# Homeowner Responses to Hurricane Risk Perceptions

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## Abstract

Homeowners upfit homes in hurricane-prone areas as a function of their perceptions of the exposure of the home to catastrophic risk. We consider these perceptions using a survey of coastal North Carolina homeowners; we measure how perceptions of hurricane damage expectations correlate with the purchase of defensive home improvements. We find that higher household income, larger insurance deductibles, and increased expectations of category 3 hurricane strikes raise the likelihood of purchasing damage-mitigating improvements. Interestingly, increasing expectations of category 4 and 5 hurricane strikes are not significantly associated with mitigation decisions. On reflection, this is actually rational, as most insurance deductibles cap homeowners' potential dollar-damages with those more severe storms. Varied stakeholders, from homeowners to insurers to policymakers and lenders, might use these findings in their own decision-making.


## Introduction

Risks to life and property from hurricanes are highlighted by the collective power of the storms of 2004 and 2005. Grace, Klein and Liu (2006) underscore these escalating hurricane losses between 1985 and 2005. The data are damning. Though unsettled arguments may exist concerning the propensity of the Tropical Atlantic to generate hurricanes in the years to come, no such disagreement exists about the enormous property damages over the past few years. While the moderate seasons of 2006 and 2007 may well establish the pattern of hurricane losses in the next few years, that pattern might just as easily have been anticipated by Hurricanes Katrina, Rita and Wilma in 2005.

Recent studies by Morgan (2007) and Graham, Hall and Schuhmann (2007) reveal statistically significant market responses by homeowners to perceptions of hurricane risks; these responses are observed following Hurricane Ivan along the Florida Gulf Coast in 2004, and with a series of hurricane strikes along the mid-Atlantic in the late 1990's. Both studies underscore anomalous market behavior adjacent to the hurricane landfalls. Morgan suggests that a real estate market "imbalance" results with subsidized flood insurance, and that residential markets do not properly account for the hurricane flood risk with such subsidies. Nonetheless, she observes negative residential pricing adjustments following Hurricane Ivan along Florida's gulf coast. Graham, Hall and Schuhman similarly observe significant market responses to seemingly greater exposure of the mid-Atlantic to hurricane strikes in the late 1990's. These market responses are tempered over time, as the nation's "hurricane alley" moved to South Florida and the Gulf coasts.

Introduced by Andrew in South Florida in 1992, this period of increasing hurricane losses invites detailed review by sundry vested interests: Insurers, lenders, policymakers and homeowners need to consider these risks of hurricane losses in their decision-making. Homeowner responses to these risks, especially in light of the grave, uninsured, and unmitigated losses reported in 2004 and 2005 in the daily press, are an especially attractive topic for review.

In this study, we extend the examination of the real estate market surrounding hurricane landfalls with a reconsideration of the risk perceptions of homeowners in an area that seems to be at an elevated risk of hurricane loss. We review actions homeowners take to limit losses with such upfits to their homes as roof tie-downs, storm windows and reinforced doors.

Though hurricanes pose a very real threat to property, it is surprising that homeowners do not, in general, purchase mitigation devices to protect against hurricane damages. Camerer and Kunreuther (1989), Kunreuther (1996) and Petak (1998) report the irregular use of available mitigation devices by homeowners at hurricane risk. Against the finding that many homeowners do not enhance their homes against hurricanes, some coastal homes that include costly mitigation actually command higher market prices. Simmons, Kruse, and Smith (2002) find that home values on a Gulf Coast barrier island increase as structural integrity increases. They suggest that the purchase of storm blinds is cost-effective as home values are increased by an amount greater than the cost of installed storm shutters. Kleindorfer and Kunreuther (1999) show that roof reinforcements reduce insurer exposure in the event of a hurricane and that homeowners are "slightly better off" with these defenses.

Given the potential returns from these home improvements, an evolving literature suggests two main reasons why homeowners don't respond to the risk of these low-probability, high-consequence events with the purchase of defensive measures. First, Kunreuther and Kleffner (1992) and Burrus, Dumas, Graham (2002, 2005) find that the availability of insurance undermines the incentive to protect against hurricane damages using structural mitigation. Most mortgages require insurance against storm damage – though some homeowners and lenders overlook flood insurance – and take the insurance-purchase decision out of the homeowner's hands before closing. Second, and perhaps the most popular explanation for the lack of mitigation devices is that homeowners underestimate hurricane strike probabilities. McClelland, Shulze, and Hurd (1990) and Kunreuther (1996) suggest that homeowners may assign a probability of zero to low-probability, catastrophic events. Camerer and Kunreuther (1989) and Kruse and Simmons, (2005) believe these homeowners have a "can't happen to me" attitude about catastrophic risk; similarly, Kunreuther and Pauly (2004) suggest that homeowners underestimate probabilities due to the search costs of obtaining good probability information. Further, and even if strike probabilities are not underestimated, Burrus, Dumas, Graham (2005) show that homeowners may underestimate damage resulting from a strike.

