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Participation in the National Flood Insurance Program: An Empirical Analysis for Coastal Properties

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Abstract

A perennial question about the National Flood Insurance Program is: how can participation be increased? An empirical analysis of individual-level data reveals that in a sample of coastal areas the participation rate is 49 percent of eligible properties. Participation responsiveness to price is inelastic, but it has been increased by the mandatory purchase requirements for mortgage borrowers. Easing conditions for participation in the program would probably not reduce flood control measures, such as seawalls, which may degrade beach conditions and coastal ecosystems.

Introduction

The National Flood Insurance Program (NFIP) was initiated through the National Flood Insurance Act of 1968 (Federal Emergency Management Agency, 1997) in response to high annual disbursements of disaster relief payments and the failure of the private market to provide flood insurance. The reasons for market failure cited by Anderson (1974) include (a) the certainty of losses in some areas, (b) the ruinous, widespread nature of flood events, and (c) adverse selection. In addition to providing subsidized insurance, the Act also contained provisions to regulate property development in flood-prone areas. Other background information on the NFIP is available in Pasterick (1998).

Since initiation of the program, several changes have been considered for NFIP. One area of concern has been the Program's operation in coastal communities. While flood zones are delineated on rate maps, there is no consideration of the added risk presented by coastal erosion. This risk is important to the NFIP because erosion reduces

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the land buffer between buildings and water, with the result that buildings become increasingly exposed to wave and wind damage over time (Davison, 1993). With Section 577 of the National Flood Insurance Reform Act of 1994 (P.L. 103-325), the U.S. Congress ordered an analysis of altering the rate structure for coastal properties exposed to the increased risk due to erosion (Leatherman, Merrell, and Friedman, 2001).

Previous research on the NFIP has been national in scope (see, e.g., Browne and Hoyt, 2000; GAO, 1983). However, research into the Program's operation in coastal areas deserves a special emphasis because of the unique differences that distinguish it from its operation in a typical riverine flood zone. Coastal areas attract wealthier property buyers with the financial means to invest in secondary homes. Therefore, coastal properties are often seasonal vacation housing rather than year-round residential or commercial buildings. These vacation properties are usually very valuable, easily exceeding the $250,000 claim limit of the NFIP. Much of the value of coastal properties stems from the limited supply of suitable beachfront land, but the NFIP offers no compensation for land consumed by coastal erosion. Riverine and coastal areas are also differentiated by the methods employed to prevent floods and storm damage. Many coastal communities engage in shoreline armoring and beach renourishment, which differ from the typical riverine protection scheme. The effect of this coastal protection upon the demand for flood insurance has never been investigated. Also, a property's distance from the shoreline has an effect on the expected loss from coastal storms, since closer properties bear the brunt of wind and waves. These and other substantial differences imply that the determinants of the flood insurance-purchasing decision may be quite divergent between coastal and riverine areas.

The main objective of this analysis is to provide some empirical evidence, specifically from the coastal setting, relating household decisions involving risk to the NFIP and the terms that insurance is offered under. In particular, we address whether NFIP would be likely to lose many customers if it raised the price of insurance in coastal areas. Integral to understanding the probable effects of changing the rate structure are the relationships that exist between the decision to purchase flood insurance, risk factors, community response to beach erosion and flooding hazards, and legal provisions regarding coastal development.

We are interested in characterizing the relationship between formal insurance and other forms of self-insurance and self-protection (following Ehrlich and Becker, 1972). It has been noted that desirable beach conditions cannot coexist with artificial flood and erosion protection structures such as seawalls and groins (Pilkey and Dixon, 1996). This is because these structures disrupt the flow of sand that replenishes the beach naturally. Thus, as owners protect themselves from erosion and storm risks they also contribute to the degradation of the coastal environment. If it is shown that formal insurance is a substitute for the property protection afforded by seawalls, then a range of policy tools to encourage higher participation in NFIP could have the beneficial side effect of reducing seawall construction. The empirical aspect of the analysis is based on primary survey data from individual households located in a sample of coastal areas, and upon these households' policies-in-force data from the Federal Insurance Administration (FIA).

DECISION TO PURCHASE INSURANCE

Smith (1968) provided a seminal formalization of the household's insurance-purchasing decision. Also, the problem is modeled in an expected utility maximization framework in standard economics textbooks (see, e.g., Varian, 1992). Assuming that (a) insurance is offered at an actuarial price, (b) the property owner is risk averse, (c) the property owner's estimate of the probability of loss equals the insurance company's estimate, and (d) the probability of total loss is greater than the insurance price (per dollar of coverage), these models suggest that the property owner will purchase an amount of insurance coverage that fully protects against the potential loss. If (d) does not hold, less than full coverage is optimal for the household. Due to the reputed subsidy in flood insurance rates, it seems likely that the insurance price per dollar of coverage is less than the probability of total loss.

