Expanding the National Flood Insurance Program to Cover Coastal Erosion Damage

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Abstract

The National Flood Insurance Program does not currently cover damage strictly attributable to coastal erosion. This paper uses the results of a nationwide survey of coastal property owners to estimate the demand for such insurance. We find that there is significant demand at prices in the range of current flood insurance premiums. Demand is influenced in the hypothesized way by increased measures of erosion risk as well as by insurance price and income.

Introduction

The National Flood Insurance Program (NFIP) underwrites flood insurance in areas that have been designated as experiencing frequent flooding risk. It is the federal government's response to the informational and adverse selection problems associated with the private sector's provision of flood insurance. Before the NFIP, the insurance industry offered very limited flood insurance, probably because little was known about the actuarial components of flood risk and because the catastrophic nature of floods can bankrupt insurance companies. Lack of private sector insurance was also due to the fact that property owners would not be willing to purchase flood insurance unless capital losses were expected in the near future - thus leading to the adverse selection problem. Because of these factors, flood insurance was not widely available until there was participation by the Federal Government.

A number of refinements have been made to NFIP over the years. The 1973 Flood Disaster Protection Act required the purchase of flood insurance for properties which received federally-backed aid of some sort (e.g., FDIC-backed home loans). This move prompted much higher participation in the program. Further refinements included the Coastal Barrier Resources Act of 1982 which delineated sensitive environmental areas along the coast and disallowed the provision of federal flood insurance in these areas.

Another refinement currently being investigated involves coastal erosion hazards. Presently, the conditions under which a flood claim will be approved are quite specific. A 'general condition of flooding' (i.e., rising water levels) must be associated with the loss event, and the flooding must affect at least two acres or at least three contiguous properties. Along an erosion-prone coast, where reduced setback distance has undermined buildings and made them susceptible to damage, there are two possible outcomes that can result when a property owner files an insurance claim. In the first case, if the damage occurs during a flood-causing storm the claim will probably be paid. In the second case, if erosion-induced undermining and damage takes place during a time when there is no widespread flooding, then the damage claim is supposed to be denied. This latter condition has become known as 'sunny day loss' and presents a problem for the NFIP and for property owners. The conditions create an incentive for property owners to stave off erosional undermining until the next storm event, at which time erosional losses become flood-related and are covered under their flood insurance policy. The number of property owners who behave this way is not known, but the Federal Insurance Administration (which administers the NFIP) is concerned about this problem and the effects it may have on the NFIP budget.

For society at large the lack of sunny day loss insurance is also a problem. This is because property owners construct sea walls, groins and other devices to protect their property. There is substantial evidence that sea walls cannot coexist with attractive recreational beaches. If it can be shown that erosion insurance would serve as a substitute for the protection afforded by sea walls, then beach degradation may be prevented by the provision of such insurance. Also, an insurance scheme for erosion losses could serve as a way to finance the compensation paid to property owners who suffer losses resulting from enforcement of minimum setback requirements of the type advocated by proponents of a policy of "shoreline retreat" (Pilkey and Dixon, 1996). For all of these reasons, it is a highly relevant to investigate how an insurance market for sunny day loss insurance would actually function. In this paper, we use the results of an extensive survey of homeowners in erosion hazard zones to estimate the determinants of demand for this kind of insurance.

Theoretical Background

Each potential insurance customer has unique risk characteristics and attitudes. Therefore, the price she would be willing to pay for erosion coverage is a unique one. This situation has been modeled within an expected utility maximization framework in standard economics textbooks (see, eg., Nicholson, 1997). The essentials of the model are presented here.

Consider an insurance market that operates with no transactions costs or industry profits. Assume a coastal property owner with the utility of income curve in Figure 1. Suppose this individual owns property that is valued at W and suppose that she has some subjective probability p that erosion will cause a capital loss L. The property owner is offered insurance that will pay her L if the loss happens, and the insurance will cost her a premium equal to πL, where π is an actuarial estimate of the loss probability.

Assuming the property owner has diminishing marginal utility of income, then $u''(W)<0$ and she is risk averse. This gives the utility curve in Figure 1 its concave shape. Suppose there is probability $\pi=0.5$ that she will suffer erosion damages that would leave her with $W-L$. Her expected wealth is then $W- .5L$ and her expected utility would be U_1. If she bought an actuarially fair insurance policy that covered a loss of size L, she would pay a premium equal to the expected value of the loss, πL, and she would be assured of wealth equaling $W-\pi L$. This level of certain wealth would give her utility at U_2, so the insurance purchase would clearly make her better off. Note that the more risk neutral the property owner is, the less curvature in her utility function and therefore the smaller utility gain from purchasing insurance at a price of πL.