The importance of risk perceptions in catastrophic event preparedness is the focus of a related literature. Two recent papers employ contingent valuation methodology to determine whether risk perceptions impact the willingness-to-pay (WTP) for hypothetical hurricane and tornado mitigation devices designed to prevent property damages and loss of life, respectively. Burrus, Dumas, and Graham (2005), find that income, the availability of insurance, the insurance deductible, and hurricane-strike probability impact the decision to purchase a hypothetical bundle of mitigation devices designed to protect the home against wind speeds up to 130 mph (ie. a category 3 hurricane). Similarly, Ozedemir (2005) finds that the perceived tornado risk has a large impact on WTP for a tornado safe room. Whitehead (2005) does not use the contingent valuation method, but finds that individuals do consider risk in deciding whether to develop an evacuation plan or prepare their property in advance of a hurricane.

We extend these earlier studies by investigating how hurricane risk perceptions impact the number of mitigation devices purchased by homeowners. Using coastal homeowner survey data, we construct a hurricane mitigation index that measures the number of mitigation devices that homeowners select. We test whether various measures of hurricane risk impact this index. We also investigate the relationships between hurricane risk measures and the probabilities of using specific hurricane mitigation devices such as window coverings and roof or door reinforcements.

We describe the survey methods and data in the next section of the paper. Following the survey description, a model is developed to test whether perceptions of risk impact the number of mitigation devices employed by the homeowner. The model's results are then provided. We summarize with a brief consideration of the implications of the study's findings.

**Data**

A telephone survey of 336 homeowners living in three coastal, hurricane-prone North Carolina counties (Brunswick, New Hanover, and Pender) provides the data for this study.[1] We collect demographic data, as well as information about home value, the extent of existing mitigation, the homeowners' perceptions about hurricane strike probabilities for hurricane categories 3 through 5, subjective information about the damages that the homeowners expect from landfalls of these major storms, and the homeowners' insurance deductible. Of the 336 homeowners, 119 respondents provide complete answers for all of the questions.

Of these 119 respondents, 53.8 percent were female, 91.2 percent were Caucasian, 83 percent were married, 39.5 percent had dependents under the age of 18 in their home, and 58.8 percent had pets in their home. The average education was the equivalent of 2 years in college, and average household income was approximately $50,000. The average home value was around $166,000, and the average wind damage deductible was about $475.

We focus in the following discourse on wind damage mitigation purchased by the homeowner months or years after the home is completed. Structural flood mitigation - such as home elevation and house relocation - is inordinately costly and rarely financially justified after home completion.

The survey respondents were asked whether their homes had one or more of these features to protect against hurricane winds: Reinforced roofs, window coverings or door coverings.. Slightly over half of the respondents reported the existence of roof reinforcements in the attic; thirty-two percent reported having storm resistant window coverings; twenty percent reported having door coverings. Homes were typically equipped with 1.04 of the three possible mitigation features.

Homeowners, on average, estimated that hurricane categories 3, 4, and 5 would do damage equal to about 10.6 percent, 22.1 percent, and 61.7 percent of the value of the home, respectively. Multiplying the percentage damage estimates by the dollar value of the homes and averaging over homeowners, expected damages were around $18,000 for a category 3 hurricane, $38,000 for a category 4 hurricane, and $100,000 for a category 5 hurricane.[2]

Homeowners estimate the annual likelihood of a category 3 hurricane strike is 0.36, while the estimated average annual probabilities of category 4 and 5 storm strikes are 0.15 percent and

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[1] A "homeowner" owns the house and is also the individual making decisions regarding hurricane preparations. The survey was conducted after Hurricane Floyd struck North Carolina in 1999, but before the 2004-2005 hurricane seasons.

[2] Note that the average expected damages are less than the average percent of damages done to the home times the average value of the home; the distributions of home value and subjective damage estimates are skewed. The owners of the more expensive homes expect, on average, lower percentage damages than the owners of the less expensive homes with a category 5 landfall; $100,00 is less than 61.7% of $166,000.

