, and 0.94, for flood, hurricane, and toxic chemical hazards, respectively.

The tax appraisal data provided structural characteristics of single-family homes. This information included home age, living area, and the number of fireplaces, bedrooms, and bathrooms. Consistent with previous studies (e.g., Ding & Knaap, 2003), a half bath is considered as 0.5 when counting the total number of bathrooms. The accessibility characteristics of each home was derived by overlaying its longitude and latitude coordinates on the location of the George Bush International Airport, the Houston central business district, and parks and open spaces in Harris County. The GIS was then used to calculate the Euclidean distances from each property to the airport, to the CBD, and to the nearest park. The measurements of the neighborhood contextual characteristics used information provided in the Summary File 3 of the 2000 Census. Median household income and percentage of White were extracted for each census block group in the study area.

Analytical Procedure

Hedonic regression analysis (Griliches, 1971; Quigley & Kain, 1970; Rosen, 1974) with a semilog function form was used to test the hypotheses. The regression model can be expressed as

$$Ln\ V_i = \beta_0 + \beta_1 S_i + \beta_2 N_i + \beta_3 A_i + \beta_4 R_i + \beta_5 P_i + e_i,$$

where V_i is the value of house i (i = 1 to 321). Accordingly, S_i is a vector of house i's structural characteristics, N_i is a vector of neighborhood characteristics, A_i is a vector of accessibility characteristics, R_i is a vector of hazard proximities, P_i is a vector of risk perceptions, β_0 to β_5 are regression coefficients, and e_i is the regression error term. A log transformation of the dependent variable was chosen because of positive skew in the raw distribution of property value data. This choice of a semilog regression function form was confirmed by a maximum likelihood Box–Cox transformation on housing value. One added benefit of the semilog function form is that the estimated coefficients represent the semielasticities, indicating the percentage change in home value because of a unit change in an explanatory variable. To determine the model specification, regressions were initially run using more independent variables than what is reported below—lot size, accessibility to golf courses, schools, hospitals, neighborhood homeownership ratio, and vacancy rate. However, these variables were all dropped from the final analysis because they were nonsignificant and did not influence the estimated coefficients of the hazard proximity and risk perception variables. Because the inclusion of both household-level variables and neighborhood-level variables in a single model introduces heteroskedasiticity, ordinary least squares (OLS) estimation with robust standard errors was applied to ease its threat to the validity of the statistical inference (Wooldrige, 2008).

The procedures for testing the hypothesized mediating effect of risk perception required a hierarchical entry for the blocks of independent variables (Lindell, 2008; Newton & Rudestam, 1999; Shrout & Bolger, 2002). The analysis began by entering only the block of structural characteristics, neighborhood characteristics, and accessibility characteristics. In successive blocks, risk perception of each hazard was added to the model, followed by the inclusion of hazard proximity. If the mediating effect was complete, we would expect that hazard proximity would not have a significant effect on property value when the corresponding risk perception variable was included in the model.

Results

Table 2 presents the intercorrelations needed to test the relationship between risk perception and hazard proximity (Hypothesis 1). Consistent with the hypothesis, perceived personal risk of flood, hurricane, and toxic chemicals hazards had a significantly negative relationship with distance to (i.e., a positive relationship with proximity to) hazard sources. Specifically, correlation coefficients were –.11 for distance to flood and flood risk perception and –.21 for distance to hurricane and toxic chemicals and the corresponding risk perception. These significant correlations support the convergent validity of hazard proximity and perceived personal risk variables (Campbell & Fiske,