In the real world the price of insurance will be greater than πL. This will occur because the NFIP and local agents must keep records, investigate claims and bear other costs, and earn normal profits. Therefore, the insurance offer price will be equal to $\pi L+ \alpha$, where α represents loading for administrative costs. Given that insurance prices must always exceed the price implied by an actuarial risk assessment, a property owner would still decide that she could benefit from the insurance depending upon her assessment of erosion risk (p) and her degree of risk aversion. According to Figure 1, she would pay an additional amount (over and above pL) given by ψ and still benefit from having insurance. ψ and α are both scalars. ψ reflects risk aversion and increases or decreases willingness to pay (WTP) for insurance depending upon its sign (increasing ψ *implies* higher levels of risk aversion) and α changes the offer price of insurance.

A property owner's maximum WTP will be an amount that gives her a utility level above U_1. Individual annual WTP is $pL+\psi$. In the context of Figure 1, she will purchase insurance at a price less than or equal to $\pi L+\alpha$, implying that her maximum WTP ($pL+\psi$) is at least $\pi L+\alpha$. If π and p are the same (or reasonably close), then the important relationship becomes that between ψ and α. If $\alpha > \psi$ then the insurance offer price greater than the individual's WTP and she would not benefit by purchasing such coverage. In this case, she would refuse the offer. However, if $\alpha < \psi$ then the individual's maximum WTP would be above the offer price and she would accept the coverage offer. This logic is crucial in the estimation method presented later, where individuals are offered erosion insurance at random prices.

An important factor which could affect the demand for erosion insurance is the existence or absence of other erosion protection measures. Seawalls, groins and other man-made structures (including beach nourishment projects) can potentially reduce short-term, immediate erosion risk. In a hedonic price study of properties on the coast of Lake Erie, the presence of natural and/or man-made erosion protection was shown to affect property price (Kriesel, Randall and Lichtkoppler, 1993). This implies that a typical property buyer considers erosion characteristics in forming her bid price. By extension, she would probably also consider their role in reducing the chance of suffering an *immediate* erosion loss. In terms of the insurance demand model, this would reduce her subjective probability of suffering a near-term erosional loss, *p*, which would thus reduce her WTP for erosion insurance.

On the other hand, erosion mitigation measures can be viewed as short-term solutions to a chronic problem (especially in light of the threat of sea level rise). In this respect, erosion insurance could be a complement to erosion protection measures. Protective structures could be seen as defensive mechanisms which 'buy more time' on the ocean front, with the holding of erosion insurance used as protection from total economic loss during an acute disaster event or with the realization of chronic shoreline recession. Thus, protective structures could be complementary to erosion insurance, the former valued for protection from short-term risk and the latter held for protection from long-term risk. If this were an accurate depiction of coastal property owners' perceptions, the latent demand for erosion insurance would probably be strong. The existence of protective structures could also induce information effects which cause homeowners to be more cognizant of erosion risk. If this were true, the presence of structures would increase *p* which would increase the demand and WTP for erosion insurance. Our data allows an empirical examination of the role of shoreline engineering projects in determining the demand for erosion insurance.

Thus, for an individual property owner the demand for erosion insurance coverage, or her willingness to pay, is determined by the size of the potential loss, her degree of risk aversion, and her subjective probability of erosion risk. This subjective probability is influenced by the historical erosion rate and the presence of erosion protection structures and beach nourishment projects. In addition, as suggested in the research by Brown and Hoyt (1999) a measure of erosion information availability was included. Individual socioeconomic characteristics, such as education and age of the property owner, also help to determine differences in risk preference.

The Method of Estimating Willingness to Pay for Insurance

Willingness-to-Pay (WTP) is an economic concept which is used to measure changes in welfare. Under certain circumstances (see Freeman,1993), it is very similar to the notion of consumer surplus which is defined as the benefit of the provision of a good, net of its current cost to the consumer. In the context of Figure 1 the property owner's maximum WTP is the insurance payment that gives her a utility level above U_1 (i.e. the utility she would have with no insurance) and this payment is equal to $pL+\psi$. The insurance industry offers a price of $\pi L+\alpha$.

In order to get an idea of the interest in erosion coverage and to estimate WTP for such coverage, a short contingent valuation-type question was included in the FEMA mail survey. It briefly described the erosion coverage problem and posed the following question:

Suppose that the National Flood Insurance Program were expanded to cover erosion damages, regardless of whether a flood had occurred.

