Willingness to Pay for Low Probability, Low Loss Hazard Insurance[1]

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Abstract: We estimate the willingness to pay for low probability, low loss hazard insurance with the contingent valuation method. The application is to household hurricane evacuation cost insurance – a new product for which there is currently no market. We find that a majority of respondents would not purchase the product at even the lowest price. In general, respondents are rational in response to the probability and costs of a evacuation. Respondents are not likely to pay anything for evacuation cost insurance.

Key Words: Hurricane evacuation, willingness to pay, expected utility

Introduction

Hurricane evacuation can be a costly endeavor. Relative to the other impacts of natural hazards (e.g., damage to housing), however, the losses associated with typical hurricane evacuation are low, even including foregone income and time (Whitehead 2003). However, these costs may constrain hurricane evacuation behavior leading to unnecessary risk-taking. One approach to mitigating evacuation costs is insurance. Households could purchase evacuation insurance and, if the household evacuates, they could submit claims to be reimbursed for their expenses. The time and money constraints of evacuation would be less binding, making evacuation a more attractive option with the approach of a dangerous storm. A market for evacuation insurance currently exists for business firms to cover business interruption losses but not for households. One purpose of this paper is to investigate the feasibility of evacuation insurance for households and their willingness to pay for the insurance.

Two studies have explicitly considered the relationship between willingness to pay for insurance against low risk, high loss natural hazards (e.g., earthquakes). McClelland, Schulze and Coursey (1993) find that experimental subjects are willing to pay for insurance against high loss events. Their results suggest that some respondents overestimate the probability of the event and others underestimate the probability resulting in a bimodal distribution of willingness to pay. Ganderton et al. (2000) conduct a similar experiment for low risk, high loss events and find that their research subjects behave more in accordance with the expected utility model. Subjects are more likely to buy insurance as the cost falls and as the risk increases. Willingness to pay is not bimodal.

Two hypothetical data field studies have considered willingness to pay for hazard mitigation. Ozdemir (2005) considers the willingness to pay for tornado safe rooms. In accordance with expected utility theory, willingness to pay rises with the perceived effectiveness of safe rooms, the perceived risk of tornados and the magnitude of the potential loss. Burrus, Dumas and Graham (2005) consider the willingness to pay for coastal homeowner mitigation against hurricane risks. They find that expected damages have no impact on willingness to pay for mitigation. Average willingness to pay is less than expected damages.

In contrast to previous research we consider the willingness to pay to avoid the low risk, low loss hurricane evacuation event. The hurricane evacuation problem may seem less important than other risks: "Analysis of behavior and policy prescriptions would not be such a problem if low probability natural disasters had small consequences." (Ganderton et al. 2000, page 272). However, evacuation costs may act as a constraint on evacuation behavior that could lead to consequences more severe than the loss of a few hundred dollars. Recent proposals that attempt to mitigate evacuation costs and encourage evacuation are private insurance and tax incentives.

In this paper we examine the demand for private hurricane evacuation cost insurance. We present a hypothetical household evacuation insurance policy scenario to a sample of respondents with prior hurricane evacuation decision-making experience. We determine the demand for insurance and consider whether the hypothetical willingness to pay decisions support expected utility theory. In the next section we sketch a brief theory of decision making under uncertainty. Next we describe the data and empirical model. Then we present the empirical results. Finally we offer some conclusions and directions for future research.

Theory

Consider individuals who face the risk of a low loss disaster-type event (e.g., the losses associated with hurricane evacuation). The expected utility of these individuals depends on consumption with and without the event weighted by the probability of the event

(1) $E(v) = rv(y-c) + (1-r)v(y)$

where $E(v)$ is expected utility, $v(.)$ is the indirect utility function, r is the probability of hurricane evacuation, y is income and c is the cost incurred by evacuation, including expenditures, time and lost income. The probability of hurricane evacuation is the joint probability of a hurricane threat or strike and evacuation choice

(2) $r = \sum_j \rho_j \pi_j$

Where ρ_j is the probability of a hurricane threat and π_j is the probability of evacuation, j = 1, …. , 5 Saffir-Simpson hurricane categories. The evacuation probability is increasing in j hurricane categories.

