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Expanding the National Flood Insurance Program to Cover Coastal Erosion Damage

Andrew Keeler, Warren Kriesel, and Craig Landry

This paper uses the results of a nationwide survey of coastal property owners to estimate the demand for insurance against erosion damage. The National Flood Insurance Program (NFIP) does not technically cover such damage, although in practice there is considerable uncertainty about this point. The ability to insure against such losses has implications for the choice of beach management strategies and for NFIP management. We find significant demand for insurance at prices in the range of current flood insurance premiums, although median willingness to pay appears to be less than the cost of providing such insurance.

Key Words: coastal erosion, insurance, risk

JEL Classifications: Q24, G22, H41

Real estate development in the coastal areas of the United States has intensified over the past several decades (Pilkey and Dixon). Coastal areas tend to be unstable, and most coastlines erode shoreward over time; the eastern U.S. loses 2 to 3 ft./y to erosion, whereas the national average is about 1 ft. (Leatherman). The combination of these two facts has made coastal erosion management an important concern for all levels of government. A central question is the role played by insurance, relative to other prevention and mitigation tools, in managing the risks to real property that coastal erosion presents. There is currently no insurance generally available that covers losses to homes caused by coastal erosion.

The National Flood Insurance Program

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(NFIP) provides the overwhelming majority of flood insurance policies in the United States. The NFIP is intended to cover damages from a “general condition of flooding” (i.e., rising water levels), and not from erosion damage associated with changes in the location of the coastline. However, current NFIP policies have produced an ambiguous outcome for properties along erosion-prone coasts, where reduced setback distance has undermined buildings and made them susceptible to damage. If houses suffer damage from erosion during a flood-causing storm, the claim will likely but not certainly be paid. However, if erosion-induced undermining and damage takes place during a time when there is no widespread flooding, then the damage claim will be denied. This latter condition has become known as “sunny day loss.”

The uncertainty surrounding erosion damage and the NFIP creates two questionable outcomes. First, property owners have an incentive to stave off erosional undermining until the next storm event, at which time losses become flood-related and are likely to be covered under their flood insurance policy. The

NFIP requires that collected premiums cover overall operating expenses and indemnities for an average loss year, and the risk of erosion damage is not figured into the premium structure. Therefore, if some share of erosion-related claims are paid, either these property owners' premiums are being subsidized by others in the program, or the premiums collected will tend to be too low.

A second problem has to do with the incentives for investing in engineering projects that mitigate the risk of erosion damage. These investments may be financial, in the case of structures built by individuals, or political, in terms of effort and resources expended to secure publicly funded erosion management projects. If homeowners do not have insurance available, they may overinvest in engineering solutions.

The amount of investment in shoreline engineering has important implications for the amenity value conferred by beaches to the very large population of recreational beach users. Coastal property owners have constructed sea walls, groins, and other devices to protect their property, and they also provide political support for public efforts to build and maintain shoreline engineering structures. There is substantial evidence that sea walls degrade attractive recreational beach qualities (Pilkey and Dixon; Dean). Furthermore, beach quality has significant impacts on property prices for a considerable distance from the beach, so these negative externalities affect property owners as well as recreational beach users (Milon, Gressel, and Mulkey).

If homeowners could buy insurance that specifically covers erosion loss, it seems likely that they would tend to invest less in shoreline engineering and therefore reduce the associated negative externalities. On the other hand, if such insurance will only be attractive at subsidized rates, it would perpetuate perverse incentives to locate in risky areas and to underinvest (from an individual point of view) in other risk-mitigating activities. It is thus interesting to investigate how an insurance market for sunny day loss insurance would actually function. In this paper, we use the results of an extensive nationwide survey of homeown-

ers in erosion hazard zones to estimate the determinants of the demand for this kind of insurance. We focus on how erosion risk, other risk mitigation measures, insurance price, and income affect individuals' stated willingness to purchase insurance that covers sunny day losses.

The paper begins with a brief review of the NFIP and proceeds to sketch the relevant theory for examining willingness to pay for insurance. We then posit an economic choice model resulting from this theory. Next, we detail the model specification and data used in the analysis. We then present the results of the model and discuss their significance.

NFIP and Flood Insurance Provision

The NFIP provides 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, in part because of the high risk of damage, the high cost of insurance, and catastrophic nature of floods (Browne and Hoyt). Lack of private sector insurance was also due to the fact that property owners would not be willing to purchase flood insurance unless damages 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 (Federal Emergency Management Agency [FEMA]).