To avoid being subsidized by tax dollars, the Program would have to charge policy holders more for this expanded coverage.

Suppose that this expanded erosion damage coverage were offered to you for an additional $______________ per year above what you now pay.

Would you purchase this coverage?

1 NO

2 YES

The \$______ space was filled in with one of 30 prices that varied from \$25 to \$30,000 The amount was manually entered onto each survey to be mailed out to property owners so that the offer price considered by any particular person was random.

WTP was estimated using the referendum question format of the contingent valuation method (see, eg. Freeman, 1993). Logistic regression is used to statistically model the discrete choice of survey respondents. The probability of a 'yes' response, indicating the individual would purchase the insurance at the offered price A (which is conceptually equal to $\pi L+\alpha$) is specified as a logistic cumulative distribution function of the random variable A. The individual response to the offer price allows the researcher to make statistical inferences about the average WTP for erosion insurance ($pL+\psi$). Explanatory variables are included to allow further analysis of the response probabilities. The logistic regression is specified as:

$$\text{Prob}\ \{\text{Yes}\} = [1 + e^{-(X'\beta\ +\ A\kappa)}]^{-1}$$

This model can be estimated with any one of the off-the-self logistic regression algorithms that are commonly available. Once this regression has been estimated the WTP can be calculated by numerical integration of the logistic function (providing mean WTP) or with Cameron's (1987) approach (providing median WTP), which is:

$$\text{WTP} = [-\Sigma\beta_j X_j] / \kappa$$

where the summation occurs over k - 1 explanatory variables (excluding the insurance offer price variable whose coefficient is κ), β_j are the estimated coefficients of those k - 1 explanatory variables, X_j are the means of the k - 1 individual and property characteristics, and κ is the coefficient of the price variable, A.

It is unfortunate that our price variable was expressed as a total price for coverage and not as a rate per \$100 of coverage. In order to standardize the price variable, it was converted to a rate using the current level of flood insurance coverage.[1] This is a good assumption to the extent that people's expectations of the size of their loss from flooding is close to their expectation of the size of their loss from erosion. If these are different, this procedure could introduce significant error in our cost-of-coverage variable.

The use of flood insurance coverage limits as a proxy for erosion insurance coverage limited the observations for this analysis to only those which had flood insurance. Analysis of NFIP participation indicated that about 40 percent of property owners had flood insurance. It was also found that 32 percent of respondents had been required to buy the insurance, implying that only eight percent bought the insurance voluntarily.

Upon estimation of the logistic regression, individual WTPs can be predicted using the parameter estimates. Thus, this approach can be used to establish estimates of the unique amount that each respondent is willing to pay for insurance against sunny day erosion loss. This unique amount is based solely on the observable individual and property characteristics which were used to estimate the logistic function. In the context of the expected utility model, the estimated WTP can be also be viewed as an upper-bound estimate of the owner's subjective probability of erosion loss p, because if WTP is equal to $pL + \psi$, so that p = WTP/L - ψ/L.

When property owners are risk-neutral, $\psi = 0$ and the estimated WTP allows us to interpret WTP/L as a measure of subjective risk assessment. The larger the risk aversion of respondents, the more this measure overstates the actual subjective risk assessment. For example, if a risk-neutral consumer whose expected loss if erosion damage were to occur is $50,000 is willing to pay an annual estimate of $1.75 per $100 coverage for erosion insurance, this implies

[1]This same assumption was used by actuaries studying the supply price of erosion insurance (Roth and Roth).

that she perceives a 0.0175 chance of suffering an erosion loss in the next year. If a consumer had an identical WTP but her ψ equaled \$300, then her subjective probability would be p + 300/50,000 = 875/50,000 or $p = 0.0115$. The upper-bound of the subjective probability approach is simply an alternative method of interpreting the WTP estimates.

Estimating average WTP as well as individual WTP of property owners will yield insights into the questions that prompted this inquiry. For example, is there a viable, self-sustaining market for this expanded coverage? Will individuals benefit if it is offered for sale? Would the insurance be an effective substitute for sea walls and other structures that degrade beaches? Does explicit knowledge of erosion trends motivate participation in an erosion insurance program?

