Modeling the Decision to Buy Flood Insurance: An Empirical Analysis for Coastal Areas

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Abstract

A perennial question about the NFIP is: how can participation be increased? An empirical analysis reveals that in coastal areas the voluntary participation rate is only nine percent and identifies important determinants of the insurance purchase decision. It suggests that insurance will not discourage undesirable risk management practices in coastal areas.

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Introduction

The US Congress is considering changes to the National Flood Insurance Program (NFIP) that involve altering the rate structure and/or the eligibility of coastal properties. Integral to understanding the probable effects of such changes are the relationships that exist between household behavior regarding risk, community response to erosion and flooding hazard, and legal provisions regarding coastal development. In an attempt to help clarify these interactions, this analysis deals with the household flood insurance purchasing decision and how it relates to other measures of risk reduction (including community response to coastal hazards) and particular aspects of flood and erosion risk.

Part of the original intent of the NFIP was to provide incentives which encouraged more responsible development of the coast. While the NFIP provided insurance where none had been offered by the private sector, it also sought to improve building standards so that coastal development would be better suited to deal with coastal hazards. Part of the motivation behind this move seems to have involved internalization of negative externalities relating to the costs of development in hazardous areas, in particular - disaster assistance. So, it seems the NFIP has attempted to alter the nature of coastal development by first providing insurance which increases the costs of living on the coast (essentially attempting to equalize the marginal social costs of coastal development with the marginal private benefits), and secondly, by providing building standards which should improve the survivability of coastal housing during hazardous events. An important objective of this analysis is to provide some empirical evidence relating household decisions involving risk to the NFIP and the terms that the insurance is offered under. In particular, we seek to address the question of whether NFIP would lose many customers if it raised the price of insurance to an actuarial level.

There are three important issues involved in specifying a model of insurance purchase behavior. The first is to choose a theoretical framework for explaining individual choice. The second is to link the theoretical framework for individual choice to the empirical specification appropriate for the degree of aggregation of the best available data. The third is to select the explanatory variables which capture the most important influences on that choice. These issues are dealt with in turn.

Theoretical Approach

Estimating the market demand for flood insurance product is problematic because each potential customer has unique risk characteristics and attitudes toward risk. Therefore, the decision to purchase insurance is governed by variables that are not directly observable. This situation has been modeled within an expected utility maximization framework in standard economics textbooks (see, eg., Varian, 1984 or 1994). The essentials of the model are presented here.

Suppose the coastal dweller owns property that is valued at W and suppose that she has a subjective probability p that a flood will cause a capital loss L. The property owner can buy insurance that will pay her an amount q if the loss happens, and the insurance will cost her a premium equal to πq, where π is an actuarial estimate of the loss probability. The main question in demand estimation is: how much coverage will the property owner buy? This is found by formulating the expected utility model:

$$\max \; p u(W - L - \pi q + q) + (1 - p)\, u(W - \pi q)$$

which posits that the property owner's expected well-being is the probability-weighted sum of her monetary well-being under both of the outcomes. Maximized expected utility is found by differentiating this function with respect to the level of insurance coverage, q, and setting the first order condition equal to zero:

$pu'(W - L + q^*(1 - \pi))(1 - \pi) - (1 - p)\, u'(W - \pi q^*)\pi = 0$, or

$$u'(W - L + q^*(1 - \pi)) \div u'(W - \pi q^*) = (1-p)/p \times \pi/(1 - \pi) \qquad (1)$$

where u' is the first derivative of utility and q^* is the optimum coverage. This condition states that the property owner will purchase insurance coverage up to the point where her marginal rate of substitution between consumption in the two outcomes is equal to the price ratio. The expected profit for the insurance company is equal to :

$-p(1 - \pi)q + (1 - p)\pi q$

where the company receives $\pi q - q$ if the loss occurs and it receives πq if it does not. Administrative costs are assumed to be zero. If conditions in the insurance industry are sufficiently competitive then economic profits will be zero:

$-p(1 - \pi)q + (1 - p)\pi q = 0$

$p(1 - \pi) = (1 - p)\pi$ or

$$(1 - \pi)/\pi = (1 - p)/p \qquad (2)$$

Since the company is just breaking even on the contract it must be charging an actuarially fair rate, where the price of insurance is equal to its expected value, and $p=\pi$. Substituting (2) into the first order condition in (1) yields:

$u'(W - L + q^*(1 - \pi)) \div u'(W - \pi q^*) = 1$ or

$u'(W - L + q^*(1 - \pi)) = u'(W - \pi q^*)$

so that the marginal utilities of a dollar are equal regardless of whether the loss occurs or it does not.

If the property owner is risk averse then the expected utility function is concave, or $u''(W)<0$. This means she will receive more utility from the certainty of using her current wealth versus the utility of using that wealth subject to the probability p, and thus will seek to insure herself. If the marginal utilities in each state are equal, then under risk aversion it follows that the total amounts of wealth in each state must also be equal:

$$W - L + q^*(1 - \pi) = W - \pi q^*, \text{ or}$$

$$L = q^*$$

and the property owner will purchase an amount of insurance coverage that fully protects against the potential loss. On the other hand, a risk loving homeowner would prefer the prospect of uncertain wealth rather than the certain outcome and therefore would have no motivation to buy insurance. It is noteworthy that this result of full insurance protection depends on the existence, rather than the degree, of risk aversion. This is because while a property owner may be risk averse, she will probably not buy coverage in excess of the loss because she probably has better competing investment opportunities.

This prediction of full insurance is at odds with the experience of the NFIP. Since its inception, a problem facing the NFIP has been the lack of participation in the program by property owners at risk of flood losses. Brown and Hoyt (1999) review the history of claims and find that in the average year between 1983 and 1993, less than ten percent of flood losses were covered by insurance. In the Mississippi River flood of 1993, less than $1 billion of the $12 billion total damages was covered by federal flood insurance. This experience is shared by the Federal Crop Insurance Program, where in 1993 the participation rate was 35 percent of eligible acres, even though the average premium is subsidized by 30 percent (Barnett and Skees, 1995). The mandatory purchase provisions of the Flood Disaster Protection Act of 1973 and the Reform Act of 1994 are efforts to increase the protection of flood prone property.

There are five contributing reasons why the NFIP does not have higher participation among owners of flood prone property. Lewis and Nickerson (1989) find that government disaster relief programs provide a disincentive for purchasing flood insurance. 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. In terms of the utility maximization, the effect of disaster relief would be to reduce the expected loss L to a lower level and the optimal coverage q^* would be reduced, perhaps to zero if the relief effect is strong enough.

Kunreuther (1984) argues that people tend to underestimate their chances of being a disaster victim. This might result from their having little or no previous experience with flooding damage. If their subjective loss probability is too low, then $p < \pi$ and actuarially-priced insurance would appear to be too expensive. The amount of subsidy required for high rates of program participation is probably untenable.

A third reason comes from the results of MacDonald, et al. (1987), where they raise the possibility that NFIP under-compensates for losses. In their case, they show that a property buyer would desire more of a risk-reducing property characteristic so he could protect himself against this monetary loss. In the context of the demand for insurance model presented above, under-compensation would mean that $L > q$, so there would not be full insurance and insurance demand would be reduced from what it would otherwise be.

A fourth reason could be that coastal property owners view the expected value of the potential loss as only a small part of their total wealth. If this is the case, then they could effectively self-insure themselves against the loss. Evidence that coastal property owners are wealthy is presented later, so this is a real possibility.

Finally, the model's results only apply to risk averse individuals. If certain properties attract risk-taking buyers, such as the properties at the ocean's edge, then that would be another factor reducing the demand for insurance. However, the results of Kriesel, Randall and Lichtkoppler (1993) from a hedonic price model of lakeshore properties suggest that buyers tend to put a premium on properties that are better protected from flood and erosion hazards. This risk premium could not exist unless the buyers were risk averse. Therefore, market domination by risk-loving buyers is probably not a leading cause of low participation in NFIP.