The government's participation was in part motivated by a desire to reduce its disaster payouts for floods. It accomplished this both by funding such claims through insurance (some of which was and is subsidized, although the majority of NFIP policies are not now explicitly subsidized), but also by requiring improved construction practices and land use restrictions that would reduce claims in the event of a flood.

A number of refinements have been made to NFIP over the years. The 1973 Flood Di-

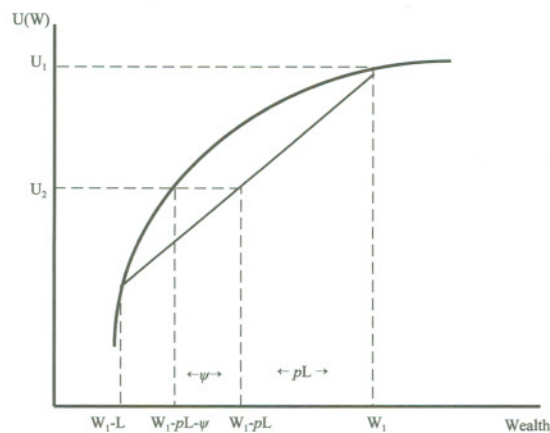


Figure 1. The Homeowner's Willingness to Pay (WTP) for Insurance Depends on the Size and Probability of Loss and on the Level of Risk Aversion

saster Protection Act required the purchase of flood insurance for properties that received federally backed aid of some sort (e.g., Federal Deposit Insurance Corporation [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.

Browne and Hoyt recently analyzed the determinants of insurance purchases in the NFIP nationwide and found that price, income, and prior year losses were important determinants of the decision to buy such insurance. They also found that changes in the subjective assessment of risk were significant determinants of the decision to make new purchases of flood insurance.

Model of the Valuation of Erosion Risk Reduction

In this section we describe our model of consumers' decisions to purchase erosion insurance. Consider an insurance market that operates with no transaction costs or industry profits. Assume a coastal property owner with the utility of wealth curve in Figure 1, reflecting a utility function $U(W)$. Each potential in-

surance customer has unique risk characteristics and attitudes leading to a unique price she would be willing to pay for erosion protection insurance. Consider a property owner that has initial wealth W_1 and a utility level of $U_1(W_1)$ in the absence of erosion risk. The property owner's assessment of the risk of loss is p . Assuming the property owner has diminishing marginal utility of wealth, then $U''(W) < 0$, and she is risk averse.

An uninsured loss of size L would leave the property owner with $W_1 - L$. Her expected level of wealth would be $W_1 - pL$, and her expected utility would be U_2 (Figure 1)—the probability-weighted average of her utility at wealth level W_1 and wealth level $W_1 - L$. She could achieve the same level of utility with a certain level of wealth less than this expected level—the point given on Figure 1 by $W_1 - pL - \psi$. The property owner would be willing to pay $pL + \psi$ for insurance that fully insured her for a loss of size L . The parameter ψ can be interpreted as the premium the insurance customer is willing to pay because of her risk aversion.

Let the insurance company's assessment of the risk of loss be parameterized by π . The cost of providing insurance by a risk-neutral insurer (an actuarially fair policy) would be πL . However, 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 these costs.

A property owner's maximum willingness to pay (WTP) will be an amount that gives her a utility level just equal to her expected utility in the absence of insurance. Individual annual WTP is therefore $pL + \psi$. She will purchase insurance whenever $pL + \psi \geq \pi L + \alpha$. The property owner's decision to purchase insurance depends on the premium (ψ) she is willing to pay to reduce risk given her assessment relative to the transactions costs and profits of the insurance provider (α) and on her assessment of erosion risk p relative to the actuarially estimated risk π . This logic is crucial in the estimation method presented later, where

individuals are offered erosion insurance at random prices.

If individuals are better placed than insurers to understand their risk of loss, those with $p > \pi$ will tend to buy insurance, and those with $p < \pi$ will tend not to buy insurance. This is the essence of the adverse selection problem. Browne and Hoyt cite evidence that for flood insurance, almost all buyers tend to underestimate their risk of loss. No corollary evidence exists for subjective assessments of the risk of erosion damage.