Model Specification

Logistic regression was used to analyze the discrete choice dependent variable. The following explanatory variables were used to predict willingness to purchase erosion insurance (their expected signs are included in parenthesis) :

- Offer price of erosion insurance per one hundred dollar coverage: *Offer Price* (-)
- Income in thousands of dollars: *Income* (+)
- Whether the property owner went to college: *Higher Education* (+)
- The age of the property owner: *Age* (+)
- The years remaining until the distance between the building and the water is reduced to zero (i.e. setback distance/erosion rate, a measure of natural erosion protection): *Geotime* (-)
- Whether the homeowner is aware of the erosion rate at the nearest shore: *Erosion Information* (+)
- Whether the property is waterfront: *Waterfront* (+)

- Community shore protection projects: *Sand Nourishment* and *Armor*, (- if substitutes, + if complements)
- Regional dummy variables: *Gulf*, *Lakes*, and *Pacific* (uncertain effect)

Data

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. An overall response rate of 39 percent to our mail survey was obtained.

The analysis was limited to the 60-year Erosion Hazard Area (EHA) because this is where the at-risk properties are located. The EHA is delineated by the state’s Coastal Zone Management staff, and it is the strip of land that could disappear in the next 60 years, given the historical erosion rate. 1,818 properties were located within the EHA, of which 717 property owners had returned the mail questionnaire. The final limiting factor on usable observations was expressing the price in terms of coverage. Since the price variable was scaled by coverage amount (with current flood insurance coverage limits used as a proxy for hypothetical erosion insurance coverage limits) only observations which had a coverage amount (either from the FIA data file or from the mail survey) could be used for this analysis. This specification created a situation where only flood insurance participants could be analyzed, since coverage amounts were only available for actual participants. This further limited the analysis to 517 observations.

Of these 517 observations, 111 were missing values for one or more of the independent variables, leaving 406 usable observations (or 22 percent of sampled EHA structures) for the contingent valuation erosion insurance analysis. Of these, 164 respondents indicated a positive response to the erosion insurance question.

Table 1 is a list of the summary statistics for the usable observations. The average annual offer price was $4.65 per $100 erosion insurance coverage - a sizable increase over the current average flood insurance rate in the sample (about $0.75 per $100 coverage). The average household income in the EHA was around $141,500, versus an average of $100,000 for all respondents. The fact that owners in the EHA tend to be richer is not surprising because those properties are mostly waterfront and it is the affluent who can afford the 30 percent price premium that those properties command. The average respondent was 58 years, and 90 percent were college graduates.

The formulation of *Geotime* is simply setback divided by erosion rate, so it is a rough estimate of the amount of time that would elapse before a house would be compromised by shoreline recession in the absence of erosion protection. The average house in the sample had about 32 years of *Geotime*. Forty-three percent of the respondents claimed to have seen information on the historical erosion rate of the shore nearest their property at sometime in the past. Sixty-six percent of the properties in the model were located on the oceanfront.

The effect of a shoreline protection project was captured as a dummy variable. If this dummy variable is found to be positively related to the probability of participation then an erosion protection device could be viewed as a complement to erosion insurance. The explanation of this result could center on informational effects produced by the presence of the project. Structural protection can diminish beach width and that would heighten awareness of the erosion problem.

Shoreline protection also operates on a shorter time-horizon and with less degree of certainty than does insurance, so that the two could be complementary in that they provide the same type of service over different time-scales and incorporate both sides of an unknown outcome. On the one hand, if shoreline protection works, the property owner can remain on the coast and enjoy the amenities associated with living there. On the other hand, if shoreline protection fails, insurance protects the homeowner from total economic loss. It is also possible that shoreline protection projects could serve as substitutes to formal insurance assuming coastal residents have faith in their efficacy, in which case they would probably be estimated to have a negative effect on the probability of opting for erosion coverage. Forty-three percent of the respondents claimed that the shore nearest their property was affected by a beach nourishment project, while only eleven percent indicated that the shoreline nearest their property was armored with structural protection.

Regional dummy variables were included to account for geographical as well as geological differences in the survey areas. Fifty-three percent of the observations were from the Gulf of Mexico region, which includes Lee, FL, and Brazoria and Galveston, TX. A very small 0.4 percent of the observations were from Great Lakes counties, specifically Sanilac, MI, and Manitowoc, WI. The West Coast, represented solely by Santa Cruz, CA, comprised 2.9 percent of the sample. The remaining observations, 43.7 percent of the total, were associated with the Atlantic Coast, including Glynn, GA, Sussex County, DE, Brevard, FL, Georgetown, SC, and Dare and Brunswick Counties, NC.

Results

The logistic regression procedure produced the results in Table 2. Seven of the 12 variables included proved to be statistically significant (at the 20 percent level or lower) predictors of the willingness-to-purchase erosion coverage. Statistically insignificant variables included the education and age variables, the *Erosion Information* and *Armor* dummy variables, and the Great Lakes regional dummy variable. The model exhibited an individual prediction success rate of 85.2 percent. The model was examined for collinearity problems. None of the pair-wise correlation coefficients were greater than 0.50, and the condition number was 14. Thus, this model probably does not suffer from damaging collinearity.