This prediction of full insurance is at odds with the experience of the NFIP. Since its inception, the NFIP has been marked by a lack of participation. Browne and Hoyt (2000) review the history of claims and find that in the average year between 1983 and 1993, less than 10 percent of flood losses were covered by insurance. In the Mississippi River flood of 1993, less than $1 billion of the total $12 billion damages were covered by federal flood insurance.[1] The Federal Crop Insurance Program, which shares many characteristics with the NFIP, has had a similar lack of participation; in 1993 the participation rate was 35 percent of eligible acres, even though the average premium was subsidized by 30 percent (Barnett and Skees, 1995). The mandatory purchase provisions of the Flood Disaster Protection Act of 1973 and the Flood Insurance Reform Act of 1994 (where borrowers of federally backed mortgages must purchase insurance prior to loan approval) were legislative efforts to increase participation in NFIP.[2]

There are several reasons contributing to the lack of NFIP participation among owners of flood-prone property. Lewis and Nickerson (1989) find that government disaster relief programs provide a disincentive for purchasing flood insurance. They suggest that property owners perhaps feel that relief in the form of low-interest loans, grants, etc., offer them at least partial compensation for potential flood losses.[3] In terms of expected utility maximization, the effect of disaster relief would be to reduce the expected loss to a lower level and the optimal coverage would be reduced, perhaps to zero if the relief effect is strong enough. Kunreuther (1996) also recognizes the potential importance of disaster relief, but casts doubt on whether the effect could be very strong. He reports that most survey respondents expected to rely on their own resources to finance their recovery.

In Smith's (1968) insurance demand model, foregoing insurance coverage can be optimal when the insurance price per dollar of coverage is greater than the probability

[1] An anonymous reviewer has suggested that some of the uninsured losses can be attributed to property owners who are not aware that under the NFIP, contents coverage is not automatic.

[2] A reviewer has noted that federal regulations are not consistent in encouraging NFIP participation. To obtain a Small Business Administration disaster loan, homeowners in flood zones must be covered by flood insurance when they apply for the loan. However, they can delay their insurance purchase until after a flood has occurred (Packer, 2004).

[3] See Platt (1999) for a thorough discussion of the politics involved and current trends in federal disaster assistance.

of total loss. We feel this is probably not the case with the NFIP, but if the perceived level of risk is much less than the actuarial level this explanation could prove to have some explanatory power. The adverse selection problem, as formulated in Rothschild and Stiglitz (1976), assumes that insurance buyers have more accurate estimates of their probability of loss than the insurance company has. In this case, property owners who believe they are less risky than average will find insurance contracts less appealing. Rather than assuming buyers have better information, Kunreuther (1984) asserts that people tend to underestimate their chances of being a disaster victim. This might result from their having little or no previous experience with flood damage. If their subjective loss probability is too low, then actuarially priced insurance would appear to be too expensive. If this were the case, then the amount of subsidy required for high rates of program participation may be untenable.

MacDonald, Murdoch, and White (1987) raise the possibility that NFIP undercompensates for losses. In the context of insurance demand models, undercompensation implies that only part of the potential loss is covered. Undercompensation is indeed a possibility because coastal properties are reputed to be worth much more than NFIP's maximum coverage of \$250,000. For houses that are valued at more than the maximum coverage, the owner may purchase coverage outside of the NFIP, or he may decide to protect himself by elevating his house or lobbying for beach renourishment. However, our data set contains the county tax assessment for individual properties, and it reveals that only 3.5 percent of houses are valued at more than \$250,000, net of the assessment for the land.[4] This low percentage is due to the fact that coastal land is very valuable. Since the prospect of undercompensation affects so few properties, it is probably a minor influence in determining NFIP participation. Furthermore, property owners may realize that most flood losses do not involve a total loss of the house. In this case, the maximum limit would constrain purchasing behavior even less.

Ehrlich and Becker (1972) define self-protection as an attempt to skew the probability distribution toward favorable outcomes. In cases where self-protection actually changes the probability of loss, and the insurance company considers it in adjusting the price of insurance, then formal insurance and self-protection are complements. This characterizes most forms of self-protection available to coastal owners, so they probably promote NFIP participation rather than detract from it. For example, elevation above the flood level is a form of self-protection that reduces the probability of loss, all else being equal. Under the NFIP, elevation is considered in adjusting the insurance premium, so elevation is complementary to formal flood insurance. Another self-protection technique is ownership of a house built after the publication of a flood insurance rate map (FIRM), after which building codes were strengthened. For reasons similar to the case of elevation, owning one of these houses should be a complement to flood insurance.