0.075 percent, respectively. Multiplying each of these subjective annual strike probabilities by the damage estimates, and averaging over homeowners for each hurricane category, expected average annual damage estimates for category 3-5 hurricanes are $6,064, $8,643, and $9,413, respectively. Summing over the hurricane categories, homeowners expect to incur damages equal to around $24,000 per year. Importantly, of this amount they expect to pay only $475 per year out-of-pocket, since the average deductible is only $475, and damages above the deductible are covered by insurance; this assumes the solvency of the insurer and insured damages paid in a timely fashion.

**Model**

Recalling factors from our survey that we believe are associated with the selection of wind-resistant mitigation devices, the following model is estimated:

$$\text{MITIGATION} = \beta_0 + \beta_1(\text{INCOME}) + \beta_2(\text{DEDUC}) + \beta_3(\text{RACE}) + \beta_4(\text{MARR}) + \beta_5(\text{FEMALE}) + \beta_6(\text{EDUC}) + \beta_7(\text{CHILD}) + \beta_8(\text{PETS}) + \beta_9(\text{PERGOV}) + \beta_i(\text{RISK}_i) + e,$$

where variable names and definitions are summarized in Table 1.

[Table 1 about here]

Two specifications of dependent variable MITIGATION are considered. First, we construct an index variable equal to the total number of mitigation features currently installed on the survey respondent's home. These mitigation measures include window coverings, door reinforcements, and roof strengthening measures. If a homeowner has window coverings and roof reinforcements, for example, the index equals two. We use a count-data Poisson regression modeling framework when MITIGATION is measured by this index. Second, and in subsequent model runs, MITIGATION is a dummy variable signaling the use of a specific mitigation measure (window, roof, or door reinforcements). When MITIGATION is a dummy, we use the limited dependent variable Probit regression modeling framework. Thus, with these two specifications of the MITIGATION variable, we are able to (1) determine the likelihood of mitigation in general as a function of the independent variables, and (2) discover the probability that a specific type of mitigation purchase is related to one or another of these factors.

Consistent with Whitehead (2005), we expect that mitigation is a normal good--mitigation purchases increase with income; we believe also that these purchases increase as a homeowner's deductible increases. Further, and consistent with prior studies by Kruse and Simmons (2005), Burrus, Dumas, and Graham (2005), and Ozdemir (2005), we believe male household decision-makers are more likely to pay for mitigation; we anticipate a negative FEMALE coefficient. As well, Ozdemir (2005) finds that the presence of children in the home leads to a higher maximum willingness-to-pay for tornado mitigation; we expect this to be echoed with a positive CHILD coefficient.

Extending Whitehead (2005), who finds that Caucasians are more likely to prepare property in advance of a hurricane strike, we expect that RACE will have a positive impact on

MITIGATION. We hypothesize that homeowners with pets (PETS) will own more mitigation devices since they may choose to stay at home with the pet during the storm, or since they may evacuate and leave the pet behind. Earlier research does not suggest results for married couples (MARR) and persons with more education (EDUC). We expect that both marriage and education will positively impact the likelihood and degree of mitigation purchases. PERGOV is a dummy denoting homeowners' attitudes toward government hurricane assistance programs. If homeowners believe that the government will pay for damages, they will be less likely to employ mitigation devices, and we would expect PERGOV to be negative.

The final variable influencing mitigation choices is one for the homeowners' perceptions of hurricane risks; this is the centerpiece of this research and provides the most meaningful of our results. We employ several measures of these risk perceptions based on the homeowners' estimates of hurricane strike probabilities and subsequent wind damages. In Model 1, both the subjective hurricane strike probabilities and damages are considered. We include the probabilities and damages for hurricane categories 3-5 separately in the regression. These variables are coded PROB3, PROB4, PROB5, DAM3, DAM4, and DAM5, respectively.

In Model 2, the risk variables considered are EXDAM3, EXDAM4, and EXDAM5, which represent the subjective annual expected damages (in thousands of dollars) that would result from category 3-5 hurricanes. Each of these variables is the product of the homeowner's strike probability estimate for a category i hurricane, the perceived percentage loss of home value that would result from a category i hurricane strike, and the value of the home.

Model 3 uses EXDAMTOT as the measure of risk. EXDAMTOT is the sum of EXDAM3, EXDAM4, and EXDAM5 (from Model 2) and is the subjective annual expected damage from all major hurricanes (in thousands of dollars). As any of these risk measures increases, we anticipate that the number of mitigation devices installed and the probability of the installation of a specific mitigation measure will increase. Coefficient estimates for each of these three models are given in Tables 2-8.