When confronted with insurance that would cover all evacuation costs individuals will compare the expected utility with and without insurance

(3) $rv(y-p) + (1-r)v(y-p) \underset{<}{\overset{>}{=}} rv(y-c) + (1-r)v(y)$

where p is the price of insurance. Willingness to pay is the payment that equates expected utility with and without insurance

(4) $rv(y-WTP) + (1-r)v(y-WTP) = rv(y-c) + (1-r)v(y)$

The individual will purchase insurance if the willingness to pay is greater than or equal to the price of insurance

(5) $\Pi(x=1) = \Pi(WTP \geq p)$

where Π is the probability of purchasing insurance, x.

The probability of purchasing insurance decreases with increases in the price of insurance and increases with increases in the probability of evacuation and evacuation cost. The effect of income on the probability of purchasing insurance is indeterminate.[3]

Data

The sample consists of residents of Brunswick, New Hanover, and Pender Counties in southeastern North Carolina.[4] A total of 411 households agreed to participate in a telephone survey. The survey response rate is 73%. Data collection occurred during March 2001, a period after a number of hurricane landings in the Carolinas. We include those respondents who had experienced one or more hurricanes (*n* = 384). Twenty-five percent of those who had experienced a hurricane evacuated their homes for Hurricane Bonnie in 1996, 17% evacuated for Hurricane Dennis in 1999, and 42% evacuated for Hurricane Floyd in 1999. Fifty-percent evacuated their homes for at least one storm.

The contingent valuation method (CVM) is used to elicit the willingness to pay for evacuation cost insurance (Mitchell and Carson, 1989). We first describe the concept of evacuation insurance and ask if the respondent had ever heard of evacuation insurance:

> *Many people in coastal areas are safer if they evacuate their home before a hurricane strikes. But evacuating can cost a lot of time, money and lost income. Some people would rather stay at home during a hurricane so that they don't spend money and lose income. To reduce this problem and increase safety, one plan is to have a hurricane evacuation insurance policy to reimburse people for the costs of evacuation. Have you ever heard of a hurricane evacuation insurance policy?*

Eleven percent of respondents answered in the affirmative.

The next question asks respondents whether they would purchase the hurricane

[3] The comparative static results are derived in the Appendix.

[4] The data is more fully described in Edwards et al. (2001).

evacuation cost insurance policy

> *Suppose you could purchase a hurricane evacuation insurance policy from an insurance agent before the next hurricane season. The price of the evacuation insurance is $p each hurricane season. With insurance, you would be reimbursed for all of your evacuation expenses throughout the hurricane season. This would include reimbursement for travel, lodging, food, medical costs and lost income. Do you think you would purchase the hurricane evacuation insurance policy?*

Each respondent was presented with one of five prices (*p*): $50, $100, $140, $190, or $240. One-fourth of all respondents stated that they would purchase the insurance. All respondents are asked how sure they are that they would purchase the insurance. Of those who would purchase the insurance 51 percent were very sure, 44 percent were somewhat sure and 3% were not sure at all. In an effort to mitigate hypothetical bias we recode all yes respondents who were not "very sure" that they would actually purchase the insurance to "no" (Whitehead and Cherry, 2004). Fourteen percent of respondents would purchase the insurance after recoding.

Those respondents who had evacuated for a recent hurricane and those who had not are both more likely to pay the lowest price relative to the higher prices (Table 1). In general, the proportion of respondents who are willing to pay is flat with the middle three prices. The proportion of yes responses increases with the highest price, *p* = $240. The portion of respondents who are willing to pay is slightly higher for those respondents who had evacuated for a recent hurricane relative to those who had not evacuated.

The independent variables are the insurance policy price, income, evacuation probability and evacuation cost. The average annual household income is $48 thousand (year 2000 dollars) for those who had evacuated and $51 thousand for those who had not (Table 2). The evacuation probability is the joint probability of evacuation and hurricane strike. The probability of evacuation given various hurricane intensities is estimated from a stated preference model of evacuation behavior. The probability of a hurricane strike is estimated from historical data. Evacuation costs are constructed from answers to survey questions for the portion of the sample that had evacuated in the past. Costs are imputed for the respondents that had not recently evacuated.