It is also possible that coastal dwellers may attempt to self-insure. Ehrlich and Becker (1972) define self-insurance as actions that reduce the size of the potential loss, and show that self-insurance is strictly a substitute to formal insurance. Self-insurance for flood and storm damage in the coastal housing market might be manifested as locating further away from the shoreline, purchasing a less expensive home, purchasing less

[4] All nine counties in the dataset assessed property at 100 percent of the fair market value.

coastal land, or foregoing upgrades to the structure. Each of these potential actions should have a negative effect on participation.

Artificial coastal protection, in the form of seawalls, groins, and/or beach renourishment, has been employed at many communities to control beach erosion and prevent storm damage, sometimes to the detriment of the coastal ecosystem (Pilkey and Dixon, 1996). Under the NFIP, insurance rates are not adjusted to reflect the degree of artificial protection at the shore, so it is possible (following Ehrlich and Becker, 1972) that shoreline protection may be a substitute for formal insurance. Therefore, if many property owners regarded these management practices as effective protection against flood-related losses, then they would discourage NFIP participation. On the other hand, property owners may believe that shoreline armoring and beach renourishment offer only limited protection, especially from a hurricane's storm surge. These practices could serve as a signal of the level of risk associated with coastal occupation, and the presence of artificial erosion protection may encourage more flood insurance purchases. Overall, the net effect of artificial protection could be positive or negative,[5] and it is a question that can be addressed with the proper data.

Finally, the prediction of full insurance only applies to risk-averse individuals. If certain properties, such as those at the ocean's edge, attract risk-taking buyers, then one might expect a lack of interest in flood insurance. However, the results of Kriesel, Randall, and Lichtkoppler (1993) suggest that buyers place a premium on properties that were better protected from flood and erosion hazards. This risk premium would not exist if the buyers were risk loving.

EMPIRICAL SPECIFICATION

Empirical analysis of the insurance-purchase decision can be modeled by random utility maximization. The utility of the *i*th household if flood insurance (subscripted by v) is purchased is given by $U_{iv}(\mathbf{q}_v, c_v, \varepsilon_v)$, where $\mathbf{q}_v$ is a vector consisting of the land ownership characteristics associated with the insurance (i.e., probability of loss, insurance payment, etc.), c_v is a composite of all other goods consumed, and ε_v is an error term. The utility associated with no insurance (subscripted by p) for the *i*th household is given by $U_{ip}(\mathbf{q}_p, c_p, \varepsilon_p)$. Homeowners evaluate whether the characteristics associated with flood insurance ($\mathbf{q}_v$ and c_v) provide higher utility than the no insurance alternative.

The probability of any homeowner choosing to purchase insurance is the expected value of a random variable P_i, which takes on the value 1 if $U_{iv} > U_{ip}$ and 0 if $U_{iv} < U_{ip}$. Each homeowner's P_i could be analyzed by a regression method that properly accounts for the dichotomous nature of this dependent variable. Logistic regression estimated by the method of maximum likelihood is a popular technique for these data. However, data for an important variable, the price of insurance, are known only for the NFIP participants. After a brief introduction to the data set, this particular data problem is discussed, followed by a further specification of our empirical methods.

[5] The US Government is also ambivalent about the protection afforded by beach nourishment. While it is ignored under the NFIP rate setting guidelines, property protection is the primary consideration in benefit-cost analyses performed by the Army Corps of Engineers for its beach nourishment projects.

The sampling frame for this study consisted of nine coastal counties that were selected by FEMA.[6] The states represented by these counties were Delaware, North Carolina, South Carolina, Georgia, Florida, and Texas. Within these counties, approximately 7,000 properties within 1,000 ft from the coast were randomly selected for inclusion in the study. Only 5.7 percent of these properties were classified as nonresidential, so a judgment was made to concentrate on the residential properties. For each property, a FEMA contractor collected physical measurements by an on-site survey. Details of the data collection effort are available in Heinz Center (2000).

Survey questionnaires were mailed to the owners of these properties during 1998–1999.[7] An overall response rate of 39 percent was obtained. The characteristics of the mail survey returns were compared with the known characteristics of the sampling frame. It was found that property owners closer to the shore were overrepresented. The FEMA contractor responsible for the geographic information system calculated weighting factors to correct the data for underrepresentation of inland properties.