**Results**

Findings with the Poisson models, where the dependent variable MITIGATION is equal to the count of all wind mitigation measures used, are presented in Table 2.

[Table 2 about here]

The coefficient estimates on INCOME are statistically significant in all three model runs and the estimate on DEDUC is statistically significant in one of the three versions of the model (Models 1). All INCOME and DEDUC coefficients have the predicted sign; higher levels of income and higher deductibles lead to higher levels of mitigation. Other significant variables include EDUC with the predicted positive sign in Model 2 and PETS in Model 3 with a negative sign, the reverse of our expectations. Perhaps homeowners with pets evacuate more readily, face less risk of personal injury, and therefore engage in less mitigation. Although the CHILD and PERGOV coefficients have the predicted signs, they are not significant. The coefficients on FEMALE, RACE, and MARR are not significant.

Model 1 results show that homeowners with higher subjective estimates of the probability of a category 3 hurricane strike are more likely to have mitigation devices. This is the only risk variable that is significant in Model 1. Mirroring the findings of the first model, Model 2 results indicate that homeowners with higher expectations of damage from category 3 hurricanes are more likely to own mitigation devices. Once again, expected damages from other hurricane categories are not significant. Model 3 shows that, overall, mitigation does respond positively to catastrophic risk; the coefficient estimate for the total of expected damages from category 3-5 storms is positive and significant. This result is likely driven by the findings from the first two model runs that show that homeowners are primarily responsive to risk from category 3 hurricanes.

Results from the Probit models for the individual home mitigation devices are found in Tables 3 – 5.

[Tables 3 – 5 about here]

The results from these model runs are generally consistent with our Poisson model findings.

INCOME is positive and significant in all nine of the models as it was in the three Poisson models. DEDUC, however, is positive and significant in only the door regressions in Table 3. Other variables that were significant in the Poisson models were EDUC and PETS; these variables also have significance in some of the individual mitigation devices models. EDUC is positive and significant in Model 2 of the window regressions, and the estimate on PETS is negative and significant in the all three roof regressions and in Model 3 of the door regressions. The only other non-risk coefficient estimate significant in the separate window, roof, and door regressions is the estimate on CHILD in Model 3 of the door regressions. This variable is not significant in any of the index model runs.

The risk associated with a category 3 hurricane is, again, important in determining whether windows, roofs, and doors are protected. PROB3 is significant in Model 1 for each of these mitigation devices and damages to the home from a category 3 storm (DAM3) and a category 4 storm (DAM4) are significant in Model 1 of the door regressions (though the sign for the DAM4 coefficient estimate is not in the predicted direction). Likewise, the expected damages from category 3 hurricanes (EXDAM3) are significant in Model 2 for each of the mitigation features. Expected damages from category 4 and 5 storms (EXDAM4 and EXDAM5) are also significant in Model 2 of the window regressions though the estimate for EXDAM4 is not in the direction predicted. EXDAMTOT is significant only in the door regression.

Since the decisions to purchase specific mitigation devices may be correlated, a multivariate Probit regression is estimated for each of Models 1-3. Results indicate that the decisions to protect windows and doors are correlated in each of the models (see Tables 6 – 8).[3]

[Tables 6 – 8 about here]

Parameter estimates generally suggest, again, that higher levels of income increase mitigation. The only other significant parameter estimates, however, are expected damages for a category 3 hurricane in the roof and door equations of Model 2 and the deductible estimate in the door equation of Model 3.

[3] The decision to install window, roof, and door reinforcements were all correlated in Model 3.

**Discussion and Conclusion**

The primary goal of this paper is to investigate the impact of subjective perceptions of hurricane risk on homeowners' structural mitigation purchases. We find that increased homeowner income and higher deductibles lead to increased levels of mitigation. With regard to risk, we find that subjective estimates of category 3 hurricane strike probabilities significantly influence mitigation decisions. It appears that subjective strike probability estimates for higher-severity category 4 and 5 storms are not influential, even though expected damages are higher for higher-severity storms. We offer three possible explanations for these findings.

First, the difference in results for category 3 hurricanes in comparison with results for. higher severity storms may indicate that homeowners take into account changes in the estimated probabilities of higher-probability, lower-intensity category 3 storms but may dismiss lower-probability, higher-consequence category 4 and 5 events. This explanation is consistent with much of the literature on natural disasters.