The results suggest that the *Offer Price* variable was a very significant, robust predictor of the willingness to purchase erosion coverage. As expected, higher offer prices garnered less positive responses. Figure 2 illustrates this relationship by indicating the probability of buying the insurance as a function of price per $100 coverage. Interpretation suggests that a one dollar increase in the average offer price (from $4.79 per $100 coverage to $5.79) leads to a 6 percent decrease in the probability of an affirmative response.

The *Income* variable was highly significant with higher income households having a higher acceptance rate for erosion coverage. Increasing income by $1,000 over the average of $141,000 leads to a 0.084 percent increase in the probability of purchasing erosion coverage. It is more interesting, however, to examine larger changes in income. For example, moving from an income of $120,000 to $160,000, produces a 3.38 percent increase in the probability of opting for erosion coverage.

The *Geotime* variable was statistically significant with the expected negative sign. Properties with higher *Geotime* face less erosion risk in the near-term, and generally speaking, they displayed a lower probability of opting for erosion insurance coverage. A one year increase in the average *Geotime* (from 32 to 33 years) leads to a 0.24 percent decrease in the probability of purchasing erosion coverage. *Geotime* exhibited a negative overall trend, but the highest acceptance rates were associated with around 20 years of *Geotime*. The *Waterfront* dummy variable proved to be statistically significant and positive, indicating that ocean-front property owners were more willing to purchase erosion coverage, all else being equal. This is probably due to their direct exposure to erosion risk. Through manipulation of the ocean-front dummy variable, we can estimate that ocean-front homeowners have a 9.94 percent higher probability of opting for erosion coverage, all else being equal.

The *Sand Nourishishment* variable (representing beach nourishment projects) was estimated to have a positive and statistically significant effect on the probability of electing for erosion coverage. All else being equal, property owners in the jurisdiction of a beach nourishment project have an estimated 8.6 percent higher probability of purchasing erosion coverage. This result suggests that beach nourishment and erosion insurance are complementary in nature. The capital-intensive maintenance associated with beach nourishment coupled with the high financial costs could be serving as an informational cue on the seriousness of coastal erosion in a particular area. Further, property owners could view beach nourishment as a short-term solution to chronic shoreline recession. Concerned property owners could support nourishment efforts in an attempt to remain on the coast as long as possible (with improved beach resources nonetheless), while seeking flood insurance for protection from total economic loss during acute disaster events or chronic coastal erosion. The *Armor* variable was statistically insignificant.

The regional dummy variables for the Gulf and Pacific Coast proved to be statistically significant. The *Gulf* variable had a positive effect compared to the Atlantic region (the base case of 42.4 percent voting probability). Gulf Coast residents are estimated to have a 11.7 percent higher voting probability (around 54.1, all else being equal). Conversely, West Coast residents have a much lower voting probability, estimated at 21.2 percent less than (or about half that of) the Atlantic region.

Mean and median WTP

There are two ways to calculate WTP from the estimated logit function: its mean and its median. The mean WTP for erosion coverage was calculated by numerical integration of the estimated logistic regression curve (see Figure 2). The average annual estimated mean WTP for erosion coverage for inhabitants of the 60-year EHA is $3.25 per $100 coverage. The mean WTP measure, as noted in the literature on consumer surplus estimation, is sensitive to extreme observations in the data (also known as outliers), and since it is based upon integration it generates strictly positive values for WTP.

The median WTP is calculated using Cameron's formula, which was presented in a previous section. Conceptually, it is the price at which the probability of purchasing erosion coverage is 0.5. The median is a smaller, more conservative estimate of WTP than the mean, and unlike the mean, it can generate WTP estimates that are negative (which we interpret as zero). For the entire data set used in the analysis the median WTP for the average respondent was $1.88 per $100 coverage. An advantage of using the median is that a bootstrapping method can yield confidence intervals about the point estimate of WTP. The 99 percent confidence interval for this estimate of $1.88 was found to be between $0.83 and $2.84 per $100 coverage. Of the 406 observations in this analysis, 320 (or 78.8 percent) had a positive WTP; the rest are clustered at zero. Figure 3 illustrates the cumulative distribution of median WTP.