In addition, access was obtained to the FIA's policies-in-force database for all policyholders in the nine counties. Observations from the sampling frame were matched with those from the FIA data on the basis of the property's address. Of the 6,570 properties in the sampling frame with complete data, 49.81 percent were identified as holders of flood insurance. However, among the 2,486 mail survey respondents with complete data, the participation rate was 83.20 percent. This overrepresentation of participants[8] was corrected by an appropriate weighting factor.[9]

As stressed in Smith's (1968) article, the price of insurance is a key determinant of the individual's decision to purchase coverage. However, data on the price of insurance, calculated as the annual premium per $100 of coverage, were only observable for those homeowners who had insurance coverage. The insurance price considered by nonparticipants was unknown to us. One feasible solution to this problem was a generated regressor approach, where predicted values of insurance price would be used instead of actual prices. Toward this end, seven risk-related variables that FEMA says are important in rate setting were regressed on insurance price. These seven risk-related variables relate to either physical or locational characteristics of the property, and all could be construed as forms of household self-protection (though most of the locational characteristics could also be considered self-insurance). In addition, a series of 48 dummy variables accounted for community-specific effects, especially local loss

[6] For the whole study there were also 10 counties in the Great Lakes and the Pacific regions. These coasts tend to be characterized by high bluffs that slope steeply down to the water. While these properties are close to the water and are vulnerable to an erosion hazard, most properties are not in a flood zone. Therefore, NFIP participation in these areas is negligible.

[7] It was expected, correctly, that few coastal properties would be the owner's primary residence. Therefore, the owner's home mailing address was used for the survey rather than the address of the coastal property.

[8] In hindsight, this over representation was predictable because FEMA and the NFIP were explicitly identified as the research sponsors. Some property owners without insurance probably concluded that the survey was not intended for them.

[9] The Logistic procedure within SAS was used to estimate the regression. Within this procedure, the Weight statement specifies a variable that applies a weight to each observation (SAS, 1997). To represent a 49.81 percent NFIP participation rate in the subsample (down from 83.20 percent), a weight of 5.2 was given to nonparticipants, and 1 was assigned to participants.

history. This regression, reported in the Appendix, analyzed 1,355 observations with complete data and yielded a model with significant coefficients for all risk attributes of the property (all with their expected sign) and 16 statistically significant community dummy variables. The 95 percent confidence interval for predicted insurance price at the means was $0.438 ± 0.01. This narrow confidence interval indicates that a generated regressor approach is suitable for overcoming the lack of data on insurance price. Thus, the variable *Price* is the predicted price of flood insurance, and a negative effect on participation is expected.

The *Income* variable was calculated from the mail survey, where respondents checked the category that their total annual household income (earned and unearned) fell into. Eight income categories were offered, ranging from $30,000 to $250,000. People with higher incomes should be able to readily afford insurance, so from a purely budgetary perspective *Income* should have a positive effect on participation.

The on-site survey gathered precise measures related to the risk of erosion and storm damage (many of which were used in the insurance price regression model in the Appendix). *Distance to ERF* is the distance between the house and the erosion reference feature, which is either the beach vegetation line or, in areas that have shore stabilization, the revetment. Distance from the erosion reference feature can be viewed as a form of self-insurance because it decreases the size of the expected loss. This variable should have a negative effect on participation as homeowners farther from the ocean-front should feel insulated from flooding and storm damage, all else being equal.

The mail survey elicited specific information on other property characteristics. Property erosion and flood protection measures can include seawalls and other structural devices. In addition, some coastal communities engage in periodic artificial beach nourishment. If a property had either type of protection, then the property was assigned a "1" for the variable *Artificial Protection*, and zero otherwise. Shoreline protection is not considered in the setting of flood insurance prices, and thus, we might expect *Artificial Protection* to have a negative effect on NFIP participation.

Shoreline protection is, in most cases however, a community response to erosion and flooding. Shoreline armoring is sometimes instituted on an individual basis, but given the externalities associated with such protection, individual households engaging in this practice often provide incentives for their neighbors to do the same. The coastal zone is very dynamic; protection of one property often comes at the expense of another (Pilkey and Dixon, 1996). Beach nourishment is infeasible on a small scale. Thus, individuals may not be able to freely choose the optimal amount of protection. If coastal protection is at least partially exogenous and the risks of living in the coastal zone are somewhat unclear, such protective schemes could serve as a signal of the hazards associated with living in the coastal zone. This alternative characterization would allow artificial protection to induce higher participation.

The variable *Mortgage* (obtained from the household mail survey) equals 1 for property owners who indicated that they were required to buy flood insurance by their mortgage lender. This variable that should reflect the FHA requirement of flood insurance for mortgaged properties, and it should have a positive effect on participation. *Hurricane Interval* is the mean return period for landfall or nearby passage of a hurricane. In the coastal areas considered in this study, floods are caused by the storm surge associated with hurricanes. Therefore, this variable should be a rough measure of overall storm damage and flood risk, and control for how communities differ in their experience with the storm hazard. Longer intervals imply lower risk and less experience, so the *Hurricane Interval* variable should have a negative effect. These data were obtained from the FEMA Website.