The subjective probability of evacuation is estimated using a stated preference methodology in which respondents are asked if they would evacuate given an approaching hurricane (Whitehead, 2003). One of five hurricane intensity scenarios is randomly assigned. For a category 1 hurricane the scenario is:

> *Next I'd like to know what you would do in case of a hurricane during the next hurricane season. The Atlantic hurricane season runs from June 1 – November 30. Please consider the following information. Hurricanes are rated on a scale of 1 to 5. Category 1 is a minimal hurricane, 2 is moderate, 3 is extensive, 4 is extreme, and 5 is a catastrophic hurricane. Floyd was a category 4 hurricane, Bonnie was a category 3 hurricane, and Dennis was a category 1 hurricane. Suppose a category 1 hurricane is approaching North Carolina. The hurricane has winds between 74 and 95 miles per hour and an expected storm surge about 4 to 5 feet above normal.*

Respondents are then told that a "hurricane watch means that a hurricane poses a possible threat within 36 hours" and asked *If a hurricane watch is announced for this hurricane, how safe would you feel in your home?* and *Would you evacuate your home to go someplace safer?*

Forty-eight percent of respondents would feel very safe in their homes and 33 percent of respondents state that they would evacuate their home. Respondents who would not evacuate are asked the same questions with a voluntary evacuation order. Fifty-three percent of respondents would feel very safe in their homes and 14 percent of those remaining respondents state that they would evacuate their home under a voluntary evacuation order. Respondents who would not evacuate under a voluntary evacuation order are asked the same questions with a mandatory evacuation order. Twenty-seven percent of remaining respondents would feel very safe in their homes and 63 percent state that they would evacuate their home under a mandatory evacuation order. Perceived safety is decreasing with hurricane intensity. Under a hurricane watch, stated evacuation behavior is increasing with hurricane intensity. For those respondents who would not evacuate under a hurricane watch, evacuation does not vary with intensity under either evacuation order scenario.

The probability of evacuation is estimated with a logistic regression model.[5] The probability of evacuation is fitted for each level of the Saffir-Simpson hurricane scale for each respondent. The mean evacuation probability ranges from 20 percent for a category 1 hurricane to 58 percent for a category 5 hurricane.

The probability of a hurricane strike is estimated with historical strike data. Baker et al. (2005) find that from 1851 to 2000, there were 21, 10, 11 and 1 category 1, 2, 3 and 4 hurricane strikes in North Carolina. In South Carolina there were 18, 6, 4 and 2 category 1, 2, 3 and 4 hurricane strikes. An estimate of the probability of a future strike is the quotient of the number of

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[5] The probability of a hypothetical hurricane increases with hurricane intensity, if the respondent lives on an island or in a mobile home, if the respondent perceives high wind risks and has flood insurance. Evacuation behavior is lower if the respondent is white. These results are presented in the Appendix.

hurricane strikes of category *j* in North and South Carolina and the number of years. For example, the annual probability of a category 1 hurricane strike is 39/150 (ρ_j = 0.26). The joint probability of a hurricane evacuation and a hurricane strike is the probability that the respondent would incur evacuation costs.[6]

For respondents who had recently evacuated the mean joint probability of a hurricane evacuation is .088, .050, .054, .011 and 0 for category 1, 2, 3, 4 and 5 hurricanes. The mean joint probability of a hurricane evacuation summed over all storm intensities is .203 (Table 2). For respondents who had not recently evacuated the mean joint probability of a hurricane evacuation is .018, .018, .024, .006 and 0 for category 1, 2, 3, 4 and 5 hurricanes. The mean joint probability of a hurricane evacuation summed over all storm intensities is .066.