Both estimation methods generate a WTP that is considerably higher than the current average annual flood insurance premium of $0.75 per $100 coverage, and even the lower confidence limit of our lowest estimate is higher than the current average premium. Thus, we feel that a substantial number of property owners inside the 60-year EHA would purchase this special insurance against erosion loss. Figure 3, the cumulative distribution of predicted median WTPs, is essentially the mirror image of a sample percentage demand curve. By flipping the price axis, we can map out an estimated percentage demand curve for erosion insurance policies in the 60 year EHA. However, we have no way of telling whether the property owners would buy the insurance as soon as it were offered, or if they would delay the purchase until just before they expected the erosion damage to happen. If the later situation prevailed, then it would amount to an adverse selection problem and the stability of the NFIP fund would be jeopardized. An obvious way to avoid adverse selection would be to make purchase of the insurance mandatory.

As argued previously, it is also possible to estimate an upper bound of property owners' subjective probabilities of erosion damage. Again, in the context of the expected utility model, the estimated WTP per $100 coverage can be also be viewed as an estimate of the sum of the owner's subjective probability of erosion loss p and her pro-rated risk premium ψ / L. Thus, our median WTP estimate of $1.88 implies that the average annual subjective probability of loss is no greater than 0.0188, while its counterpart associated with the mean measure is 0.0325.

Conclusions

The National Flood Insurance Program does not currently cover losses from "sunny day" erosion loss. This paper modeled the decision to buy erosion insurance using data from a national survey of homeowners living in areas with erosion risk. The results indicate that there was considerable, but far from unanimous, interest in such a product at the range of prices under investigation. Forty-two per cent of the respondents elected for erosion coverage. The mean offer price was $4.79 per $100 coverage and the median was $1.57 per $100 coverage. The average flood insurance price seen in the sample was $0.75 per $100 coverage.

Censored logistic regression was used to model the erosion insurance purchasing decision of coastal households. The logistic function fit the data reasonably well (85.2% correct prediction rate), and just over half of the independent variables were significant and exhibited their expected signs. The marginal effects of the independent variables were examined by interpreting their slope coefficients. The most significant variable affecting the purchase of erosion insurance coverage was the price of the expanded coverage. A one dollar increase in the average offer price (from $4.79 per $100 coverage to $5.79) leads to an estimated 6 percent decrease in the average probability of purchasing erosion coverage. Also important in the decision to purchase erosion coverage was household income, which has a significant positive effect on the purchasing decision.

Erosion risk was measured through a proxy which combined a property's setback distance with its historical erosion rate to give the expected number of years until the property faced flooding or structural damage due to erosion. This measure had a significant and negative effect on the probability of purchasing erosion coverage, indicating that erosion risk motivates the purchase of such coverage. Ocean-front properties exhibited higher probabilities of accepting a given offer price.

Community response to erosion risk can include the construction of erosion protection devices and beach nourishment projects. These types of large-scale projects were included in our model to examine the effect they have on contingent erosion insurance purchasing. Whether the property was under the jurisdiction of a beach nourishment project was estimated to have a positive effect on the probability of purchasing erosion coverage, while the effect of coastal armoring was statistically insignificant. More work is needed to determine the underlying cause of this observed relationship.

The demand for erosion insurance was estimated to be the strongest on the Gulf Coast, with an estimated acceptance rate of around 54 percent, all else being equal. On the Atlantic coast the reported average acceptance rate was 42 percent. Coastal residents on the West Coast had the lowest estimated acceptance rate at around 21 percent. The Great Lakes region was not estimated to be significantly different (in terms of acceptance rate) than the Atlantic Coast.

From the estimated logit regression function we estimated the maximum willingness-to-pay for erosion insurance for each property owner in our data set. Our most conservative estimate of the average WTP is $1.88 per $100 coverage, with a 99 percent confidence interval between $0.83 and $2.84 per $100 coverage. This high WTP suggests that there is a potential market for erosion insurance among property owners in the 60-year EHA. However, the provision of this insurance may suffer from adverse selection if the insurance is not mandatory. It is likely that such coverage would have to be mandatory because of adverse selection problems, including the possibility that individuals will wait to purchase insurance until erosion damage becomes imminent. These results suggest that at a price of around $2 per $100 coverage, about half of the homeowners in erosion zones would voluntarily purchase this kind of insurance. If this is correct, mandatory erosion insurance through the NFIP in areas of high erosion risk is unlikely to produce overwhelming political opposition from homeowners as long as the price can be kept close to this level.

Literature cited

Browne, Mark J. and Robert E. Hoyt, 1999. "The Demand for Flood Insurance: Empirical Evidence." Paper available at http://papers.ssrn.com/paper.taf?abstract_id=169448.

Cameron, Trudy Ann, and Michelle D. James. 1987. "Efficient Estimation Methods for 'Closed-ended' Contingent Valuation Surveys", *Review of Economics and Statistics*. v69(2): 269-276.