These variables are similar to the ones employed by Browne and Hoyt (2000) in their investigation of overall participation in the NFIP using a pooled time series and cross-sectional data set composed of the 50 states, for the years 1983–1993. In addition to these variables, they also included a measure of the likelihood of government disaster relief, with the hypothesis that this would serve as a substitute for formal insurance.[10] The time-series aspect of their data set contained variation in relief expenditures, and it was a significant variable. The nature of our data set presents problems for including the likelihood of disaster relief because there is little cross-sectional variation in this variable. One source of variation could be peoples' past experience with disasters. Where there have been hurricanes and floods, people probably realize that disaster relief typically is not free and they will be more likely to participate in NFIP. Our *Hurricane Interval* variable should reflect this aspect of the problem. This reinforces our expectation of a negative coefficient.

Another source of variation in expectations of disaster relief could arise from the political influence that resides in different communities. Property owners may believe that their influence could be used to marshal more public resources following a disaster. Differences in political influence are frequently used to explain why poor and minority neighborhoods may have lower environmental quality and public services such as education, police protection, etc. However, our data set of coastal property owners contained few minorities or poor people. On the contrary, results from our mail questionnaire suggest that the average owner's annual income is $101,000. The average age is 57 years; 43.7 percent are retired, and 73.2 percent have college degrees. These characteristics suggest that coastal communities are probably above the threshold for having significant political influence. However, across the 49 communities in the data set there is significant variation in the reported average household income (standard deviation is $98,180). Therefore, it is possible that in some communities there is a greater sense of empowerment than in others.[11] The *Income* variable may serve as a proxy for the likelihood of disaster relief, thus tempering our expectations of a positive coefficient.

EMPIRICAL RESULTS

Information from all four data sources, the on-site survey, the FIA policies-in-force data, the mail survey questionnaires, and the FEMA Website were utilized in this

[10] Another potentially important variable for our analysis concerned properties located in a Coastal Barrier Resource Act of 1983 (CBRA) area. By law, these properties are prohibited from participating in NFIP. Preliminary analysis, however, revealed that only one percent of properties were inside a CBRA area, and among these, a substantial number had been grandfathered into the NFIP.

[11] Indicators of empowerment that could be obtained from Census data are less useful in coastal communities. The narrow strip of houses with beach amenities usually are owned by people whose characteristics are much different from their inland neighbors. The level of detail required for an accurate analysis is not available in Census data.

TABLE 1
Summary Statistics of Variables Used in the NFIP Participation Model, 1998–1999

Variable	Description	Mean	Standard Deviation
Participation	Whether the property had flood insurance backed by NFIP. The dependent variable	0.498	0.650
Price	Price of flood insurance, dollars per $100 of coverage	0.438	0.328
Income	Annual household income, earned and unearned	$101,000	98,180
Distance to ERF	Distance from the house to the erosion reference feature	380.09	336.55
Artificial protection	Whether the property had seawall, groin, or nourished beach protection	0.413	0.640
Mortgage	Whether the property was subject to the mandatory insurance-purchase requirement	0.275	0.580
Hurricane interval	Interval, in years, between hurricane landfalls	22.566	46.037

Note: N = 2,486 observations in nine coastal counties.

analysis. Data were compiled on 2,486 individual properties. The summary statistics of the weighted variables used in the participation regression are presented in Table 1. Concerning the dependent variable, 49.81 percent of the properties have flood insurance. It is interesting to note that 27.54 percent of the survey respondents in the average community indicated that they had been required to buy insurance. If this is subtracted from the average participation rate, the result suggests that of the owners for whom insurance was not required, 22.3 percent freely elected to buy flood insurance. *Insurance Price* had an average of $0.43 per $100 coverage. The annual income of survey respondents averaged $101,000. The prevalence of artificial shoreline protection is moderate, with 41.34 percent of the properties protected by shoreline armoring and/or beach renourishment.

This unique database reveals other interesting features about coastal properties and their buyers not listed in Table 1. For recent property transactions, i.e., within 5 years of the survey response, the purchase price in the average community was $276,300. Only 21.1 percent of the properties were used as a primary residence; most properties are vacation rental homes. The NFIP dominated the market for this type of insurance, since only 4 percent of respondents in the average community indicated that their policy was not backed by the Program. About 11 percent had filed a flood insurance claim at sometime in the past.[12]

The regression results are reported in Table 2.[13] The logit model performs well with all six of the independent variables significant at the 0.05 percent level. The ratio of

[12] An anonymous reviewer has suggested that the loss history is more severe than this figure may indicate. For the NFIP as a whole, while there are 40,000 repetitive loss properties, they represent one-third of all payments (FEMA, 2002).

[13] The model was examined for ill-conditioning associated with multicollinearity. The condition number was 15.69, indicating that there were no strong linear associations between the independent variables.