The costs of evacuation are the sum of the lodging, food and beverages, transportation, entertainment, other expenditures and lost income. More than one third of the respondents who evacuated spent $75 or less for lodging and about two-fifths spent between $75 and $225. About one-fifth spent more than $225. A little over half of the respondents spent $50 or more on food

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[6] The hurricane strike probabilities are for the entire Carolinas when the lower strike probabilities for northeastern South Carolina and southeastern North Carolina may be more appropriate. Hurricane strikes are a downwardly biased estimate of hurricane activity that may lead to evacuations. False alarm evacuations, those evacuations that are not associated with hurricane landfall, are a common occurrence. These two factors increase and decrease, respectively, the joint evacuation probability estimate used here. Also, subjective strike probabilities may be larger than objective strike probabilities (Burrus, Dumas and Graham, 2005). If respondents base their insurance purchase decision on subjective probabilities then the evacuation probability estimates used here are too low.

and beverages. Most spent $50 or less on transportation. A large majority spent $10 or less on entertainment and other expenses. Almost one-half of the respondents missed some time at work, and three-fourths of these lost income from the time they missed. Although most lost less than $1000 income, a few stated they lost $1000 or more. Also, three-fourths of respondents stated that other household members missed time at work and lost income with some losing $1000 or more. The mean total evacuation cost for the portion of the sample that had evacuated is $394 (*n* = 191).

Evacuation costs for the 50 percent of respondents that have not experienced a recent evacuation is missing data. We impute these data with conditional mean imputation. The mean of the conditional mean imputed variables is $380 (*n* = 193).[7]

The expected evacuation cost is the product of the joint probability of hurricane evacuation. The mean expected evacuation cost is $90 for those respondents who had recently evacuated and $27 for those respondents who had not recently evacuated.

Other variables considered in models below are factors that explain the evacuation decision. For those respondents who had previously evacuated, 18 percent live on an island, 33 percent live in a mobile home, 85 percent are white, 56 percent own pets, 47 percent perceive high hurricane wind risk and 34 percent own flood insurance. For those respondents who had not previously evacuated, 3 percent live on an island, 10 percent live in a mobile home, 85 percent are white, 61 percent own pets, 26 percent perceive high hurricane wind risk and 20 percent own flood insurance.

[7] We use Tobit regression model to estimate evacuation costs (see Appendix).

Empirical Model

The logistic regression model is used to determine the factors that affect the willingness to pay for evacuation cost insurance. The dependent variable in the logistic regression model is

$$(6) \qquad x = \begin{cases} 1 & \text{if } WTP \geq p \\ 0 & \text{if } WTP < p \end{cases}$$

where x=1 indicates whether the respondent answered *yes* to the willingness to pay question.

While discrete choice willingness to pay questions are less burdensome on survey respondents than open ended questions[8], generating willingness to pay estimates is not as straightforward. We use Cameron's (1988, 1991) censored logistic regression model to estimate the probability of a *yes* response and willingness to pay

$$(7) \qquad \Pi(x = 1) = \Pi\left(\frac{\alpha' X_1 - \ln p}{\kappa} \geq \frac{e}{\kappa}\right)$$

where α is a vector of coefficients, X_1 is a vector of independent variables, e is the logistically distributed error term and κ is the scale parameter (i.e., the inverse of the coefficient on ln p).

The full model is

$$(8) \qquad \begin{aligned} \Pi(x = 1) &= \left\{1 + \exp\left[-\left(\frac{\alpha_0 + \alpha_1 \hat{r} + \alpha_2 c' + \alpha_3 y - \ln p}{\kappa}\right)\right]\right\}^{-1} \\ \hat{r} &= \sum_j \rho_j \pi_j^S \\ \pi_j^S &= \beta' X_2 \\ c' &= \begin{cases} c & \text{if } \sum_t \pi^R > 0 \\ \hat{c} = \gamma' X_3 & \text{if } \sum_t \pi^R = 0 \end{cases} \end{aligned}$$

[8] Open-ended questions are of the form: "What is the maximum amount that you would be willing to pay?" (Ganderton et al. 2000).

Where β and γ are vectors of regression coefficients, and X_2 and X_3 are vectors of independent variables. The superscripts *S* and *R* indicate stated and revealed preference data, respectively. The revealed preference evacuation, π^R, is summed across three hurricane evacuation seasons, $t = 1, 2, 3$.