Empirical Specification

Empirical analysis of the insurance purchase decision can be based on a model of random utility maximization. The utility of the *i*th household if flood insurance (subscripted by *v*) is purchased is given by $U_{iv}(\mathbf{q}_v, c_v, \epsilon_v)$ 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 $U_{ip}(\mathbf{q}_p, c_p, \epsilon_p)$. 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 $U_{iv} < U_{ip}$ Because of the presence of the error term, U_{iv} and U_{ip} are random variables. Therefore, the dependent variable in this study is the proportion of homeowners who purchase flood insurance. This is given by $\rho_j =$

$(\sum P_{vj})/N_j$, where N is the total number of homeowners and the subscript j denotes the coastal community.

Our dependent variable is a proportion, and each observation actually represents the sum of individual choices by underlying populations of varying size. OLS estimates will therefore suffer from problems of heteroscedasticity, and will be inefficient although unbiased (Greene, 1993). There are two estimation methods that can be applied to this type of data set: (a) weighted least squares and (b) maximum likelihood estimation.

In the weighted least squares approach, the dependent variable is the log odds of purchasing flood insurance $\ln [P_j / (1 - P_j)]$, where P_j is the aforementioned proportion of properties that have flood insurance in community j. According to Gujarati (1995, p.558), the weights are provided by a consistent estimator of the variance of the heteroscedastic errors:

$s_j^2 = N_j P_j (1 - P_j)^{-1}$.

where N is the number of observations in group j. The estimated equation takes the form:

$s_j^{-1} \ln[P_j / (1 - P_j)] = s_j^{-1} \alpha + (s_j^{-1} \mathbf{X}_j) + u_j$.

The maximum likelihood estimation is described in Greene (p. 654). For these data, the log likelihood function is:

$\ln L = \sum_j N_j [P_j \ln F(\mathbf{B}'\mathbf{X}_j) + (1-P_j) \ln(1 - F(\mathbf{B}'\mathbf{X}_j))]$

where F is the cumulative distribution function. This was estimated using Proc Logistic within SAS.

The sampling frame for this study consisted of eighteen coastal counties that were selected by FEMA. Within these counties, approximately 11,000 properties were selected randomly for inclusion in the study. For each property, a team of surveyors collected on-site data, another team collected descriptive data from county courthouses, and we mailed survey questionnaires to the property owners during 1998-99. An overall response rate of 39 percent to our mail survey was obtained. In addition we had access to the Federal Insurance Agency's (FIA) data base for policies in force for all policy holders in the 18 counties.

In choosing the unit of observation it is preferable to use a definition of "coastal community" which yields a geographically small unit with more sample variation than a larger unit, such as a county, could provide. Therefore, we used the smallest unit available in our data sets, the "gps_city" as defined by the U.S. Census. Another alternative was to use the FIA's definition of community. However, this would have produced larger units of observation with many properties lumped together in unincorporated parts of their respective counties.

Before deciding whether to buy flood insurance, each property owner must evaluate the availability and pricing of flood insurance and make a decision based upon risk preferences and their personal assessment of coastal risk and substitute protection measures (which can include building standards and community protection projects like sand nourishment, structural fortification, and dune restoration). The variables we use in this model of participation rates are described below.

1. *Participation* - the dependent variable. The proportion of properties in a community with flood insurance. An observation from the sampling frame was deemed to have a NFIP policy if (a) its address had been matched with an observation from the FIA data set, or if (b) the survey respondent indicated they had flood insurance. Source: Federal Insurance Administration's policy data for 1997, and survey questionnaire data.