TABLE 2
Logit Regression Results for the NFIP Participation Model in Nine Coastal Counties, 1998–1999

Variable	Hypothesized Effect	Coefficient	Standard Error	Marginal Effect	Elasticity
Intercept		−0.111	0.146	n.a.	n.a.
Price	Negative	−0.591*	0.173	−0.293	−0.259
Income ($1,000s)	Positive	0.0048*	0.0005	0.0024	0.492
Distance to ERF	Negative	−0.0023*	0.0002	−0.0011	−0.881
Artificial protection	Uncertain	0.491*	0.089	0.121	n.a.
Mortgage	Positive	4.359*	0.191	0.730	n.a.
Hurricane interval	Negative	−0.010*	0.001	−0.005	−0.230

Note: N = 2,486 properties. *Indicates that the variable is significant at the 0.05 level. Dependent variable equals 1 if the property was protected by flood insurance, 0 otherwise. Correct prediction rate was 86 percent.

correct predictions, a goodness of fit statistic for dichotomous models, is 86 percent. All of the estimated coefficients have their hypothesized signs.

Table 2 also reports each variable's marginal effect on the probability of participating in the NFIP. In the logit model, marginal effects for the *j*th variable can be calculated from the expression (Griffiths, Hill, and Judge, 1993):

$$\partial P/\partial x_j = \Delta(x'\beta)\beta_j,$$

where mean values of the x covariates are used, and $\Delta(\cdot)$ refers to the logistic cumulative distribution function. For the case of a dummy independent variable, the marginal effect is calculated as the difference in predicted probability calculated at $\beta_d = 0$ and $\beta_d = 1$, with the other independent variables held at their means. Finally, Table 2 reports elasticities associated with each of the continuous variables. These are calculated as:

$$(\partial P/\partial x_j) \times (x_j/P),$$

where the value of the first derivative is from the previous column of Table 2, and x_j and P are measured at their means.

The results suggest that the price of flood insurance has a negative effect on participation. These results indicate a marginal price effect of −0.293, meaning that when the price is raised by $1, the probability of participation decreases by 29.3 percent. The price elasticity is −0.259 percent. Previous studies of NFIP participation have also shown a low degree of price responsiveness. Browne and Hoyt (2000) estimated price elasticities of −0.109 and −0.997, and the 1983 study by the GAO reports an elasticity of −0.38. In a study of Federal crop insurance, another insurance product that has many characteristics in common with NFIP, Barnett and Skees (1995) estimated price elasticities ranging from −0.14 to −0.33. Our results do not refute those findings of a low price response.

Respondents with higher incomes were more likely to have flood insurance, with an elasticity of 0.492 percent. We conjectured that income may also serve as a proxy for the influence of political power on expectations of disaster relief, and thus the pure income elasticity, net of this expectation, could be higher than what we have estimated. We characterize distance from the shoreline as a form of self-insurance. Locations further from the shore are exposed to a similar flood risk, but are better protected from storms. Houses located closer to the shore bear the brunt of hurricane winds and storm waves. As such, we expected a negative relationship between *Distance to the ERF* and our dependent variable. Our results support this characterization. A 1 percent increase in distance from the erosion reference feature decreases the probability of holding flood insurance by 0.88 percent.

An important motivation for this study was to examine the effects of artificial shoreline protection on participation in the NFIP. The dummy variable *Artificial Protection* could have two opposite effects. First, if property owners regard the devices as offering some flood protection, and since flood insurance prices do not take account of this type of protection, the shoreline protection may have a negative effect on NFIP participation. On the other hand, if the presence of shoreline protection projects heightens owners' awareness of the risk inherent in living on the coast, then the variable would have a positive coefficient. In Table 2, the effect of *Artificial Protection* on participation is positive, significant, and relatively large. Results suggest that households located in the vicinity of artificial shoreline protection are 12 percent more likely to purchase flood insurance.

Owners of mortgaged properties exhibited a higher probability of participation. Browne and Hoyt (2000) and the authors of the GAO report (1983) hypothesized this effect, but both of those studies found a *negative* relationship between the demand for flood insurance and FHA mortgages. Their unexpected results were probably due to an inconsistent relationship between FHA mortgages and flood insurance requirements during the time period covered by those studies. The additional mortgage requirements mandated under the National Flood Insurance Reform Act of 1994 apparently had their intended effect, as our data are measured after the promulgation of this law. However, the Reform Act has not caused 100 percent compliance, a result that agrees with Kunruether's (1996) observation that the requirements can be avoided. Results from Table 2 suggest that a mortgaged property is 73 percent more likely to have flood insurance.

The overall level of storm risk faced by a community was represented by the *Hurricane Interval* variable. This variable also reflects the amount of experience with hurricane hazards. For both of these reasons, we expected a negative sign on the coefficient. Aside from the pure risk argument, we suspect that a longer mean elapsed time between landfall or nearby passage of a hurricane might be associated with a reduced vigilance on the part of coastal residents, and thus lead to lower participation in the NFIP. Also, recent experience with hurricane damage could be indicative of a more grounded view of disaster relief programs (i.e., that these programs are not composed of grants or "free money"). Our results support these expectations, though unfortunately we cannot parse out the importance of storm risk from experience with storms and perceptions of disaster relief. The estimated coefficient on *Hurricane Interval* was negative and significant, with an estimated elasticity of −0.23 percent.