When using the log-linear (i.e., ln *p*) functional form the willingness to pay distribution is truncated at zero with a long right hand side tail. The median of the logistic distribution is

$$(9) \qquad \overline{WTP} = \exp\left(-\kappa(\alpha_0 + \alpha_1\bar{r} + \alpha_2\bar{c} + \alpha_3\bar{y}\right)$$

where $\bar{r}$, $\bar{c}$ and $\bar{y}$ are the means of the independent variables. The median willingness to pay is the value at which the representative consumer in the sample is indifferent between paying and not paying [i.e., $\Pi(x = 1) = .5$]. The median willingness to pay is not heavily influenced by outliers in the upper tail of the distribution. The median willingness to pay will be lower than the lowest price presented to respondents ($50) since the percentage of respondents agreeing to pay the lowest price is less than 50 percent. The mean of the logistic distribution, what the average consumer is willing to pay, is undefined when the log-logistic distribution is used (Haab and McConnell).[9]

Results

Two dependent variables are used in the logistic regression willingness to pay models (Table 3). The first dependent variable includes all of the *yes* responses to the willingness to pay question, "*all yes*." The second dependent variable is the *yes* responses with only the "*very sure*

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[9] The probit model allows both median and mean estimation. Attempts to estimate the mean willingness to pay with these data generated unrealistically large estimates of willingness to pay (i.e., mean willingness greater than the highest price offered).

yes" respondents considered, *yes-sure*. We split the sample into those who had evacuated for a recent hurricane and those who had not to determine if preferences differ between these two groups. Overall model performance is similar for all four models. The model χ^2 statistic indicates that each of the models' vector of coefficient estimates are jointly statistically significant. The pseudo-R^2 statistics are similar across each model.

In general, the coefficient estimates obtained are as expected. The probability of a yes response decreases with the price amount. The probability of a yes response is unaffected by the evacuation probability except in the *all yes* model for those respondents who had not previously evacuated. The coefficient on the evacuation cost is statistically significant in all models. The coefficient on income is positive and statistically significant in the *very sure yes* model for those respondents who had not previously evacuated.

The willingness to pay estimates are low relative to the range of the insurance policy prices, as expected. The willingness to pay estimates are not significantly different from zero for those respondents who had evacuated previously.[10] The willingness to pay estimates for those who had not evacuated previously are $34 in the *all yes* model and $20 in the *very sure yes* model. Both of these estimates are statistically different from zero. In each *very sure yes* model the 90 percent confidence interval around the willingness to pay estimate includes the mean of the expected evacuation cost.

The performance of the models in Table 3 suggests that respondents do not consider the probability of an evacuation when determining whether they will purchase evacuation cost

[10] Willingness to pay is not statistically different from zero even when the policy price is the only independent variable included.

insurance. This result could indicate that the expected utility model is not a good description of behavior or that measurement error or other econometric problems associated with the evacuation probability variable preclude reliable empirical modeling.[11] We examine additional models of willingness to pay by directly including factors that lead to hurricane evacuation as factors that might explain the hurricane cost insurance purchase decision (Table 4). Overall model performance is similar for all four models. The model χ^2 statistic indicates that each of the models' vector of coefficient estimates are jointly statistically significant. The pseudo-R^2 statistics are similar across each model.

Results on the variables that are included in all models of Table 3 and Table 4 are similar. The probability of a yes response decreases with the price amount. The coefficient on the evacuation cost is statistically significant in all models except the *all yes* model for those who had not previously evacuated. The coefficient on income is positive and statistically significant in the *very sure yes* model for those respondents who had not previously evacuated.

In each model one of the factors that is correlated with hurricane evacuation helps explain the insurance purchase.[12] For households that had previously evacuated, those who live in a mobile home are more likely to purchase insurance. For those respondents who are very sure about their purchase, living in a mobile home does not matter but pet ownership increases demand. For those respondents who had not previously evacuated, those who perceive high wind risks are more likely to purchase the insurance. These results are mixed but suggest that those

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[11] These concerns are detailed in the conclusions and Appendix.

[12] Too few respondents who had not evacuated lived on an island to reliably estimate this coefficient.

who are more likely to evacuate are more likely to purchase the insurance as expected utility theory suggests.

The willingness to pay estimates are not significantly different from zero for all respondents. This is due to the inclusion of additional independent variables, many of which have statistically insignificant coefficients.