Table 2. Means (*M*), Standard Deviations (*SD*), And Intercorrelations (R_{ij}) Among Variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Housing value	136655	99038																
2. Home age	24.72	16.80	−.46*															
3. Living area	2116.8	827.6	.79*	−.49*														
4. Fire place	0.73	0.50	.40*	−.51*	.49*													
5. Bedrooms	3.38	0.71	.41*	−.35*	.68*	.33*												
6. Bathrooms	2.17	0.72	.68*	−.54*	.80*	.53*	.65*											
7. Airport distance	14.23	5.78	.11*	−.22*	.17*	.26*	.10*	.14*										
8. CBD distance	16.77	6.34	−.04	−.32*	.22*	.40*	.22*	.22*	.49*									
9. Park distance	1.26	0.99	.04	−.41*	.20*	.33*	.21*	.20*	.45*	.42*								
10. HH income	62.85	26.99	.65*	−.45*	.61*	.46*	.45*	.55*	.18*	.23*	.22*							
11. Percentage White	71.97	24.12	.37*	−.24*	.35*	.33*	.20*	.30*	.21*	.46*	.15*	.54*						
12. Flood risk	0.46	0.39	.15*	−.12*	.03	−.04	−.03	−.00	.03	−.13*	.10*	.11*	.02					
13. Hurricane risk	9.37	8.12	.08*	−.35*	.16*	.27*	.20*	.18*	.39*	.21*	.54*	.23*	.04	.10*				
14. Hazardous material risk	2.26	1.41	.20*	−.28*	.33	.28*	.24*	.30*	.02*	.39*	.18*	.23*	.25*	.04	.41*			
15. Flood risk perception	2.22	0.94	−.21*	.11*	−.15*	−.18*	−.06*	−.16*	−.12*	−.08	.03	−.16*	−.13*	−.11*	−.09	−.12*		
16. Hurricane risk perception	2.53	0.91	−.19*	.14*	−.16*	−.18*	−.11*	−.18*	−.18*	−.08	−.13*	−.15*	−.08	−.10	−.21*	−.17*	.69*	
17. Hazardous mat. perception	2.25	1.07	−.20*	.13*	−.20*	−.16*	−.12*	−.15*	−.12*	−.04	−.08	−.15*	−.14*	−.10	−.18*	−.21*	.47*	.54*

Note: *significant at 5% level. $N = 321$.

1959). However, the correlations on the validity diagonal (average $r = -.18$) were not much larger than the off-diagonal correlations that measured the association between risk perception of one hazard (e.g., toxic chemicals) with proximities to other two hazards (e.g., hurricane and flood; average $r = -.15$). Therefore, there is only weak evidence supporting the discriminant validity of hazard proximity and risk perception measures.

Although not predicted by H1, perceived personal risk variables of flood, hurricane, and toxic chemicals hazards were significantly related to each other. In particular, flood risk perception had correlations of .69 with perceived hurricane risk and .47 with perceived toxic chemicals risk. The latter two had a correlation of .54. However, the correlations among the hazard proximities were not as nearly as strong. Proximity to hurricane hazard had a significantly positive relationship with proximity to toxic chemicals hazard (r =.41), but proximity to flood was not correlated with proximity to hurricane and toxic chemical hazards.

Following the procedures described previously for testing the mediating effect of risk perception, a base regression model predicting logged housing value was run using structural characteristics, accessibility measures, and neighborhood contextual variables (Table 3, Model I), after which each individual risk perception measure for flood, hurricane, and toxic chemicals hazards was added to the regression, followed by the corresponding hazard proximity variable. Model I accounts for a substantial amount of the variance in housing value (adjusted $R^2 = .835$), indicating that structural variables, accessibility measures, and neighborhood contextual variables are important factors in determining housing value. Consistent with Hypothesis 2, flood risk perception had a negative effect on housing value. One unit increase in the risk perception scale (1 to 5) represented a 3.3% drop in housing value, holding all else constant (Table 3, Model II). Similarly, hurricane risk perception and toxic chemicals risk perception also showed negative effects (therefore, support Hypothesis 2). With a unit increase in the risk perception scale, housing value reduced by 3.1% (Table 3, Model IV) and 3.7% (Table 3, Model VI), respectively. However, comparing to Model I, the addition of risk perception variables accounts for only a small increment of the variance in property value (Model II adjusted $R^2 =$ .836, $\Delta R^2 = .001$; Model IV adjusted $R^2 = .837$, $\Delta R^2 = .002$; Model VI $R^2 =$ .839, $\Delta R^2 = .004$).