Second, many after-market mitigation devices are rated only to category 3 wind strengths (Burrus, Dumas, and Graham, 2002). The few mitigation measures with ratings up to a category 4 and 5 wind speeds are very expensive. Since mitigation measures rated above a category 3 hurricane are not generally available or are very expensive, and as homeowners may not believe the claims that such devices would withstand higher intensity storms, homeowners likely ignore higher category storms when deciding whether to install mitigation devices.

Third, differences in the expected damages caused by hurricanes of differing severities in comparison with insurance deductible thresholds may explain why changes in category 3 strike probabilities appear to affect mitigation behavior, while changes in the strike probabilities of more severe hurricanes do not. If we assume that tropical storms and category 1 and 2 hurricanes can be expected to cause negligible damage, then category 3 storms would be the weakest storms expected to cause any significant damage and therefore to potentially influence mitigation decisions. Based on homeowners' reported, subjective estimates of category 3 storm damage, these storms would be expected to cause damage beyond the typical insurance deductible. However, homeowners are only liable for damage below the deductible; any damage above the deductible is covered by insurance.

So what about the category 4 and 5 storms? Although one of these storms is expected to cause more damage than a category 3 storm, the additional damage is irrelevant to the homeowner, since it is far above the deductible. It becomes rational for homeowners to focus on changes in the likelihood of category 3 storms, and to neglect any foreseeable changes in the likelihoods of category 4 and 5 storms, when making mitigation decisions.

In closing, we offer the caveat that hurricane strike probabilities for a particular geographic location are relatively low, and studies find that most people have difficulty evaluating low probability risks. However, it could be argued that coastal North Carolina residents are very familiar with the type of low-probability threat in question, as the region frequently experiences hurricane watches, tropical storm strikes, and low-severity (Category 1 and 2) hurricane landfalls.

Finally, the purpose of this study is not to investigate whether homeowners make mitigation decisions correctly, but rather to understand how homeowners make mitigation decisions with the limited information at hand and with current, imperfect public policies in place. We believe that an understanding of how homeowners make these decisions is critical to the policy improvement process. This understanding is important also to all the stakeholders in the coastal real estate markets, including insurers, builders, lenders, and homeowners; each can harvest invaluable dividends from a better understanding of this behavior.

"These findings are of value to at least five audiences: first, the homeowner and prospective buyer will be able to use the study's findings to motivate market behavior as a function of the market participant's views on the susceptibility of the market to catastrophic risk; second, these results may assist institutional lenders/insurers as they consider lending/insuring policies for a given area; third, the findings are valuable to local and regional governing bodies as they consider area land uses, perhaps tailoring planning activities according to the degree to which an area is at risk; fourth, these results may anticipate the manner with which similarly afflicted markets may behave in the time following one or multiple hurricane landfalls; finally, the results are important as a complement to existing academic research, and as an encouragement for later studies. "

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| **Table 1: Variable Names and Definitions** | |
|---|---|
| INDEX | The number of the following features with which the home is equipped: roof reinforcements, window coverings, and door coverings. |
| INCOME (in thousands of $) | Homeowner income: categories are $0 - $10,000; 10,001 - 15,000; 15,001 - 20,000; 20,001 - 25,000; 25,001 - 30,000; 30,001 - 40,000; 40,001 - 50,000; 50,001 - 60,000; 60,001 - 75,000; 75,001 - 150,000; above $150,000. Incomes are coded as the midpoint of the income categories, and, thereafter, are divided by 1,000. |
| DEDUC (in hundreds of $) | Homeowner's insurance deductible divided by 100. |
| RACE | 1=white; 0=other |
| MARR | 1=married; 0=other |
| FEMALE | 1=homeowner is female; 0=homeowner is male |
| EDUC | Years of education |
| CHILD | 1=dependents under the age of 18 live in the home; 0=other |
| PETS | 1=homeowner has pets; 0=other |
| PERGOV | Attitude toward government assistance. 1=very positive or somewhat positive; 0=other |
| PROBi | Perceived annual probability of a category i hurricane strike (expressed as a ratio) |
| DAMi | Percentage of home value expected to be completely destroyed in a category i hurricane strike (expressed as a ratio) |
| EXDAMi (in thousands of $) | Expected dollar damages from a category i hurricane strike divided by 1,000 |
| EXDAMTOT (in thousands of $) | Sum of EXDAMi |