2. *Price* - the average price of flood insurance in the community per $100 of coverage. If the price charged by NFIP is an actuarially fair rate, then *Price* would be a perfect linear combination of variables that reflect the property's riskiness, and *Price* would add no

additional explanatory power to the model. However, the rate charged by NFIP deviates from an actuarially fair one because there are administrative costs, Increased Cost of Compliance coverage, and the community probation surcharge. Also, an out-of-date FIRM may place a property in the wrong rating class. A negative effect is expected. Source: Federal Insurance Administration's policy data for 1997, and survey questionnaire data.

3. *Income* - average income in the community, as calculated from the survey questionnaires. Communities with more income should be able to readily afford insurance. However, richer communities may also be able to self-insure their property. If the former effect outweighs the latter, then *Income* should have a positive effect on NFIP participation. Source: survey questionnaire data.

4. *Waterfront* - percent of properties that have frontage on the water. This variable should have a positive effect on participation as ocean-front homes should face a higher risk of flooding and erosive undermine, all else being equal. Source: on-site survey of properties.

5. *Armor* - percent of survey returns indicating the existence of coastal armoring at the nearest shore. Coastal armoring could serve, similar to nourishment, as a signaling device which suggests to people the hazards of living in the coastal zone. This would induce higher participation. However, if coastal residents view armoring as a substitute protection measure, armoring could motivate lower participation. Source: survey questionnaire data.

6. *Sand Nourishment* - percent of survey returns indicating that the nearest shore has been nourished. Beach nourishment could serve as a substitute for flood insurance if individuals believe such projects decrease the risk of flooding and erosion hazards (assuming erosion risk motivates participation). On the other hand, such projects could serve to educate the

coastal populace about coastal hazards making them more likely to seek out insurance. Source: survey questionnaire data.

7. *Elevation* - average elevation above current base flood elevation. This is a standard measure of flood risk, and it should have a negative effect on participation. Source: on-site survey of properties.

8. *Erosion Rate* - average 60-year erosion rate in the community. A community with a higher erosion hazard should have higher insurance participation. Note that the *Geotime* variable was not used. This is because the second component of *Geotime*, the setback distance, has a near-zero variance across the set communities because of the sampling procedure. Source: on-site survey of properties.

9. *Built Post-FIRM* - the percent of houses built after the FIRM was promulgated. Building codes to ensure flood resistance are instituted when communities enter the NFIP (after a flood insurance rate map (FIRM) has been completed). If property owners view a flood-resistant house as not needing flood insurance, then communities with higher proportions of post- FIRM houses should have lower participation in NFIP. Furthermore, a house that is built *Post-FIRM* is not supposed to have any part of its insurance premium subsidized, whereas older houses might be grandfathered into a lower rate. This price effect should be a disincentive for newer houses to be insured. Source: on-site survey of properties.

10. *Hurricane Interval* - the mean return period for landfall or nearby passage of a hurricane. This variable should control for how communities differ in their experience with the flooding hazard, and whether their subjective probabilities are accurate. Source: FEMA, 1998.

11. *Mortgage* - the percent of property owners who indicated that they were required to buy flood insurance by their mortgage lender. This is an obvious explanatory variable which should reflect the FDIC requirement of flood insurance for mortgaged properties, and it should have a positive effect on participation. Source: survey questionnaire data.
12. *CBRA* - the percent of properties located in a CBRA area where the house was built after 1983. By law, these properties are prohibited from participating in NFIP, so *CBRA* should have a negative effect. Source: on-site survey of properties.
13. *West* - a dummy variable that is one if the community is in California or Oregon, and zero otherwise.
14. *Gulf* - a a dummy variable that is one if the community is in Texas or western Florida, and zero otherwise.

These variables are similar to the ones employed by Brown and Hoyt (1999) where they investigated participation in NFIP using a pooled time series and cross sectional data set composed of the 50 states, for the years 1983 to 1993. In addition to these variables they also included one that measured the likelihood of government disaster relief, with the hypothesis that this would serve as another substitute for formal insurance. However, while the time-series aspect of their data set contained variation in relief expenditures, our data set does not so it was pointless to include the variable.