As discussed above, the demand for erosion insurance could be affected by 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 increase property price (Kriesel, Randall, and Lichtkoppler). 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 erosion loss. In terms of the insurance demand model, this would reduce her subjective probability of suffering a near-term erosion-related loss, p , which would thus reduce her WTP for erosion insurance.

In summary, we have posited that an individual property owner's willingness to pay for erosion insurance coverage 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.

Estimation of Willingness to Pay for Insurance

WTP is estimated using the referendum question format of the contingent valuation method (see, e.g., Freeman). 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 CDF is specified as

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

where the \mathbf{X} vector consists of the independent variables, A is WTP, and β and κ represent the coefficients. The associated regression equation is

$$(2) \quad \ln[p/(1 - p)] = \mathbf{X}_i'\beta + A\kappa + u_i$$

Once this regression has been estimated, the WTP can be calculated by numerical integration of the logistic function (providing mean WTP) or with the approach of Cameron and James (providing median WTP), which is

$$(3) \quad \text{WTP} = [-\sum \beta_i \mathbf{X}_i] / \kappa,$$

where the summation occurs over all of the explanatory variables (excluding the insurance offer price variable whose coefficient is κ), the β_i are the estimated coefficients of the independent variables, and the \mathbf{X}_i are the means of the individual and property characteristics.

Individual WTPs can also be predicted using these 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 that were used to estimate the logistic function.

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 cov-

erage? 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

The following explanatory variables are used to specify the logistic regression that predicts willingness to purchase erosion insurance (their expected signs are included in parentheses).

Information supplied by the homeowner

- (1) Offer price of erosion insurance per \$100 coverage: *Offer Price* (-)
- (2) Income in thousands of dollars: *Income* (+)
- (3) Whether the homeowner is aware of the erosion rate at the nearest shore: *Erosion Information* (+)

Information from other sources

- (1) 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* (-)
- (2) Whether the property is waterfront: *Waterfront* (+)
- (3) Community shore protection projects: *Sand Nourishment* and *Armor* (- if substitutes, + if complements)
- (4) Regional dummy variables: *Gulf*, *Lakes*, and *Pacific* (uncertain effect)

Data

The H. John Heinz III Center for Science, Economics, and the Environment, pursuant to a contract with FEMA, undertook a mail survey of coastal property owners in 1998–1999. The survey included a question designed to produce information about respondents' valuation of erosion insurance. 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.

This price question in the survey 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. 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. This same assumption was used by insurance industry actuaries studying the erosion insurance question (Roth and Roth).

The sampling frame for this study consisted of 18 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 survey questionnaires were mailed to the property owners. An overall response rate of 39% to the 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 each state's Coastal Zone Management staff and is defined as the

Table 1. Summary Statistics of Variables Used to Model the Decision to Purchase Erosion Insurance for 506 Respondents to a Mail Questionnaire, 1999

Variable	<i>M</i>	Median	SD	Minimum	Maximum
Offer price (\$ per \$100 coverage)	3.045	0.667	7.661	0.007	48
Income (thousands)	150.503	175	104.178	20	250
Geotime	31.32	26.217	22.204	0.113	100
Erosion information (0–1)	0.275	0	0.631	0	1
Waterfront (0–1)	0.515	1	0.707	0	1
Sand nourishment (0–1)	0.631	1	0.683	0	1
Armor (0–1)	0.053	0	0.318	0	1
Gulf region (0–1)	0.703	1	0.646	0	1
Great Lakes region (0–1)	0.003	0	0.077	0	1
Pacific region (0–1)	0.077	0	0.378	0	1

strip of land that could disappear in the next 60 years, given the historical erosion rate. Out of the total of 11,000 properties, 1,818 were located within the EHA, out of which 717 property owners 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 for which we had data on the coverage amount could be used for this analysis. This specification created a situation where the sample was not representative, since coverage amounts were only available for properties in the NFIP database. Ninety-eight percent of the usable sample was enrolled in the NFIP (a few households not in the NFIP were in the database because they had recently dropped coverage) compared with an estimated 49% NFIP participation for the study sampling frame as a whole. An appropriate weighting factor was therefore used to correct for the overrepresentation of NFIP participants in this data set.¹ There were 506 usable observations in the data set we analyzed. Of these, 215 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 \$3.04 per \$100 erosion insurance coverage—a sizable increase over the current average flood insurance rate in the sample (about \$0.50 per \$100 coverage). The average household income in the EHA was around \$150,000 versus an average of \$100,000 for all respondents. About 50% of the properties were located on the waterfront.

