

SHORTER ARTICLES

Flood Hazard Pricing and Insurance Premium Differentials: Evidence From the Housing Market

Don N. MacDonald, Harry L. White, Paul M. Taube
and William L. Huth*

Abstract

In this article, a model is developed of the rational consumer's willingness to pay for a marginal reduction in the probability of an undesirable state (flooding) occurring in the residential location decision. The model incorporates a hedonic price gradient for low-probability, high-loss flood hazards. Individuals can self-insure against flooding hazards by locating in residential areas where the probability of flooding hazard is relatively low and, all other things equal, consumers should pay more for houses located in relatively less hazardous areas. A relationship between housing price differentials and insurance premiums for housing located inside and outside of a hazard zone is developed, as well as tests for noninsurable costs.

In an efficient market, property value differentials reflect the perceived probability of hazards. Sales price differentials on homes located in and out of a hazard zone should reflect the expected loss associated with the hazard occurring, as well as any market determined risk premium (assuming all other factors influencing price are held constant). If all costs associated with the hazard are insurable, the efficiency of market hazard pricing can be tested using insurance premium differentials associated with the hazard.

In this article, a model characterizing the consumer's location decision is specified and estimated using data on individual housing transactions.¹ Specifically, a methodology is developed for estimating consumer willingness to pay for a reduction in the probability of flooding hazard in an urban area.

Don N. MacDonald is an Assistant Professor of Finance at the University of North Texas; Harry L. White is an Assistant Professor of Finance at Boise State University; Paul M. Taube is an Associate Professor of Economics at the University of Texas-Pan America; and William L. Huth is an Associate Professor of Economics at the University of West Florida.

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¹Hydrologic and topographic information was obtained from the Federal Flood Insurance Rate Maps, 1988.

The price that consumers are willing to pay is extracted by examining the prices of like homes in and out of the flood hazard zone. The estimated price (willingness to pay) to avoid the flood hazard from housing market data is then compared to flood insurance premiums to test market efficiency. If any differences in the market price of the flood hazard and the expected loss represented by the difference in insurance premiums exists, then either (1) costs which are not insurable exist or (2) the market for housing is not efficient.

Theoretical Issues

In an efficient market, the prices of houses in and out of a flood hazard zone, holding other characteristics constant, should reflect the expected loss from flooding. The risk neutral or risk averse consumer should be willing to pay an amount at least equal to the expected loss from flooding to locate outside the flood hazard zone. In the absence of a risk premium, the house price differential will equal the expected loss from flooding. Since insurance premiums on like houses in and out of the flood hazard zone should also reflect the expected loss from flooding, the difference in these premiums should also provide an estimate of the expected loss from the flood hazard. In the absence of noninsurable costs, and given market efficiency, the estimated differential in house prices (holding all other factors constant) should equal the expected loss from flooding reflected in the discounted value of the difference in flood insurance premiums for like housing located in and out of the flood hazard zone.²

The house price differentials can be estimated using an hedonic model (Rosen, 1974) with flood hazard entered as an argument. The predicted sales price differential from housing market data can then be compared to the insurance premium differentials to gain some insight into the market's pricing of the hazard. If the house price differential is less than the insurance premium differential, it indicates the market is not fully pricing the expected loss, perhaps because of information or perception problems. If the house price differential is greater than the insurance premium differential, it indicates that the perceived loss from flooding by market participants exceeds that predicted by the actuaries, perhaps because of noninsurable costs associated with the hazard.

² In practice, the insurance premium differential may not necessarily equal the expected loss differential due to expenses and profit loading by the insurer. Also, the consumer's loss includes implicit costs (e.g. time spent taking inventory of the damage, hiring contractors, replacing damaged items, making temporary repairs, etc.) as well as nonpecuniary costs (e.g. psychological costs, loss of sentimental items, etc.). It is difficult to measure precisely the effect of these variables on consumer willingness to pay for flood hazard reduction, but one method with promise is the contingent value survey method proposed by Thunberg and Shabman (1989).