Empirical Results

Information from all three data sources, the on-site survey, the FIA policy data and the survey questionnaires, were utilized in this analysis. From the 19 counties for which we have completed data sets, we were not able to use any counties from the Great Lakes region because very few properties in those counties had flood insurance. In addition to these, 16 communities in other regions had participation rates of zero and these had to be excluded from the analysis because no insurance price variable could be calculated for them. From the remaining 12 counties there were 62 communities with complete data that were used in the regression analysis. The data used in this analysis are community-wide averages that are compiled from 7,521 individual properties.

The summary statistics of the variables used in the participation regression are presented in Table 1. In the average community in this sample, 40.4 percent of the properties from our sampling frame of 10,000 have flood insurance, and this varies from 1.4 up to 81 percent. *Insurance Price* has an average of $0.45 per $100 coverage and this varies from a low of $0.09 to a high of $1.23. Since all of these properties, by definition, are located in a 100-year flood zone, the actuarial rate for their insurance should average at least $1 per $100 coverage. Thus, the amount of subsidy for these properties is significant.

In the average community, 40 percent of the properties are on the water front. It is interesting to note that 31 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 all the owners for whom insurance was not required only eight percent elected to buy flood insurance.

The regression results are reported in Table 2. The weighted least squares model performs quite well with a 76 percent r-square, and three of the twelve independent variables are significant at the 0.2 percent level, another two are significant at the 0.05 level, and two are significant at the 0.001 level. These variables are *Income*, *Waterfront*, *Armor*, *Elevation*, *Built Post-FIRM*, *Mortgage,* and *Pacific* and they have their hypothesized signs. The maximum likelihood procedure produced betas that are very close to the weighted least squares, but the standard errors are reduced by half. As a result the significance levels for all the variables are much higher. In addition to the variables that were significant before, *Hurricane Interval* and *Gulf* join the list.

The results suggest that communities with a higher proportion of water front properties will have higher participation rates. Those with a higher proportion of houses built after publication of the FIRM will also have higher participation in NFIP, and this result is contrary to our expectation that people would be less inclined to keep a policy for a house that is damage resistant. Apparently, people buy insurance for these newer houses as a result of the mortgage requirement and they tend to keep the policies in force. The fact that the house is more resistant to storm damage provides little disincentive for buying insurance. Furthermore, it can be concluded that property buyers do not tend to view a house's damage resistance as a substitute for formal insurance, but rather resistance might be a complementary good.

Table 2's results also suggest that communities where more mortgage borrowers had been required to buy the insurance will have higher participation rates. This effect had also been hypothesized by Brown and Hoyt (1999) and the authors of the GAO report (1983), but to their surprise 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 inexact relationship between FHA mortgages and flood insurance requirements. Also, Kunreuther (1996) has noted that the requirements are easily avoided.

Communities with more houses built after 1983 in *CBRA* areas have higher participation. This positive effect was not expected, but it is not signficantly different from zero. Communities with higher average incomes have higher participation rates, so flood insurance is a normal good.

If higher incomes had been associated with lower participation, this would have been evidence in favor of self-insurance as a reason for low participation in NFIP, however this is not the case.

There are four property characteristics that are potential substitutes for formal insurance. *Armor* and *Sand Nourishment* and *Elevation* all have a negative effect on NFIP participation. This means that communities that have more properties with these types of protection have less NFIP participation, implying that they are substitutes for flood insurance. Also, as the community's average erosion rate decreases so does its participation, so that natural erosion resistence could also be an insurance substitute. However, of these four variables only *Armor* and *Elevation* are weakly significant and the other two show no significance. This result, that there is no strong evidence that certain property characteristics might be insurance substitutes, tends to agree with the result of our other, separate hedonic price analysis for these properties (Kriesel, Landry and Keeler). That result showed that even though property buyers have the option of buying insurance, they still place price premiums on properties with natural and/or man-made protection from flooding and erosion risks. This result is incompatible with the notion that natural protection and formal insurance are equal substitutes in providing asset protection. As in the hedonic model an explanation for this could be that buyers regard flood insurance as incomplete asset protection. The model of expected utility maximization presented earlier in this paper suggested that homeowners will seek to insure themselves fully and as a result they prefer having natural protection in addition to flood insurance. Therefore, formal insurance is probably a complement to natural and/or man-made risk protection.