The formulation of *Geotime* is simply setback divided by the historical 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 a seawall or other erosion protection. The average house in the EHA subsample had about 31 years of *Geotime*. Twenty-seven percent of the respondents claimed to have seen information on the historical erosion rate of the shore nearest their property at some time in the past. The effect of a shoreline protection project was captured as a dummy variable. If this dummy variable is found to be negatively related to the probability of participation, then an erosion protection device could be viewed as a substitute for erosion insurance.

Regional dummy variables were included to account for geographical as well as geological differences in the survey areas. Seventy percent of the observations were from the Gulf of Mexico region, which includes Lee, FL, and Brazoria and Galveston, TX. A very small number (0.3%) of the observations were from Great Lakes counties, specifically Sanilac, MI, and Manitowoc, WI. The West Coast, represented solely by Santa Cruz, CA, comprised

¹ The LOGISTIC procedure within SAS was used to estimate the regression (SAS). The WEIGHT statement was used to apply a weight to each observation. To achieve the same representation in our sample as in the study areas, a weight of 64 was given to nonparticipants, and a weight of 1 was given to participants.

Table 2. Regression Analysis of the Decision to Purchase Erosion Insurance for 506 Respondents to a Mail Questionnaire, 1999

Variable	β	SE
Intercept	1.701	0.408*
Offer price (\$ per \$100 coverage)	-0.591	0.051*
Income (thousands)	0.007	0.001*
Geotime	-0.063	0.007*
Erosion information (0-1)	0.470	0.235*
Waterfront (0-1)	0.142	0.232
Sand nourishment (0-1)	-0.726	0.272*
Armor (0-1)	0.871	0.475*
Gulf region (0-1)	1.147	0.277*
Great Lakes region (0-1)	1.315	2.917
Pacific region (0-1)	-5.890	0.675*

Notes: $N = 506$. * indicates that the variable is significant at the 0.05 level or lower.

7.7% of the sample. The remaining observations, 22% of the total, were from 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. Eight of the 10 variables were statistically significant (at the 5% level or lower) predictors of homeowners' decisions to purchase erosion coverage. The statistically insignificant variables were the *Waterfront* dummy variable and the Great Lakes regional dummy variable (this latter result is likely caused by the small number of observations from the Great Lakes region in our sample). The model exhibited an individual prediction success rate of 83.3%. 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.

We discuss the results of the model by using the estimated equation to examine the results of changing the variable of interest while keeping other variables at their mean values. The results suggest that the *Offer Price* variable has a very significant, robust influence on the willingness

to purchase erosion coverage. As expected, higher offer prices were associated with fewer positive responses. Interpretation suggests that a \$1 increase in the average offer price (from \$3.04 per \$100 coverage to \$4.04) leads to a decrease from 29.5% to 18.8% in the probability of an affirmative response.

Higher-income households showed a higher acceptance rate for erosion coverage, and the coefficient on *Income* was highly significant. Increasing income by \$1,000 over the average of \$151,000 leads to an increase from 29.5% to 29.7% 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 \$130,000 to \$170,000 increases the probability of opting for erosion coverage from 26.6% to 32.4%.

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 1-year increase in the average *Geotime* (from 31 to 32 years) reduces the probability of buying insurance from 29.5% to 28.2%. Our results did not provide evidence that the *Waterfront* dummy variable was statistically significant. Surprisingly, for this sample it appears that oceanfront property owners are not more willing to purchase erosion coverage than other homeowners, all else being equal.

The *Sand Nourishment* variable (which indicates the existence of beach nourishment projects) was estimated to have a negative 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 24.3% probability of purchasing erosion coverage compared with 39.8% for those not living near such a project. This result suggests that beach nourishment is viewed as lowering the risk of damage, and therefore is a substitute for insurance.

The *Armor* variable, also statistically significant, had an opposite effect on insurance decisions. Homeowners who live in areas with shoreline armoring have a probability of

48.9%, much higher than the 28.9% probability of those not living in these areas. This may reflect that the presence of armoring is associated with severe erosion risk not captured through *Geotime*, and may also indicate that homeowners are doubtful about the permanence of such structures.

The erosion information variable was positive and significant, indicating that people concerned enough with erosion problems to be aware of their local erosion rates were more likely to be willing to purchase insurance. All else being equal, respondents with such knowledge has a probability of purchasing insurance of 37.0%, whereas those without such information exhibited a probability of 26.9%.