Data

The data used were obtained from Monroe, Louisiana a well defined urban area with a population of almost 120,000 that has experienced flooding in the past and participates in the National Flood Insurance Program (NFIP).³ The flooding hazard exists because of the low elevation of the entire urban area. Water generally drains from the bayous and canals into the Ouachita River. However, when the river rises (springtime) or the drainage passages become blocked (anytime there are heavy rains, and especially in the winter) the water must be diverted with stationary or portable pumps. The flooding damage to residential housing occurs when the pumps fail or the water backs up too quickly or both. In either case, flooding occurs in the lower areas and does not necessarily occur in the same place, since the pumps and drains can fail in any area. The event of a flooding hazard is truly probabilistic, but the likelihood of greatest potential damage is to lower lying areas. Insurance premium differentials reflect this because they are based solely on elevation. Monroe has addressed the flooding hazard by constructing diversionary canals and purchasing newer and larger pumps.

Housing characteristics and selling prices were determined from all properties sold between January, 1988 and July, 1988.⁴ Several variables were available including heated square feet of interior living space (HSQFT), other square feet (OSQFT), number of bathrooms (BATH), type of air conditioning (AIR), fireplace (FIRE), high endowment area (HIGH), Medium Endowment area (MEDHIGH), low endowment area (LOW), flood hazard (FLOOD, O-A zone, 1 otherwise), taxing authority (1-Monroe, O-Ouachita Parish) and selling price (SP). Variations in selling price due to accessibility, location, and local public services were partially controlled for by the relatively small homogeneous urban area chosen for this study. The remaining variation was controlled for by grouping the data through the use of dummy variables into High, Medium and Low areas as described below. The probability of flooding for each home was determined from the Flood Insurance Rate Maps using the addresses of the sold properties and on-site inspections to determine the hazard rating. A dummy variable was created called FLOOD that equaled zero if the home was in an "A" flood zone and equaled one if it was outside an "A" zone.⁵ Thus, FLOOD is a proxy variable for the probability of flooding hazard and the estimated coefficient for this variable indicates the influence of flood hazard on the home price. The data set includes 301 observations with complete data.⁶ To make a comparison between house price differentials and

³For a review of the flood insurance program see Anderson (1974).

⁴Data on sold properties were obtained from the local MLS Realty Board and only include homes sold through a licensed Real Estate agent or broker. The agents are required to reveal the flood hazard rating before closing.

⁵The 'AO' and 'A1' flood rating are rated equivalently by the Army Corp of Engineers. They are more hazardous and have higher insurance premium rates than 'B' zones.

⁶Descriptive and summary statistics on all dependent and independent variables are available upon request from the authors.

insurance premium differentials, federal flood insurance data were also obtained. This information was obtained from a local insurance agent.⁷

The average selling price of homes in this market was about \$62,763, ranging from a low of \$9,000 to a high of \$262,000. The interior area ranged from 724 square feet to 5,147 square feet, with an average of 1,722 square feet. Homes have between 1.5 and 2 bathrooms. Central air conditioning was present in 86 percent of the homes, while 66 percent have a fireplace. About 85 percent of the homes were sold in areas that were High or Medium in their endowments of desirable accessibility, location, amenities and local public good provision. Twenty-five percent (75) of the homes were located in the "A" designated flood zones; the most hazardous flood zones.

Empirical Results

Specification Issues

An estimated hedonic price function is presented in the first column of Table 1. Several researchers (Bender, Gronberg and Hwang, 1980; Milon, Gressel and Mulkey, 1984 and Halvorsen and Pollakowski 1981) have questioned the actual functional form of the hedonic price equation. Therefore, a Box-Cox (1964) transformation on SP was performed using a maximum likelihood (ML) estimator as described in Spitzer (1982). A grid search over the transformation is utilized to find the maximum value of the concentrated log likelihood function. The Box-Cox transformation is given by $(SP^\theta - 1)/\theta$ meaning that the likelihood function depends on θ as well as the coefficients on the independent variables. A grid search over the transformation variable (θ) is utilized to find the maximum likelihood estimate, which equals .3 for the models estimated here.⁸ To test the linear and semilog specifications, the log of the likelihood function value obtained from ML estimation is compared to the constrained value (either $\theta = 0$ or $\theta = 1$). Minus two times the difference of these values is distributed chi-square with two degrees of freedom.

Data were not available on neighborhood characteristics such as crime rates, school quality, racial composition, and home density. The local Realty Board did, however, categorize the data into fairly homogeneous area controls. In the original data set, there were seventeen areas. After dropping data in areas not rated by the NFIP, nine areas were left. These were grouped into HIGH, MEDIUM and LOW categories by testing restrictions on coefficients. These groupings represented endowments of neighborhood characteristics and, as a result of the grouping, the estimate for θ and the FLOOD coefficient remained robust while its standard error decreased slightly.