The data failed to support Hypothesis 3a because, although proximity to flood hazard did have a direct effect on housing value, the obtained relationship was in the opposite direction of the prediction. The regression analysis showed that every mile away from the flood hazard, housing value would

Table 3. Regression Results

Concept	Variable	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII
Structural characteristics	Home age	−.008***	−.008***	−.008***	−.008***	−.008***	−.008***	−.008***	−.008***
	Living area	.038***	.038***	.038***	.038***	.038***	.000***	.000***	.038***
	Fire place	.114***	.109***	.117***	.110***	.111***	.107***	.107***	.117***
	Bedroom	−.032	−.030	−.027	−.031	−.029	−.033	−.031	−.019
	Bathroom	.101***	.099***	.103***	.096***	.095***	.104***	.103***	.099***
Accessibility characteristics	Distance to airport	.010***	.010***	.009***	.009***	.010***	.009***	.011***	.013***
	Distance to CBD	−.029***	−.029***	−.027***	−.028***	−.029***	−.028***	−.030***	−.031***
	Distance to park	−.041**	−.038**	−.042***	−.042**	−.037**	−.041**	−.043**	−.030
Neighborhood characteristics	Household income	.003***	.003***	.003***	.003***	.003***	.003***	.003***	.003***
	Percentage White	.007***	.007***	.007***	.007***	.007***	.007***	.007***	.007***
Risk perception	Flood risk perception		−.033***	−.030***					
	Hurricane risk perception				−.031**	−.032**			
	Haz materials risk perception						−.037***	−.032**	
	Risk perception								−.036**
Hazard proximity	Flood risk			.080**					.068*
	Hurricane risk					−.002			−.005*
	Hazardous materials risk							.022*	.034**
Adj. R^2		0.835	0.836	0.840	0.837	0.837	0.839	0.841	0.845
F (df_N, df_D)		157.2 $_{(10,310)}$	143.5 $_{(11,309)}$	134.7 $_{(12,308)}$	144.3 $_{(11,309)}$	131.9 $_{(12,308)}$	146.1 $_{(11,309)}$	135.3 $_{(12,308)}$	118.9 $_{(14,306)}$

Note: $N = 321$.
*significant at 10% level, **significant at 5% level, ***significant at 1% level.

increase by 8.0% (Table 3, Model III). Therefore, proximity to flood maintained a direct negative effect on housing value even after controlling the mediation of flood risk perception. Moreover, distance to hurricane hazard showed a direct negative effect (i.e., proximity to hurricane hazard had a positive effect) on housing value, net of hurricane risk perception (Table 3, Model V). But the regression coefficient was not significant even at a .10 level. The data failed to support Hypothesis 3b as well, which expects that proximity to toxic chemical facilities have no direct effect on property value that is independent of risk perception. The regression showed that distance to toxic chemicals hazard had a direct significant positive effect (i.e., proximity to toxic chemicals hazard had a direct negative effect) on housing value, even after controlling the mediation of risk perception (Table 3, Model VII). When distance from toxic chemical facilities increased 1 mile, housing value increased by 2.2%. It should also be noted that, comparing to Model I, the addition of both hazard proximity and risk perception measures only accounted for a marginal increment of the variance in property value (Model III adjusted R^2 = .840, ΔR^2 = .005; Model V adjusted R^2 = .837, ΔR^2 = .002; Model VII adjusted R^2 = .841, ΔR^2 = .006).

As discussed earlier, three risk perception measures were highly correlated and had only weak discriminant validity. We made a minor respecification of the regression model to assess the stability of the support for Hypotheses 2 and 3. A composite risk perception variable was constructed by averaging three individual measures and was included in a full model (Table 3, Model VIII), which also used hazard proximities to flood, hurricane, and toxic chemical hazards. As Model VIII indicates, the coefficients for the structural, neighborhood, and accessibility variables retained similar values and an identical pattern of statistical significance (compared to Models II to VII). Similarly, the coefficient for the overall risk perception is quite similar to the coefficients for the three hazards. Therefore, the supporting evidence for Hypothesis 2 is consistent; that is, risk perception has a negative effect on housing value. With every unit increase in the overall risk perception scale (1 to 5), housing value would drop by 3.6%. The direct positive effects of distance to flood and toxic chemicals hazards still remained (i.e., contrary to Hypotheses 3a and 3b) when controlling perceived personal risk. However, distance to hurricane hazards started to show a significant, direct, negative effect (i.e., proximity to hurricane had a positive effect) on housing value, independent of risk perception. This finding is in agreement with Hypothesis 3a. Thus, the evidence against Hypothesis 3a should be classified as weak, whereas the evidence against Hypothesis 3b are consistent.