Conclusions

We estimate the willingness to pay for household hurricane evacuation insurance – a new product for which there is currently no market – with the contingent valuation method. The CVM is well-suited to this task because it elicits behavioral intentions to hypothetical questions. Respondents are presented with a randomly selected price from a range of prices that might lead to a profitable insurance product and asked if they would purchase the product. We find that a majority of respondents would not purchase the product at even the lowest price. Our results indicate that hurricane evacuation insurance would not be a profitable product.

We also test the predictions of expected utility theory. In low risk, high loss studies respondents may have difficulty perceiving and calculating the expected costs of the hazard event (e.g., McClelland, Schulze and Coursey, 1993). Some may narrowly focus on the low risk and base their behavior on subjective expected costs that are lower than objective expected costs. Others may narrowly focus on the high loss and base their behavior on subjective expected costs that are higher than objective expected costs. Either misperception may lead to behavior that deviates from the expected utility model. With low risk, low loss hazard events, focus on either the risk or the loss may not cause subjective expected costs to deviate much from objective expected costs and the expected utility model may be a good description of behavior.

We find some evidence that respondents are rational in response to evacuation probabilities and costs. These results for a low risk, low loss hazard event are in contrast to previous research that has found expected utility theory to be lacking as a good description of behavior under uncertainty.

Respondents who have not evacuated for a recent hurricane are more likely to be willing to pay for insurance. Those respondents who have experienced the inconvenience and expenditures related to a hurricane evacuation are those least willing to pay for it. This result may be somewhat surprising. Considering, however, the assertion that evacuation costs are a constraint on evacuation behavior, this result is not so surprising. Respondents who see evacuation costs as a constraint, but would like to evacuate during a hurricane event, are willing to purchase insurance that would reimburse them for their evacuation costs making them more likely to evacuate. Not surprisingly, in a follow-up question, respondents state that they would be more likely to evacuate if they purchased the evacuation cost insurance.

Further research should consider the moral hazard of evacuation insurance. The potential for increased evacuation behavior could lead to significantly more congestion and evacuation costs. Future research should also incorporate better measures of hurricane activity, including objective and subjective measures.

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Table 1. Willingness to Pay at Alternative Prices

Had Evacuated

Price	*All yes*	Percent	*Very sure yes*	Percent	Cases
50	17	41.46	15	36.59	41
100	10	25.00	2	5.00	40
140	9	28.13	4	12.50	32
190	7	17.95	4	10.26	39
240	10	25.64	6	15.38	39

Had Not Evacuated

Price	*All yes*	Percent	*Very sure yes*	Percent	Cases
50	16	42.11	11	28.95	38
100	9	20.45	3	6.82	44
140	6	15.38	3	7.69	39
190	3	8.33	1	2.78	36
240	7	19.44	4	11.11	36

Table 2. Data Summary

	Had Evacuated			Had Not Evacuated		
	Mean	Min	Max	Mean	Min	Max
Probability	0.203	0.020	0.484	0.066	0.020	0.405
Cost	393.51	0	2718	380.29	41.90	906
Expected cost	90.04	0	1298	27.36	5.89	211
Income ($1000s)	47.98	5	150	50.97	5	150
Island	0.178	0	1	0.03	0	1
Mobile	0.325	0	1	0.104	0	1
White	0.848	0	1	0.850	0	1
Pets	0.560	0	1	0.617	0	1
Windrisk	0.471	0	1	0.264	0	1
Insurance	0.335	0	1	0.197	0	1
Cases		191			193	

Table 3. Logistic Regression Willingness to Pay Models

	Had Evacuated				Had Not Evacuated			
	All yes		*Very sure yes*		*All yes*		*Very sure yes*	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	0.84	0.56	2.16	1.23	1.46	0.86	1.66	0.82
ln *Price*	-0.50	-1.69	-0.86	-2.40	-0.99	-2.92	-1.20	-2.84
Probability	1.24	1.22	-0.91	-0.70	5.93	1.71	5.29	1.39
Cost	0.001	3.30	0.001	3.26	0.003	2.81	0.002	1.78
Income	-0.002	-0.36	-0.001	-0.17	0.005	0.93	0.011	1.68
χ^2	18.47		18.07		22.20		15.94	
Pseudo-R^2	0.10		0.11		0.11		0.12	
Cases	191		191		193		193	
WTP	15.94	0.82	14.83	1.18	34.41	2.31	20.14	1.72