Because our data lacked variation, a direct test of how disaster relief programs affect participation was impossible. However, we can say that relief programs probably do not have a major role in reducing NFIP participation. If the role had been very important, then we should have observed zero impact from *Armor* and *Elevation.* This is because disaster relief would not only reduce NFIP participation but it would also crowd out the protection offered by natural flood and erosion protection. This proposition is reinforced by our hedonic modeling results. There, if buyers were forming their bid prices with the expectation that disaster relief would reduced their risk to zero, then there could be no price premiums for properties with *Geotime* and *Elevation*, but that was not the case.

Of particular importance is the effect of *Price* on NFIP participation. In Table 2, the *Price* coefficient is positive, contrary to our expectations but the effect is never significantly different from zero. Previous studies of NFIP participation have shown a low degree of price responsiveness. Brown and Hoyt estimated a price elasticity of -0.320, 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 estimated price elasticities ranging from -0.14 to -0.33. Our results do not refute those findings of a low price response.

A more clear-cut test of price responsiveness could have been performed by deleting from the data set those mortgage borrowers who had been required to buy flood insurance. Then, the analysis would be performed on only those property owners who had discretion about their insurance participation. However, while it is easy to identify these observations from the survey questionnaires it was impossible to identify them from the FIA data. This inability to weed out completely the mortgage borrowers would have yielded results that were misleading.

If FEMA were to change substantially the premiums for NFIP policies, how would property owners react, given that the range of our insurance prices was from a low of $0.09 to a high of $1.23, and the average was $0.45? We feel that price increases within this range would probably not cause significant reaction by NFIP policy holders. Higher price increases would probably cause outrage among some policy holders and they might cancel their policies. However, the owners who might do this are the ones not required to have insurance and they amount to only eight percent of properties at risk of flooding. If price increases were phased in over a period of a few years, FEMA could probably avoid complaints and bad publicity.

These conclusions were reached because the data suggest that people are motivated buy flood insurance for reasons other than price, such as whether they are water front, the mortgage requirement, etc. If the opposite occurred and FEMA lowered prices, we doubt that property owners would respond by buying more policies. Indeed, NFIP was characterized by very low participation in the 1970's when policies were highly subsidized.

Conclusions

This model of participation in NFIP has been formulated to address a very specific question: If insurance rates were raised to actuarially fair levels, how many people would opt out of NFIP? A result from this model is that the average price of insurance (per $100 coverage) in the community does not have a statistically significant effect on participation in NFIP. Price insensitivity is a result almost guaranteed because the data reveal that out of all the people in these flood-risk areas who were not required to buy flood insurance, only eight percent purchased it voluntarily. Other factors such as the requirements by mortgage lenders and the property's *Waterfront* status have a more important role than *Price* in determining the decision to buy flood insurance. The mortgage requirement will probably not encourage more participation in the future because so many coastal properties are bought with cash. This result is from the hedonic price model reported in Kriesel, Landry and Keeler, where it was estimated that 34 percent of coastal properties were purchased with cash, versus a national cash-purchase rate of 11 percent.

In the introduction, five reasons were cited for low participation in NFIP: (1) property owners think that government disaster relief programs will compensate them, (2) owners systematically underestimate their subjective probabilities of loss, (3) owners' perceptions that NFIP undercompensates for losses, (4) owners can self-insure, and (5) owners of coastal property are risk takers. Of these five reasons, our results can only refute the fourth and fifth as major causes.

The fourth reason is ruled out because higher incomes are associated with higher participation, so self-insurance cannot be predominant. Concerning the fifth reason, if risk loving preferences prevailed among these owners, then our finding that *Armor* and *Elevation* are negatively associated with participation could not have been made. Furthermore, these variables could have had no effect in the hedonic price models for these properties unless buyers tended to be risk averse.