Freeman, A. Myrick III. 1993. *The Measurement of Environmental and Resource Values*. Washington: Resources for the Future.

Kriesel, Warren, Alan Randall and Frank Lichtkoppler. "Estimating the Benefits of Shore Erosion Protection in Ohio's Lake Erie Housing Market". *Water Resources Research*. 29(4):795-801. April, 1993.

Nicholson, Walter. 1997. *Intermediate Microeconomics*, 2nd ed. Ft. Worth: Dryden.

Pilkey, Jr., Orrin H., and Katharine L. Dixon. 1996. *The Corps and the Shore*. Washington: Island Press.

Roth, Richard J., Sr., and Roth, Richard J., Jr. 1999. *Erosion Ratemaking Procedures and Tables.* Mimeo, The Heinz Center for Policy Studies: Washington, D.C.

Table 1: Summary Statistics of Variables used to Model the Decision to Purchase Erosion Insurance, for 406 Respondents to a Mail Questionnaire, 1999.

Variable	Mean	Standard Deviation	Minimum	Maximum
Offer Price ($ per $100 coverage)	4.653	8.009	0.007	48
Income (thousands)	141.475	86.906	20	250
Higher Education (0-1)	0.904	0.332	0	1
Age (years)	57.968	13.037	40	94
Geotime	31.908	20.066	0.113	100
Erosion Information (0-1)	0.431	0.559	0	1
Waterfront (0-1)	0.656	0.536	0	1
Sand Nourishment (0-1)	0.430	0.559	0	1
Armor (0-1)	0.106	0.348	0	1
Gulf Region (0-1)	0.531	0.563	0	1
Great Lakes Region (0-1)	0.005	0.085	0	1
Pacific Region (0-1)	0.029	0.189	0	1

Table 2: Regression Analysis of the Decision to Purchase Erosion Insurance, for 406 Respondents to a Mail Questionnaire, 1999.

Variable	Beta	Std. Error
Intercept	-0.687	0.914
Offer Price ($ per $100 coverage)	-0.320	0.046***
Income (thousands)	0.004	0.001**
Higher Education (0-1)	-0.073	0.454
Age (years)	0.005	0.011
Geotime	-0.012	0.007*
Erosion Information (0-1)	0.086	0.248
Waterfront (0-1)	0.510	0.271*
Sand Nourishment (0-1)	0.421	0.248*
Armor (0-1)	0.302	0.432
Gulf Region (0-1)	0.584	0.262*
Great Lakes Region (0-1)	1.676	1.981
Pacific Region (0-1)	-1.552	0.843*

N=406. * 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.