Table 4. Expanded Logistic Regression Willingness to Pay Models

	Had Evacuated				Had Not Evacuated			
	All yes		*Very sure yes*		*All yes*		*Very sure yes*	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	0.729	0.44	1.107	0.57	1.206	0.63	0.410	0.17
ln *Price*	-0.536	-1.70	-0.776	-2.10	-0.899	-2.60	-1.088	-2.49
Cost	0.001	2.84	0.001	2.06	0.003	1.32	0.006	1.73
Income	0.003	0.52	-0.001	-0.16	0.005	0.81	0.015	2.01
Island	0.009	0.02	-0.715	-0.97				
Mobile	1.250	2.83	0.284	0.57	1.041	1.33	1.472	1.51
White	-0.840	-1.71	-0.267	-0.44	-0.265	-0.37	-0.104	-0.12
Pets	0.597	1.44	0.964	1.78	-0.169	-0.23	-1.114	-1.17
Windrisk	0.039	0.10	0.043	0.10	0.945	2.28	0.874	1.67
Insurance	0.371	0.90	0.455	0.95	0.232	0.45	-0.954	-1.28
χ^2	35.5		23.94		29.68		22.06	
Pseudo-R^2	0.16		0.15		0.15		0.16	
Cases	191		191		193		193	
WTP	14.61	0.79	10.12	0.86	21.52	1.51	11.80	1.13

Appendix

Comparative Statics

The difference in expected utility with and without hurricane cost insurance is

(A-1) $$\Delta E(v) = rv(y-p) + (1-r)v(y-p) - [rv(y-c) + (1-r)v(y)]$$

After some algebra the difference in expected utility simplifies to

(A-2) $$\Delta E(v) = v(y-p) - v(y) - r[v(y-c) - v(y)]$$

Households will purchase insurance if the difference in expected utility is positive or equal to zero. The difference in expected utility, and the likelihood of purchase, decreases as the price increases

(A-3) $$\frac{\partial \Delta E(v)}{\partial p} = \frac{\partial v(y-p)}{\partial p} < 0$$

The difference in expected utility increases as the evacuation cost increases

(A-4) $$\frac{\partial \Delta E(v)}{\partial c} = -r\frac{\partial v(y-c)}{\partial c} > 0$$

Since utility is higher when evacuation costs are not incurred the difference in expected utility increases as the evacuation probability increases

(A-5) $$\frac{\partial \Delta E(v)}{\partial r} = -[v(y-c) - v(y)] > 0$$

Changes in the difference in expected utility are ambiguous to income changes

(A-6) $$\frac{\partial \Delta E(v)}{\partial y} = \left[\frac{\partial v(y-p)}{\partial y} - \frac{\partial v(y)}{\partial y}\right] - r\left[\frac{\partial v(y-c)}{\partial y} - \frac{\partial v(y)}{\partial y}\right] \gtrless 0$$

With diminishing marginal utility of income the sign of both terms in brackets is positive. The price of evacuation insurance should be considerably lower than the evacuation cost making the first bracketed term smaller than the second. The magnitude of the second bracketed term is weighted downward by the probability of evacuation.

Estimating the Evacuation Probability

We estimate the hurricane evacuation probability given storm intensity with a stated preference model. Table A-1 presents some alterative models that were considered. The first model combines the evacuation behavior associated with hurricanes Bonne (j = 2), Dennis (j = 1) and Floyd (Hurricane Floyd approached North Carolina as a borderline category 3 and category 4 hurricane but landed as a category 2 and is coded j = 3 and 4). We combine these revealed preference (RP) data with the stated preference (SP) evacuation behavior to create RP-SP panel data with four "time" periods. Since all survey respondents were not at home during each storm event we lose n = 58 cases for a total of n = 326.

The random effects probit panel data results are as expected. Evacuation behavior is increasing in storm intensity. Respondents who live on an island and in mobile homes are more likely to evacuate. Respondents who perceive that their residence faces high wind risk and those who own flood insurance are more likely to evacuate. We find no evidence of hypothetical bias in this model with a statistically insignificant coefficient on the stated preference dummy variable.