| **Table 2: Poisson Results (Mitigation Index = Dependent Variable )** | | | | | | |
|---|---|---|---|---|---|---|
| | *Model 1* | | *Model 2* | | *Model 3* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -2.150 | -2.81* | -1.786 | -2.37** | -1.434 | -2.01** |
| INCOME | 0.011 | 4.12* | 0.010 | 3.67* | 0.000 | 4.19* |
| DEDUC | 0.036 | 1.75*** | 0.022 | 1.08 | 0.000 | 1.47 |
| RACE | -0.168 | -0.40 | -0.084 | -0.21 | -0.271 | -0.69 |
| MARR | 0.025 | 0.08 | -0.046 | -0.16 | 0.219 | 0.75 |
| FEMALE | 0.027 | 0.13 | -0.050 | -0.25 | -0.069 | -0.35 |
| EDUC | 0.065 | 1.44 | 0.077 | 1.73*** | 0.055 | 1.26 |
| CHILD | 0.110 | 0.52 | 0.118 | 0.56 | 0.134 | 0.65 |
| PETS | -0.206 | -1.03 | -0.222 | -1.12 | -0.293 | -1.53 |
| PERGOV | -0.018 | -0.09 | -0.025 | -0.12 | 0.051 | 0.27 |
| PROB3 | 0.927 | 2.90* | | | | |
| PROB4 | 0.333 | 0.71 | | | | |
| PROB5 | 0.262 | 0.61 | | | | |
| DAM3 | 2.130 | 1.42 | | | | |
| DAM4 | -0.964 | -0.90 | | | | |
| DAM5 | 0.172 | 0.42 | | | | |
| EXDAM3 | | | 0.030 | 3.66* | | |
| EXDAM4 | | | -0.004 | -0.91 | | |
| EXDAM5 | | | 0.004 | 1.29 | | |
| EDAMTOT | | | | | 0.002 | 1.75*** |
| LL | -137.222 | | -139.655 | | -144.869 | |
| Res. LL | -161.428 | | -161.428 | | -161.428 | |
| Chi | 48.41153* | | 43.54579* | | 33.11804* | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

| **Table 3: Probit Results (Window Coverings = Dependent Variable)** | | | | | | |
|---|---|---|---|---|---|---|
| | *Model 1* | | *Model 2* | | *Model 3* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -3.893 | -3.19* | -2.712 | -2.53** | -2.317 | -2.28** |
| INCOME | 0.016 | 3.35* | 0.013 | 2.95* | 0.014 | 3.27* |
| DEDUC | 0.038 | 1.16 | 0.021 | 0.67 | 0.032 | 1.03 |
| RACE | -0.501 | -0.84 | -0.486 | -0.89 | -0.551 | -1.08 |
| MARR | 0.018 | 0.04 | -0.168 | -0.41 | 0.081 | 0.20 |
| FEMALE | 0.096 | 0.31 | 0.004 | 0.01 | -0.010 | -0.04 |
| EDUC | 0.101 | 1.45 | 0.115 | 1.69*** | 0.091 | 1.40 |
| CHILD | -0.276 | -0.85 | -0.184 | -0.61 | -0.067 | -0.23 |
| PETS | 0.193 | 0.63 | 0.131 | 0.45 | -0.024 | -0.09 |
| PERGOV | 0.115 | 0.38 | 0.027 | 0.10 | 0.038 | 0.14 |
| PROB3 | 1.717 | 2.97* | | | | |
| PROB4 | 0.358 | 0.38 | | | | |
| PROB5 | 1.185 | 1.21 | | | | |
| DAM3 | 2.590 | 1.16 | | | | |
| DAM4 | -1.551 | -1.00 | | | | |
| DAM5 | 0.823 | 1.31 | | | | |
| EXDAM3 | | | 0.048 | 2.67* | | |
| EXDAM4 | | | -0.013 | -1.67*** | | |
| EXDAM5 | | | 0.012 | 1.66*** | | |
| EDAMTOT | | | | | 0.003 | 1.39 |
| LL | -53.04 | | -57.52 | | -62.65 | |
| Res. LL | -74.54 | | -74.54 | | -74.54 | |
| Chi | 42.99 | | 34.03 | | 23.77 | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