The data include homes sold within Monroe and West Monroe as well as in Ouachita parish. There are slight property tax advantages to living in the

⁷State Farm Agent Brod Kennedy.

⁸The independent variables can also be transformed, but the data contain zeros in all variables except HSQFT and BATH. All independent variables were left linear.

parish as opposed to the city, however, the city provides more services.⁹ In addition, 48 percent of the homes in the "A" flood zone (the most hazardous) are located within Monroe. This means that FLOOD could be partially measuring the differential tax treatment (property taxes are higher in Monroe than in the Parish). On the other hand, services such as water, sewage, garbage collection and homeowner's insurance are more expensive in the parish. To control for these effects, a dummy variable was entered to represent living in Monroe (TAX).

As an additional test of the influence of the FLOOD variable, a hedonic equation was estimated with a subset of the data. The subset represents a homogeneous portion of the oldest and most established neighborhoods within Monroe. Severe flooding damage occurred in the 1978 and 1983 100-year floods in some of the lower elevations of this area. The locations in this area are all approximately the same distance to the river, the shopping districts, and schools.

The estimated equations are given in the second and third columns of Table 1. The influence of the FLOOD variable increases from 2.206 in the full sample to 2.876 in the sub sample. All full-sample coefficients, including the FLOOD coefficient, are significant at the 5 percent level or better with the coefficient for FLOOD remaining positive and significant at the 5 percent level or better in the sub-sample. All other sub-sample coefficients, except for OSQFT and FIRE, remain significant at the 5 percent level or better. Also shown in Table 1 are chi-square tests for the linear and semilog forms. Although the linear and semi-log functional forms are rejected for the full-sample, the semi-log form cannot be rejected for the sub-sample. Below, price differentials are calculated based on both the full and sub sample specifications.

The Hedonic Price of Flood

The interpretation of the coefficients presented in Table 1 is more difficult than with a linear or semilog form because of the transformation on SP. The influence of the flood variable can be determined as follows. Let SP_t equal the transformed value for SP, assuming $FLOOD = 0$. The predicted sales price is given by:

$$SP = [.3SP_t + 1]^{3.33}.$$

The influence of the flooding hazard is the difference between SP when $FLOOD = 1$. Consequently, the differential in predicted selling price due to an increased flood hazard is

$$[.3SP_t + 1]^{3.33} - [.3(SP_t - 2.206) + 1]^{3.33}$$

⁹Property taxes are extremely low in Monroe and Ouachita Parish. For example a \$75,000 home in the parish would be assessed zero property tax. In Monroe the assessment would be around \$185 per year.

for the full sample equation. Since this differential depends on the predicted selling price, the influence of the flooding hazard changes in relation to the predicted selling price.

The predicted house price differentials for three hypothetical homes are presented in Table 2 for both equations. These are compared to the annual insurance premium differentials for the same homes.¹⁰ The insurance premiums are somewhat ad hoc in that the amount insured on contents could vary significantly.

Insurance Considerations

The comparisons between the predicted house price differentials and the present value of the annual insurance premiums for the full sample and sub-sample for three hypothetical homes are presented in Table 2. The 'Average Home,' for example, is assumed to have 1,700 heated square feet, 450 other square feet, 2 bathrooms, central air, a fireplace and be located in a HIGH endowment area. Insurance premium differentials and the estimated house price differentials were calculated based on these assumptions, and similar assumptions were made for the 'Below Average' and 'Above Average' homes (see Table 2).

Since the annual insurance payments are constant, it is implicitly assumed that they increase at the same rate as the house price. They should therefore be discounted at the real rate of interest.¹¹ Also shown in Table 2 are the discount rates which set the house price differential equal to the discounted value of the insurance payments in perpetuity. For example, the insurance premium differential for the 'Average Home' discounted in perpetuity is \$6,400 ($192/.03$) and the implied discount rate is 3.48 percent ($192/5,513$). Any difference in these two measures could be a premium resulting from the perception that insurance does not fully compensate for the loss. The differential is greater for the city than for the parish and greater for the subsample which included mostly average to above average priced homes. This may indicate that for individuals who purchase higher priced homes, the payment from the insurer does not fully compensate for the loss which includes the inconvenience of being displaced while repairs are being made. The difference between the predicted price differential for the full sample and the sub-sample also indicates that in some areas the payment from the insurer is perceived to more than compensate for the loss from flooding. This could

¹⁰The insurance rates in the A, AE, A1-A30, A0, AH and D designated flood zones are \$.55/100 for 0-\$40,000 and \$.17/100 for \$40,000-\$185,000 on structure and \$.65/100 for 0-\$15,000 and \$.30/100 for \$15,000 - \$60,000 on contents. In the B, C, X and A99 zones the rates are \$.25/100 for 0-\$40,000 and \$.07/100 for \$40,000 - \$185,000 on structure. For contents the rates are \$.40/100 for 0-\$15,000 and \$.12/100 for \$15,000 - \$60,000.