Discussion

The data reported here substantially support the hypothesized model. Nonetheless, there were important deficiencies in the measurements because three perceived personal risk variables seem to have poor discriminant validity. Moreover, there were deficiencies in the causal chain because some of the expected paths were not statistically significant or even performed in opposite directions.

More specifically, there was significant support for Hypothesis 1 because perceived personal risk for flood, hurricane, and toxic chemicals hazards was positively correlated with proximity to the corresponding hazard. This is important because it indicates that residents in hazard-prone areas could personalize the potential threats associated with living close to natural and technological hazards. The apparent lack of discriminant validity among the three perceived personal risk measures appears to be due, in part, to correlations among the proximity to hazards variables, especially the correlation ($r = .41$) between proximity to hurricane hazard and proximity to toxic chemical facilities. That is, the correlation between perceived personal risk for chemicals and personal risk for hurricane ($r = .54$) might be nothing more than the effect of the proximity of chemical facilities to Galveston Bay.

Although the correlations between the risk perception measures can be partially attributed to hazard proximity, this explanation cannot account for the fact that the correlations between perceived risk measures (average $r = .57$) were considerably larger than correlations between hazard proximities (average $r = .18$). In particular, the correlation between perceived flood risk and perceived hurricane risk was .69, whereas the correlation between the corresponding hazard proximity measures was only .10. Similarly, perceived flood risk had a strong correlation with perceived toxic chemicals risk ($r = .47$), but the corresponding proximity measures were just barely correlated ($r = .04$). One possible explanation is the general psychological tendency for people either to be concerned about all environmental hazards or concerned with none of them (Lindell, 1994). In addition, it is possible that perceived personal risk is related to factors other than hazard proximity. Proximity to hazard sources may lead to more perceptual cues of danger (e.g., odors, noise, and visible pollution from the chemical facilities) and more personal experiences with hazard events, which in turn raise residents' risk perception. However, there is considerable evidence that perceived personal risk is also related to hazard information sources (i.e., authority types, news media; for a review, see Lindell & Perry, 2004), institutional trust (Weyman, Pidgeon, Walls, & Horlick-Jones, 2006), and risk information dissemination methods

(Arlikatti et al. 2006; Troy & Romm, 2004; Zhang, Lindell & Prater, 2004). For example, Troy and Romm (2004) reported that the 1998 California Natural Hazard Disclosure Law (AB 1195) required a more rigorous hazard disclosure approach than the National Flood Insurance Program (NFIP). AB 1195 demanded that property sellers present a hazard disclosure statement to prospective buyers prior to closing. Moreover, it granted a 3-day rescission period during which buyers can terminate a signed contract if proper disclosure is not made. As a result, residents were better informed of flood hazard than they previously were under the NFIP.

Consistent with Hypothesis 2, perceived personal risk for flood, hurricane, and toxic chemical hazards has a significant negative effect on property value. This finding indicates that when people perceive environmental hazards as threats to their property and personal safety, they are willing to pay more for a house located elsewhere than for a similar property in hazard-prone areas. In other words, properties in vulnerable areas receive lower prices to offset potential losses associated with environmental hazards. Moreover, a one-unit increase in the (5 point) flood risk perception scale corresponds to a 3.3% drop in property value, holding all else constant (Table 3, Model II). For the average home in this sample, this represents a decrease of $4509.62. Similarly, a one-unit increase in the hurricane risk perception scale reduces property value by 3.1% (Table 3, Model IV)—$4236.31 for the average home. Finally, a one-unit increase in the toxic chemical risk perception scale reduces property value by 3.7% (Table 3, Model VI)—$5056.24 for the average home.