| Table 4: Probit Results (Roof Reinforcement = Dependent Variable) | | | | | | |
|---|---|---|---|---|---|---|
| | *Model 1* | | *Model 2* | | *Model 3* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -1.989 | -1.92*** | -1.519 | -1.52 | -1.445 | -1.48 |
| INCOME | 0.017 | 3.35* | 0.015 | 3.03* | 0.015 | 3.23* |
| DEDUC | -0.007 | -0.21 | -0.026 | -0.84 | -0.016 | -0.52 |
| RACE | 0.152 | 0.29 | 0.180 | 0.34 | 0.104 | 0.21 |
| MARR | 0.187 | 0.47 | 0.218 | 0.56 | 0.278 | 0.72 |
| FEMALE | 0.034 | 0.12 | -0.082 | -0.30 | -0.099 | -0.37 |
| EDUC | 0.072 | 1.11 | 0.043 | 0.65 | 0.044 | 0.71 |
| CHILD | -0.022 | -0.08 | -0.120 | -0.41 | -0.025 | -0.09 |
| PETS | -0.496 | -1.75*** | -0.456 | -1.64*** | -0.493 | -1.82*** |
| PERGOV | 0.184 | 0.68 | 0.241 | 0.91 | 0.306 | 1.20 |
| PROB3 | 0.951 | 1.68*** | | | | |
| PROB4 | 1.131 | 1.16 | | | | |
| PROB5 | -0.953 | -1.09 | | | | |
| DAM3 | 2.529 | 1.17 | | | | |
| DAM4 | -0.709 | -0.46 | | | | |
| DAM5 | -0.650 | -1.19 | | | | |
| EXDAM3 | | | 0.049 | 2.22** | | |
| EXDAM4 | | | 0.004 | 0.47 | | |
| EXDAM5 | | | -0.002 | -0.35 | | |
| EDAMTOT | | | | | 0.004 | 1.05 |
| LL | -65.68 | | -66.44 | | -69.51 | |
| Res. LL | -82.38 | | -82.38 | | -82.38 | |
| Chi | 33.39 | | 31.87 | | 25.74 | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

| **Table 5: Probit Results (Reinforced Doors = Dependent Variable)** | | | | | | |
|---|---|---|---|---|---|---|
| | *Model 1* | | *Model 2* | | *Model 3* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -5.128 | -3.195* | -3.745 | -2.693* | -2.843 | -2.354** |
| INCOME | 0.016 | 2.881* | 0.012 | 2.309** | 0.014 | 2.847* |
| DEDUC | 0.160 | 3.323* | 0.126 | 2.886* | 0.125 | 3.115* |
| RACE | -0.284 | -0.361 | -0.346 | -0.457 | -0.709 | -1.106 |
| MARR | -0.053 | -0.083 | -0.186 | -0.321 | 0.458 | 0.821 |
| FEMALE | 0.323 | 0.839 | 0.304 | 0.822 | 0.232 | 0.685 |
| EDUC | 0.102 | 1.175 | 0.110 | 1.32 | 0.056 | 0.749 |
| CHILD | 0.651 | 1.579 | 0.612 | 1.616 | 0.636 | 1.861*** |
| PETS | -0.541 | -1.394 | -0.563 | -1.519 | -0.640 | -1.881*** |
| PERGOV | -0.431 | -1.091 | -0.492 | -1.297 | -0.377 | -1.129 |
| PROB3 | 1.844 | 2.774* | | | | |
| PROB4 | 1.022 | 0.907 | | | | |
| PROB5 | 0.304 | 0.321 | | | | |
| DAM3 | 5.491 | 1.937*** | | | | |
| DAM4 | -4.044 | -1.973** | | | | |
| DAM5 | 1.054 | 1.391 | | | | |
| EXDAM3 | | | 0.068 | 3.561* | | |
| EXDAM4 | | | -0.011 | -1.164 | | |
| EXDAM5 | | | 0.008 | 1.313 | | |
| EDAMTOT | | | | | 0.004 | 1.714*** |
| LL | -34.45 | | -37.33 | | -44.90 | |
| Res. LL | -59.82 | | -59.82 | | -59.82 | |
| Chi | 50.75 | | 44.98 | | 29.85 | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