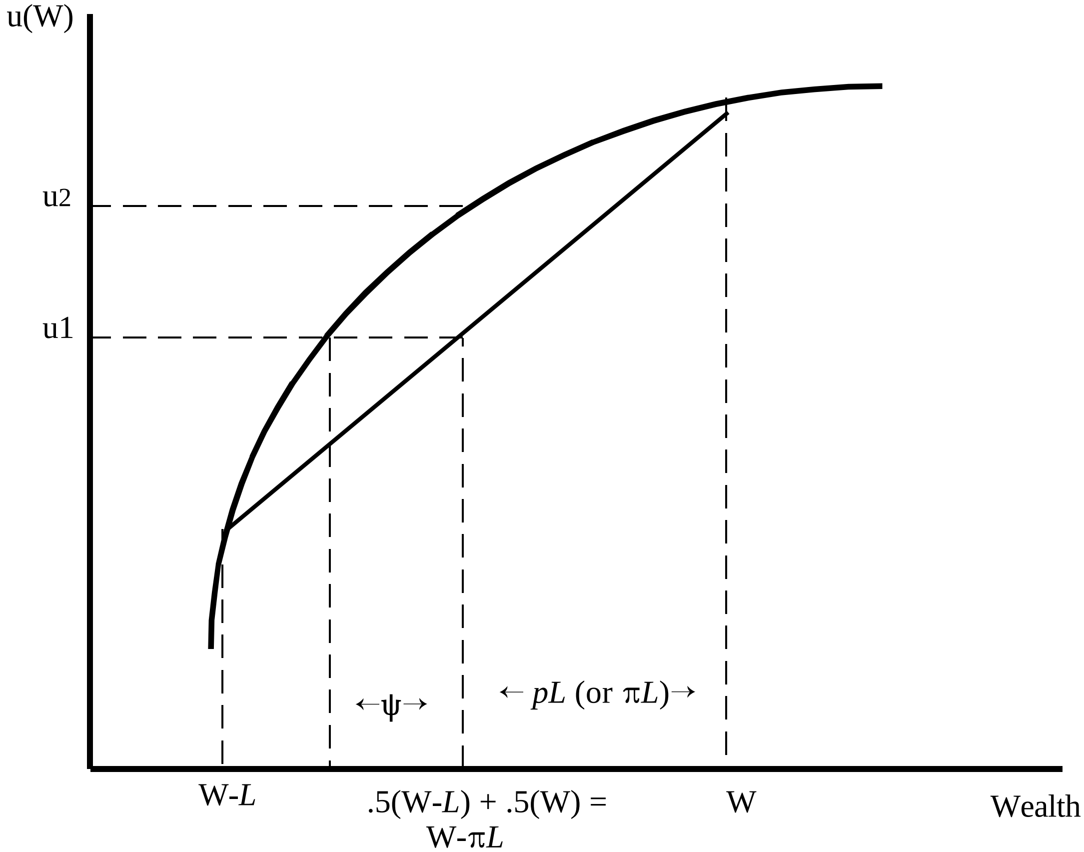

Figure 1: The utility of wealth, risk aversion and the result that the property owner's maximum willingness to pay for insurance equals $pL+\psi$, which can be inferred from the offer price $\pi L+\alpha$. (NOTE: In this figre, it is assumed that p and π are equal (or reasonably close))

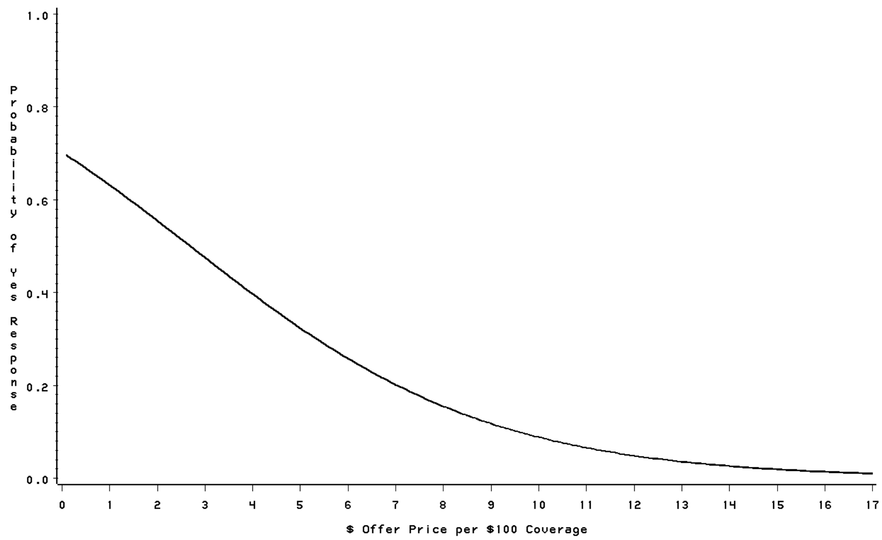

Figure 2: The Fitted Logistic Curve as a Function of Offer Price (per $100 Coverage)

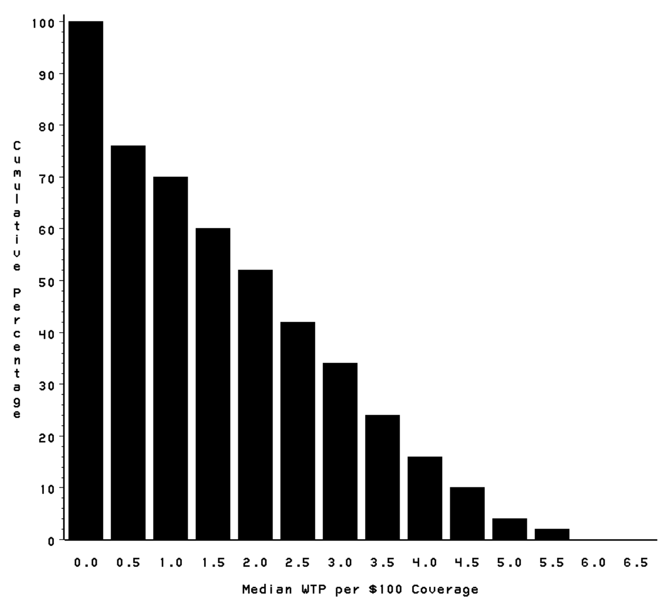

Figure 3: Cumulative Percentage of Individual Median Willingness-to-Pay for Erosion Coverage.