The findings regarding the direct negative effect of proximity to flood hazard and toxic chemical facilities on housing value were surprising because any environmental disamenity associated with these hazards was expected to be mediated by the corresponding risk perception measure. One plausible explanation is that there might be some important components of perceived personal risk that are not being measured by personal consequences (i.e., property damage, personal injury, health problems) listed in the questionnaire but, nonetheless, mediate the relationship between hazard proximity and housing value. Possible additions include institutional trust (Weyman et al. 2006), outrage factors (Sandman et al. 1993), and other personal consequences of hazard impacts such as psychological stress (Lindell & Prater 2000). Another possible explanation for the direct negative effect of hazard proximity to flood and toxic chemical facilities is that there might be some (unmeasured) variables other than perceived personal risk that also mediate the relationship between hazard proximity and housing value. In other words, people might differentiate environmental risk from other environmental disamenities associated with being adjacent to streams and chemical plants. For example, it is conceivable that some people consider noise coming out of a plant as an annoyance, therefore, a disamenity, but not necessarily perceive it as a risk that can result in adverse personal health consequences. In fact, many rivers and streams in the study area are relatively small, slow moving, turbid, and (in some places) industrialized—thus providing more of a disamenity, but less of an amenity than would ordinarily be associated with river proximity. Obviously, further research is needed to confirm these possibilities.

There is weak support for the proposition that proximity to coastal line (i.e., hurricane hazard) has a direct positive effect on housing value. An insignificant regression coefficient was found in Model V, but a significant coefficient was found in Model VIII. This might be due to an unexpected characteristics of this geographic area. Table 2 shows that coastal distance and park distance were strongly correlated ($r = .54$). Thus, the hypothesized amenity value of coastal proximity is likely to have been captured by park proximity. This seems likely because a coastal amenity effect would be consistent with a previous finding that coastal properties demand higher prices than equivalent units elsewhere because of ready access to recreational opportunities (Smith & Palmquist, 1994). In addition, coastal proximity and toxic chemical proximity are also strongly correlated ($r = .41$), which would depress the amenity value of coastal proximity.

Nevertheless, the significant evidence supporting hurricane risk perception's negative effect on housing value (Hypothesis 2) and the weak evidence supporting costal proximity's direct positive effect on housing value confirmed, to a certain extent, the idea that distance to hurricane hazard can be interpreted in both ways, either as a potential danger or as an amenity. Thus, the net effect of proximity to hurricane hazard on housing value is determined by a combination of these two competing factors. If perceived personal risk outweighs perceived amenity, one would expect a net negative effect and vice versa.

Finally, the analysis proved that risk perception is a mediating factor between hazard proximity and housing value. When residents in vulnerable areas of natural and technological hazards translate the distance to hazard sources to perceived personal risk, their willingness to pay for residential properties in hazard-prone areas will decrease. Therefore, housing value in proximities of hazard sources will be lower than the value of similar properties elsewhere. However, the analysis also suggested that the effect of distance to hazard sources on housing value could also be mediated by an unmeasured perceived amenity variable (i.e., Hypothesis 3a, hurricane hazard). That is, proximity to a hazard source is considered as a desirable feature for which people are willing to pay more. The opposite perceptions of proximity to a hazard source provide an explanation for the conflicting results reported in the literature. The reported negative effect of hazard proximity on housing value (e.g., Shilling et al., 1985) might be a result of risk perception outweighing perceived amenity. Similarly, the finding of a positive effect of hazard proximity (e.g., Montz, 1993) might be attributed to perceived amenity being greater than perceived risk.

This research has some of the same limitations as other studies on environmental behavior (Brunting & Guelke, 1979). First, the study is cross-sectional, so the temporal ordering of the antecedents and response variables cannot be verified with certainty. This makes it difficult to determine whether perceived personal risk of flood, hurricane, and toxic chemicals hazards might have changed after respondents bought their current residence (Lindell & Hwang, 2008). In addition, the study is nonexperimental (i.e., households were not randomly assigned to hazard proximity), so the omission of other important causal variables could have biased the regression estimates (Lindell, 2008).