DISCUSSION

If FEMA were to change substantially the premiums for NFIP policies in coastal areas, how would property owners react? Our findings suggest that price increases within the range encompassed by our data ($0.08–$1.18 per $100 coverage) would probably not cause significant reaction by NFIP policyholders. Predicting the effect of changes outside of this range is not supported by our data. Higher price increases could cause dissatisfaction among some policyholders, and they might cancel their policies. If price increases were phased in over a period of a few years, FEMA might avoid complaints and bad publicity. These conclusions are based on our results, which suggest that other motivations are equally if not more important, such as whether households choose to self-insure by locating farther from the shore, the mortgage requirement for holding flood insurance, and household perceptions and experience with erosion and hurricane hazards. Conversely, if FEMA lowered prices, it is doubtful that property owners would respond by buying more policies. Indeed, NFIP was characterized by very low participation in the 1970s when policies were highly subsidized.

Contrary to the findings of other papers (Browne and Hoyt, 2000; GAO, 1983), we find that the flood insurance requirements of FDIC-backed mortgage lenders do increase the probability that homeowners in the flood zone hold such insurance. Our results only apply, however, to the coastal environment. In addition, previous studies utilized data sets covering earlier periods of time, while ours covers a recent period of history (1998–1999). In light of the earlier findings, our results could indicate that the additional mortgage requirements mandated under the National Flood Insurance Reform Act of 1994 had their intended effect. Nonetheless, we do not find evidence of 100 percent compliance with the mortgage requirements, supporting Kunruether's (1996) observation that the requirements can be avoided.

Our empirical evidence suggests that artificial shoreline protection, in the form of seawalls, other structural devices, and/or beach renourishment, is complementary to the holding of flood insurance, all else being equal. The flooding risk associated with hurricanes within the community is controlled by the *Hurricane Interval* variable, so this result corresponds with the effect of community response projects independent of the level of hurricane risk. This result could reflect the fact that indemnification offered by such protection is not plenary. Artificial shoreline protection is designed primarily to stem erosion damage (though beach nourishment certainly produces flood protection as well), and thus the holding of flood insurance represents an additional element in the coastal hazard protection portfolio. Also, we conjecture that the presence of shoreline armoring and periodic beach nourishment may behave as a signal to coastal homeowners, highlighting the risk associated with living at the shoreline.

CONCLUSIONS

A perennial concern associated with the NFIP has been how to increase participation. Many of the articles on NFIP from the early 1970s addressed the problem of how to get more people voluntarily enrolled in the Program. This was during an era of highly subsidized, low insurance prices. Even though the insurance was inexpensive, few people bought flood insurance until more recently when its purchase was made mandatory under mortgage requirements, and the benefits of NFIP were advertised to the public. As enrollment has increased, concerns about the program have gravitated toward ameliorating the NFIP balance sheet, by decreasing the amount of subsidization or removing subsidies altogether.

Several explanations have been offered as to why the NFIP does not have higher participation among owners of flood-prone property. The first reason is that government disaster relief programs provide a disincentive for purchasing flood insurance. Unfortunately, our data did not permit a direct test of this proposition. To do so, one needs variation in the expectation of disaster relief, which is difficult to obtain in a cross-sectional data set. Other propositions that could not be tested are: (i) people underestimate their probability of suffering a loss, (ii) NFIP undercompensates for losses, and (iii) the coastal property market is dominated by risk-loving households.

This model of participation in NFIP has been formulated to specifically address the vagaries of the program associated with properties located in the coastal zone. Coastal properties differ from their riverine counterparts by: (i) the types of households encountered (tend to be wealthier), (ii) the use of these properties (tend to be part-time rental and vacation homes), (iii) the value of the properties (tend to be more valuable, especially the value of land relative to structure), (iv) the nature of flood risk (which can be augmented by coastal erosion), and (v) in the methods employed to prevent floods and storm damage. Beachfront land is in limited supply, making this land quite valuable. The NFIP, however, offers no compensation for land consumed by coastal erosion. In addition, many coastal communities are protected with shoreline armoring and/or beach renourishment. These erosion and storm protection strategies differ from the typical riverine protection systems, and their effect upon the demand for flood insurance has not been previously investigated.