We next estimate similar models with only the stated preference data. The first model, SP-1 Probit, uses the same sample of n = 326 respondents as the RP-SP model. The second model, SP-1 Logit, uses the same sample but the logistic distribution. The third model, SP-2 Logit, uses the full sample. Coefficient results for the three SP models are similar in magnitude to the RP-SP models. The major difference is that white respondents are more likely to state that they will evacuate than the model in which the race effect is constrained to be equal between the revealed and stated behavior (RP-SP model). We conclude that there is little bias to using the SP-2 model. The gain is the increased econometric efficiency of the willingness to pay models due to the increased sample size.

The standard instrumental variables approach in this context requires that the predicted evacuation probability be obtained from a model that includes all of the variables that affect willingness to pay, the evacuation factor variables and instrumental variables. Instrumental variables are those that are correlated with the evacuation probability but not willingness to pay. The instrumental variables in this model are the evacuation orders. Further, the willingness to pay model should include the other variables that affect evacuation in order to determine if the effect of the evacuation probability is distinct from preferences measured by the evacuation factors. However, in this context, the evacuation factors should only influence willingness to pay through their effect on the evacuation probability. We do not include these in the willingness to pay model.

Estimating the Evacuation Cost

We estimate hurricane evacuation costs for those respondents who had not evacuated for a recent hurricane (Table B-2). We use a Tobit regression model to account for the number of zero values. White respondents, older respondents and those who live on an island spend less on an evacuation. Those who live in mobile homes spend less, perhaps because they are most likely to evacuate to shelters. Those who have pets spend more on evacuation, perhaps due to kennel fees or increased search costs for motels or the homes of friends or family that allow pets. Those who receive an evacuation order spend more.

The predicted values from this model are used in the willingness to pay models for those respondents who had not recently evacuated. For those who had recently evacuated we include the total cost variable. We test for the endogeneity of this variable by including the residual from Table B-2 as an additional regressor. The coefficient on this variable is not significantly different from zero. Joint estimation of evacuation probabilities and evacuation costs (i.e., a sample selection model) was attempted to improve the efficiency of estimation of evacuation costs for non-evacuees. This model proved unreliable.

Table A-1. Evacuation Models

	RP-SP Probit		SP-1 Probit		SP-1 Logit		SP-2 Logit	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	-1.89	-5.35	-1.05	-3.14	-1.87	-3.09	-2.32	-4.08
Category 2	0.59	3.73	0.50	1.60	1.01	1.75	1.14	2.19
Category 3	1.34	7.78	0.76	2.63	1.38	2.53	1.61	3.16
Category 4	1.50	4.14	0.87	2.83	1.64	2.87	1.87	3.58
Category 5	2.29	8.15	1.52	5.14	2.71	4.90	2.79	5.47
Income	0.00	-0.80	0.00	-1.39	-0.01	-1.37	0.00	-0.81
Island	0.24	0.61	-0.12	-0.23	-0.28	-0.31	1.59	2.68
Mobile	1.00	4.58	0.76	3.40	1.31	3.40	1.56	4.61
White	-0.36	-1.46	-0.60	-2.48	-1.04	-2.51	-0.95	-2.42
Pets	-0.34	-1.95	-0.18	-0.95	-0.32	-1.00	-0.23	-0.77
Windrisk	0.35	1.96	0.41	2.20	0.66	2.03	0.55	1.84
Insurance	0.20	1.02	0.31	1.40	0.58	1.50	0.81	2.38
Evacorder	1.58	4.92	0.84	3.22	1.49	3.24	1.37	3.10
Mandatory	0.43	0.99	2.04	3.14	3.48	2.87	2.87	2.44
SP	-0.10	-0.67						
ρ	0.54	10.42						
$\chi 2$	538.08		155.56		155.20		192.15	
Cases	326		326		326		384	
Periods	4		1		1		1	

Table A-2. Tobit Evacuation Cost Model

	Coeff.	t-ratio
Constant	472.53	2.21
Island	-457.97	-2.81
Mobile	-406.80	-3.86
White	-245.45	-1.85
Pets	354.27	3.73
Wind	65.28	0.68
Insurance	118.44	1.09
Age	-5.12	-1.87
Order	437.44	3.72
Mandatory	154.48	0.99
σ	591.14	16.42
Cases	191	