Furthermore, there are questions that arise from the measurement of perceived personal risk. The results revealed that the three risk perception variables were highly correlated and had only weak discriminant validity that made it difficult to distinguish the direct effect of perceived personal risk of one hazard from the effect due to its covariations with the other two risk perception variables. Moreover, the findings on the direct negative effect of proximity to flood and toxic chemical facilities and net of perceived personal risk raise the possibility that there might be components of risk perception not measured in this study that also mediate the relationship. It is also plausible that respondents differentiated risk perception from an unmeasured perceived disamenity variable that accounted for the remaining direct effect of hazard proximity. Of course, further research is needed to test these propositions.

Conclusion

Despite the substantial amount of literature on environmental hazards' effect on residential property value, the findings are inconsistent. Most studies have considered properties' hazard proximity (distance to hazard sources) as a proxy for homebuyers' risk perception (perceived personal risk). Much less attention has been given to the relationship between hazard proximity and risk perception and their distinct roles in affecting property values. Moreover, few research studies have examined property values across multiple environmental hazards. This study attempts to fill these gaps in the literature by proposing and testing a multistage model in which the influence of hazard proximity on property value is mediated by risk perception.

The model is substantially supported by the data. Perceived personal risk is a significant mediating factor between hazard proximity and property value. When people consider proximity to hazard sources as a potential threat to property and personal safety, they are likely to pay less for the housing units, therefore, driving down property values in hazard-prone areas. Although hazard proximity is significantly correlated with the level of risk perception, it accounts for only a small portion of the variation in perceived personal risk. Other factors may influence public risk perception, such as hazard information sources (i.e., authorities, news media, and peers; for a review, see Lindell & Perry, 2004), institutional trust (Weyman et al., 2006), and risk information dissemination methods (Arlikatti et al. 2006; Troy & Romm, 2004; Zhang et al., 2004). In addition, the study found evidences that hazard proximity can be perceived as a potential risk and an environmental amenity at the same time for certain types of hazards such as hurricanes (i.e., proximity to coastline). These two perceptions operate in opposite directions when affecting housing value.

This study's results have important policy implications because existing hazard disclosure policies in the United States focus on informing prospective buyers about the hazard exposure of properties they are considering (e.g., Palm, 1981). The basic assumption of such legislation is that the disclosure of environmental risk areas will lead people in hazard-prone neighborhoods to offset potential losses by offering lower bids. However, this study's findings are consistent with those of other research by indicating that interventions need to be made carefully to ensure the accuracy of people's risk perceptions. Information about hazard proximity is a necessary but not sufficient condition for adequate decision making. In other words, simply making risk information publicly available will not be sufficient if people do not know whether it exists or where to find it; requiring hazard disclosure during real estate transactions will not be sufficient if realtors have the discretion to distort or bury the information (Palm, 1981); and identifying hazardous sources may not be sufficient if people have inaccurate perceptions of risk gradients, the distance from the hazard source at which they can be affected (Lindell, 1994; Lindell & Earle, 1983).

Because information about hazard proximity alone cannot guarantee risk perception because hazard proximity can also be perceived as an amenity for some natural hazards, hazard disclosure policies should instead focus on promoting public risk perception in hazard-prone areas by tailoring messages for different types of hazards that can be communicated through proper channels to the target audiences (Lindell & Perry, 2004). Future research is needed to further develop policy instruments that can better achieve this objective.

Given the significant effect of risk perception on property values, it is important to ensure that these perceptions are accurate. Consumer protection policies are one means of facilitating appropriate protective behavior in the housing market. It should also be noted that informing the general public of scientifically estimated risk areas does not always promote appropriate risk perception. There is considerable evidence showing that people strongly oppose some hazards that experts estimate to be quite safe (Slovic, 2001) while ignoring other hazards that are statistically more risky, such as floods, hurricanes, and earthquakes (Kunreuther, 1978, Slovic 1987). As discussed previously, risk perception can be influenced by many factors other than geographic adjacency to hazard sources. Policy makers should also incorporate these factors in designing instruments for disclosing natural and technological hazards.

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