The regional dummy variables for the Gulf and Pacific Coast proved to be statistically significant. The *Gulf* variable had a positive effect compared with the Atlantic region (the base case of 22.7% probability choosing to purchase erosion insurance). Gulf Coast residents are estimated to have a 25.3% higher probability (around 48.0% would purchase insurance, all else being equal). Conversely, West Coast residents have a much lower probability of electing to purchase erosion insurance, estimated at more than 20% below that in the Atlantic region.

Mean and Median WTP

There are two ways to calculate WTP from the estimated logistic function: its mean and its median. The mean WTP for erosion coverage was calculated by numerical integration of the estimated logistic regression curve. The average annual estimated mean WTP for erosion coverage for inhabitants of the 60-year EHA is \$2.09 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 (Cameron and James).

The median WTP is calculated using Cameron's formula (Equation [3]). Conceptually, it is the price at which a random household in our sample is equally likely to purchase or not

purchase erosion coverage. The median is a more conservative estimate of WTP than the mean, since it gives less weight to extreme observations on the high side. For the entire data set used in the analysis, the median WTP for the average respondent was \$1.51 per \$100 coverage. An advantage of using the median is that a bootstrapping method can yield confidence intervals about the point estimate of WTP (Greene, p. 843). The 99% confidence interval for this estimate of \$1.51 was found to be between \$1.05 and \$1.98 per \$100 coverage. Of the 506 observations in this analysis, 78.8% had a positive WTP; the rest are clustered at zero.

Comparison with the Cost of Insurance Provision

There is only preliminary information available on the cost of providing such insurance. A team of actuaries produced estimates for FEMA for the cost of provision by region when purchase is mandatory for all households (Roth and Roth). For properties that are either oceanfront or about to become oceanfront, premiums range from \$3.52 per \$100 of coverage (Great Lakes region) to \$13.90 per \$100 of coverage (Pacific region). We believe that our sample of oceanfront homes is reasonably comparable with the group rated by these actuaries. Our median WTP for oceanfront properties is \$1.63 per \$100, and the mean is \$2.18 per \$100. If these estimates of the supply price and of demand are correct, it indicates that the majority of owners of high-risk properties in our sample are not willing to pay the cost of providing these policies. However, they are willing to pay a substantial percentage of that cost.

Conclusions

This paper modeled the decision to buy erosion insurance using data from a national survey of homeowners living in areas with erosion risk. Logistic regression was used to model the erosion insurance purchasing decision of coastal households. The logistic function fit the data reasonably well (83.3% correct prediction rate), and the majority of the inde-

pendent variables were significant and exhibited their expected signs.

We found that there is considerable interest in erosion insurance, and that this interest was sensitive to its price. Also important in the decision to purchase erosion coverage was household income, which has a significant positive effect on the purchasing decision.

Our measure of erosion risk also had a significant effect on the probability of purchasing erosion coverage.

Homeowners living in communities protected by beach nourishment were substantially less likely to purchase erosion protection insurance. This implies that the availability of such insurance might well reduce political demands for publicly funded beach projects. However, those living near shoreline armoring showed a much higher inclination to buy insurance, indicating that residents do not believe these projects offer effective protection. The demand for erosion insurance was estimated to be the strongest on the Gulf Coast and weakest on the West Coast.

From the estimated logistic 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 \$1.51 per \$100 coverage, with a 99% confidence interval between \$1.05 and \$1.98 per \$100 coverage. The fact that this WTP is high relative to current flood insurance premiums suggests that there is a potential market for erosion insurance among property owners in the 60-year EHA. However, comparison with preliminary work by actuaries indicates that only a minority of our sample would be willing to pay the full cost of providing this insurance.

It may be that insurance coverage for erosion might be a good way to reduce other public costs of such erosion—negative externalities to other coastal dwellers, publicly funded shoreline protection, and emergency relief resulting from publicized losses. Our results suggest that at a price of around \$1.50 per \$100 coverage, about half of the homeowners in erosion zones would voluntarily purchase this kind of insurance. If this is correct, then 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, and any subsidy should be evaluated relative to the costs of not providing insurance. Plausible estimates of what subsidy, if any, is actually necessary to keep premiums at a level acceptable to property owners is the subject of future research.

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