Our empirical results for coastal homeowners confirm earlier findings on the overall NFIP, indicating that flood insurance demand is price inelastic. We find that flood insurance is a normal good for coastal homeowners and that enrollment is responsive to the level of storm risk. Other factors are also important in the probability of enrollment, such as proximity to the shoreline, the existing community response to erosion and storm risk, and the requirements of mortgage lenders. Our results indicate that homes located further from the shoreline have a lower probability of holding flood insurance, all else equal. We construe locating away from the shoreline as a form of self-insurance, which should lower the demand for formal insurance (Ehrlich and Becker, 1972). The existence of shoreline armoring and/or beach nourishment was found to have a positive effect on the holding of flood insurance. We interpret this result as indicative of a signaling role.

The National Flood Insurance Reform Act of 1994 mandated further restrictions to ensure that homes with FDIC-backed mortgages hold flood insurance. We find evidence in support of the efficacy of these provisions, but compliance is not full. Indeed, it appears that foregoing the insurance requirement for mortgaged properties is not difficult (as suggested by Kunruether (1996)).

APPENDIX

The data on the price of flood insurance, expressed as the annual premium per $100 of coverage, were obtained from the FIA's policies-in-force database. Therefore, the price considered by nonparticipants was not known. A generated regressor solution was applied to this data problem, where predicted values of insurance price would be used instead of actual prices. Data for this analysis came from a subset of the sampling frame for which all variables were available, i.e., 1,355 participants. Their insurance price was regressed on the variables, which, according to FEMA, are most important in rate determination (see, e.g., http://www.fema.gov/nfip/premium.htm).

The house's first floor elevation, measured in feet, relative to the 100-year flood (denoted *Elevation* and obtained in the on-site survey) should have a negative effect. A dummy variable that was one if the house was constructed subsequent to the community's admittance into the NFIP (denoted *post-FIRM* and determined from the mail survey in conjunction with program information from FEMA) should be negative, and a dummy variable for whether the house was located in the *V* ("velocity") flood zone (denoted *Vzone* and obtained from FIRM maps) should be positive. However, houses located in a *Vzone* and also were constructed in the *post-FIRM* period should pay more. An interaction dummy variable for this effect (*Vzone-FIRM*) should have a positive coefficient. Houses located in a B or C zone should pay less, so the dummy variable denoted *Bzone* should have a negative coefficient. All remaining houses were in the normal Azone. If the house was elevated on piles above the ground its price will be lower, so the *Elevated* dummy variable (obtained from the on-site survey) should have a negative effect. Houses that had an obstructed ground floor area were charged more, so the *Obstruction* dummy variable (also obtained from the on-site survey) should have a positive effect. In addition, a series of 49 dummy variables accounted for community-specific effects such as the local loss history. These represent the communities among the nine coastal counties. Virtually none of the properties in the sampling frame had a basement. Construction codes in coastal areas probably prohibit basements, and this otherwise-important variable was not included. The estimated equation (omitting the community dummies) is in Table A1.

TABLE A1
Summary Statistics and Regression Results for Generated Regressor

Variable	Average	Standard Deviation	Expected Effect	Beta Coefficient	Standard Error
Intercept				−0.980	0.042*
Vzone	0.421	0.563	+	0.530	0.047*
Bzone	0.119	0.370	−	−0.189	0.059*
Post-FIRM	0.534	0.569	−	−0.642	0.043*
Vzone-FIRM	0.259	0.500	+	0.682	0.059*
Elevated	0.545	0.568	−	−0.128	0.039*
Obstruction	0.243	0.490	+	0.212	0.037*
Elevation	3.24	4.520	−	−0.011	0.003*

Note: N = 1,355 properties. $R^2 = 63.4$ percent. *Indicates rejecting the null hypothesis at the 5 percent significance level. Condition number = 9.09. Goldfeldt–Quandt test of heteroscedasticity was insignificant.
Dependent variable: Natural log of the annual price of insurance per $100 of coverage.

This regression yielded a model with significant effects for each of the independent variables, and they all has their hypothesized signs. In addition, 16 of the 48 community dummy variables were significant at the 5 percent level. The condition number of 9.09 does not indicate a collinearity problem. The Goldfeld–Quandt test for heteroscedasticity was applied to the model, and the F-statistic of 1.069 did not indicate a problem. The intercept reflects homes located in the Azone, homes built before the publication of FIRMs, the excluded baseline community of Galveston, Texas, plus the baseline cases for the remaining dummy variables. The model was examined for potential problems from collinearity, but the model's condition index of 9.5 indicated there was no problem. Additionally, no problems related to heteroscedasticity were detected. The coefficient of determination of 63.4 percent was acceptable, and the 95 percent confidence interval for prediction at the means was \$0.43 $\pm$ 0.01. This narrow confidence interval implied that a generated regressor approach is useful in overcoming our data problem (i.e., lack of an insurance price for nonparticipants). Thus, in the model of NFIP participation the variable, *Price* is the predicted price of flood insurance, calculated using each property's risk characteristics, and a negative effect on participation is expected.

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