Concerning reasons (1) and (2) we doubt that they reduce NFIP participation in a major way. Again if they had been big influences then we could not have observed any significant role for risk-reducing property characteristics in these results or the hedonic results. This leaves reason #3, undercompensation by NFIP, as the most likely major cause of low participation with the other three factors having minor contributions to the problem. As noted by anyone who has experienced a car accident, undercompensation is an inherent feature of all insurance.

The finding of the unimportance of insurance price in this model of NFIP participation and the hedonic price model agrees with the historical experience of NFIP. Many of the articles on NFIP from the early 1970's 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 recently when its purchase was made mandatory under mortgage requirements, and the benefits of NFIP were advertized to the public.

The final implication of these results is what they mean for preserving fragile coastal environments. It has been noted that good beach conditions cannot coexist with artificial erosion protection structures such as seawalls and groins. Thus, as owners protect themselves from flooding and erosion risks they also contribute to beach and ecosystem destruction. If it could have been shown that formal insurance is a substitute for the property protection afforded by seawalls, then a wide range of policy tools to encourage higher participation in NFIP would have the beneficial side-effect of reducing seawall construction. However, this is not the case. Our results show a positive relationship between man-made risk-reducing attributes and formal insurance. This indicates that insurance availability will not reduce seawall construction and other methods of limiting human impacts on coastal ecosystems must be investigated.

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Table 1: Summary Statistics of Variables Used in the NFIP Participation Model, 62 Coastal Communties, 1999.

Variable	Mean	Standard Deviation	Minimum	Maximum
Participation Rate	0.404	0.204	0.014	0.811
Price ($/$100 coverage)	0.455	0.282	0.094	1.236
Income (thousands)	106.132	37.643	28.958	203.416
Waterfront	0.404	0.173	0.012	0.801
Armor	0.185	0.229	0	1
Sand Nourishment	0.295	0.310	0	0.947
Elevation (feet)	10.143	17.931	-4.651	84.389
Erosion Rate (feet/year)	2.173	2.597	0.010	13.633
Hurricane Interval (years)	32.376	41.788	3.900	97.000
Built Post-FIRM	0.671	0.269	0.047	1
Mortgage	0.317	0.207	0	0.768
CBRA	0.028	0.078	0	0.379
Pacific Region (0-1)	0.209	0.410	0	1
Gulf Region (0-1)	0.209	0.410	0	1

Table 2: Regression Results for the NFIP Participation Model, 62 Coastal Communities, 1998-99. (Dependent variable: proportion of the community's properties protected by flood insurance)

	Weighted Least Squares Estimates		Maximum Likelihood Estimates	
Variable	Beta	Std. Error	Beta	Std. Error
Intercept	-2.305	0.525***	-2.427	0.253***
Price ($ per $100 coverage)	0.059	0.334	0.094	0.165
Income (thousands)	0.005	0.002**	0.005	0.001***
Waterfront	0.683	0.464*	0.719	0.226***
Armor	-0.443	0.347*	-0.471	0.169**
Sand Nourishment	-0.095	0.280	-0.108	0.132
Elevation (feet)	-0.009	0.007*	-0.010	0.003**
Erosion Rate (feet/year)	0.002	0.024	0.002	0.012
Hurricane Interval (years)	0.002	0.002	0.002	0.001*
Built Post-FIRM	1.450	0.363***	1.539	0.176***
Mortgage	1.571	0.535**	1.608	0.256***
CBRA	0.548	1.194	0.693	0.580
Pacific Region (0-1)	-1.315	0.362***	-1.343	0.174***
Gulf Region (0-1)	-0.241	0.207	-0.266	0.102**

N = 62 cities; * indicates that the variable is significant at the 0.2 level or lower, ** is significant at the 0.05 level, and *** means it is significant at the 0.001 level.