¹¹In discounting the insurance premiums on contents at the real rate, it is implicitly assumed that the home owners are insuring for replacement cost which would rise with the rate of inflation. This may be an oversimplification but many insurance companies do offer this type of coverage. If the premiums on contents were discounted at higher rates, the change in insurance cost would decrease indicating a higher premium captured by the sales price differential.

result from the perception that the repairs made after flooding (new carpet, painting, etc.) enhance the value of the home beyond its original value before the flood. This proposition was not tested directly because a homogeneous lower priced subset with enough data points is not in the data set.

Conclusions

A model characterizing the residential homeowner's location decision with flood risk was specified and estimated using data on individual housing transactions. The decision to purchase flood insurance on structures was not separable from the location decision in our sample because financial intermediaries require that flood insurance be purchased for homes located in "A" designated flood zones. As a result, insurance was treated as exogenous, conditional on the location of the home.

For homes located in the flood zone, the full differential for flood-zone prices (adjusting for other characteristics) equals the sum of: (1) the sales price differential, (2) the capitalized cost of differential insurance premiums and (3) the difference in noninsurable costs. If full insurance is assumed with no noninsurable costs then market efficiency implies that (1) and (2) be equivalent. The sales price differential equaled the change in insurance costs for three different priced homes at a 2.47 percent to 3.78 percent discount rate in perpetuity. These results are consistent with the hypothesis that noninsurable costs are not large.

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Table 1

Estimated Hedonic Price Function Dependent Variable = $(SP^{-3} - 1)/.3$
 (t-values are in parentheses)

Variable	Full-Sample	Sub-Sample
CONSTANT	43.56 (29.96)	56.56 (21.64)
HSQFT	0.0098 (12.24)	0.0117 (6.73)
OSQFT	0.0038 (3.00)	0.0014 (0.52)
BATH	4.876 (5.52)	3.882 (2.32)
AIR	8.767 (8.51)	5.308 (2.38)
FIRE	2.439 (3.06)	1.694 (1.16)
HIGH	6.396 (5.03)	—
MEDIUM	5.509 (4.37)	—
FLOOD	2.206 (2.28)	2.876 (2.16)
TAX	2.94 (3.12)	—
R-Square	.82	.89
Observations	301	64
Log Likelihood Value	-2,804.2	-587.1
Chi-Square for testing linear functional form	95.1	63.4
Chi-Square for testing semilog functional form	37.9	1.2*

*Fail to reject the semilog form.

Table 2
Comparisons Between House Price Differentials
and the Present Value of Insurance Payments^a

Type of Home	Premium Differential	Present Value at 3%	Predicted Differential	Predicted Differential	
			Full-Sample	Sub-Sample	
			City	Parish	Total
			(Implied Discount Rate)		
Below Average Home (\$25,000)	\$77/year	2567	3114 (2.47%)	2837 (2.71%)	5067 (1.52%)
Average Home (\$65,000)	\$192/year	6400	5513 (3.48%)	5127 (3.74%)	7334 (2.62%)
Above Average Home (\$99,000)	\$240/year	8000	6779 (3.54%)	6344 (3.78%)	8947 (2.68%)

Note: A below average home is assumed to have HSQFT = 1,000, OSQFT = 150, BATH = 1, AIR = 1, FIRE = HIGH = MEDIUM = 0, AND \$10,000 of insurance on the contents.

An average home is assumed to have HSQFT = 1,700, OSQFT = 450, BATH = 2, AIR = 1, FIRE = 1, HIGH = 0, MEDIUM = 1, and \$20,000 of insurance on the contents.

An above average home is assumed to have HSQFT = 2,400, OSQFT = 750, BATH = 2, AIR = 1, FIRE = 1, HIGH = 1, MEDIUM = 0, and \$30,000 of insurance on the contents.

^aThe discount rate equating SP and insurance premium differentials is given in parentheses.

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