| **Table 6: Multivariate Probit Results (Model 1)** | | | | | | |
|---|---|---|---|---|---|---|
| | *Mitigation Device* | | | | | |
| | *Window* | | *Roof* | | *Door* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -4.070 | -1.626 | -2.149 | -1.451 | -5.506 | -1.552 |
| INCOME | 0.015 | 2.127** | 0.016 | 2.276** | 0.017 | 1.445 |
| DEDUC | 0.040 | 0.515 | -0.004 | -0.073 | 0.150 | 1.261 |
| RACE | -0.501 | -0.321 | 0.187 | 0.205 | -0.038 | -0.031 |
| MARR | 0.043 | 0.058 | 0.182 | 0.302 | -0.093 | -0.065 |
| FEMALE | 0.093 | 0.186 | 0.034 | 0.086 | 0.520 | 0.647 |
| EDUC | 0.111 | 0.722 | 0.083 | 0.923 | 0.125 | 0.653 |
| CHILD | -0.244 | -0.476 | 0.001 | 0.004 | 0.629 | 0.757 |
| PETS | 0.166 | 0.380 | -0.507 | -1.199 | -0.300 | -0.437 |
| PERGOV | 0.145 | 0.251 | 0.159 | 0.436 | -0.584 | -0.68 |
| PROB3 | 1.730 | 1.504 | 1.043 | 0.966 | 1.862 | 1.402 |
| PROB4 | 0.266 | 0.113 | 1.090 | 1.128 | 0.533 | 0.163 |
| PROB5 | 1.094 | 0.311 | -1.040 | -0.453 | 0.163 | 0.095 |
| DAM3 | 2.870 | 0.788 | 2.839 | 0.845 | 5.798 | 0.995 |
| DAM4 | -1.430 | -0.513 | -0.752 | -0.29 | -4.031 | -0.882 |
| DAM5 | 0.768 | 0.744 | -0.707 | -0.935 | 0.631 | 0.384 |
| LL | -143.57 | | | | | |
| Res. LL | -194.74 | | | | | |
| Chi | 102.34 | | | | | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

**Table 7: Multivariate Probit Results (Model 2)**

| | *Mitigation Device* | | | | | |
|---|---|---|---|---|---|---|
| | *Window* | | *Roof* | | *Door* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -3.141 | -1.73*** | -1.572 | -1.14 | -3.848 | -1.81 |
| INCOME | 0.013 | 2.22** | 0.014 | 2.11** | 0.013 | 1.64*** |
| DEDUC | 0.019 | 0.32 | -0.024 | -0.49 | 0.113 | 1.09 |
| RACE | -0.477 | -0.53 | 0.215 | 0.29 | -0.094 | -0.07 |
| MARR | -0.213 | -0.32 | 0.213 | 0.36 | 0.036 | 0.04 |
| FEMALE | 0.033 | 0.07 | -0.111 | -0.33 | 0.488 | 1.00 |
| EDUC | 0.143 | 1.21 | 0.045 | 0.50 | 0.079 | 0.53 |
| CHILD | -0.145 | -0.37 | -0.089 | -0.23 | 0.469 | 0.77 |
| PETS | 0.117 | 0.29 | -0.463 | -1.19 | -0.332 | -0.48 |
| PERGOV | 0.055 | 0.14 | 0.226 | 0.70 | -0.601 | -0.80 |
| EXDAM3 | 0.053 | 1.08 | 0.051 | 1.66*** | 0.069 | 2.35** |
| EXDAM4 | -0.012 | -0.77 | 0.005 | 0.38 | -0.010 | -0.24 |
| EXDAM5 | 0.009 | 0.65 | -0.003 | -0.17 | 0.007 | 0.45 |
| LL | -148.36 | | | | | |
| Res. LL | -194.74 | | | | | |
| Chi | 92.76 | | | | | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level

| **Table 8: Multivariate Probit Results (Model 3)** | | | | | | |
|---|---|---|---|---|---|---|
| | *Mitigation Device* | | | | | |
| | *Window* | | *Roof* | | *Door* | |
| *Variable* | *Coefficient* | *T stat* | *Coefficient* | *T stat* | *Coefficient* | *T stat* |
| Constant | -2.513 | -1.56 | -1.483 | -1.10 | -3.058 | -1.96** |
| INCOME | 0.015 | 2.83* | 0.015 | 2.40** | 0.014 | 1.89*** |
| DEDUC | 0.037 | 0.72 | -0.014 | -0.29 | 0.123 | 1.89*** |
| RACE | -0.551 | -0.67 | 0.097 | 0.16 | -0.674 | -0.73 |
| MARR | 0.036 | 0.06 | 0.278 | 0.52 | 0.581 | 0.65 |
| FEMALE | 0.003 | 0.01 | -0.131 | -0.41 | 0.292 | 0.71 |
| EDUC | 0.100 | 0.96 | 0.047 | 0.53 | 0.058 | 0.56 |
| CHILD | -0.063 | -0.18 | 0.020 | 0.06 | 0.487 | 1.03 |
| PETS | 0.032 | 0.09 | -0.491 | -1.40 | -0.468 | -0.93 |
| PERGOV | 0.056 | 0.15 | 0.320 | 1.06 | -0.347 | -0.82 |
| EXDAM3 | 0.003 | 0.89 | 0.003 | 0.50 | 0.004 | 0.74 |
| LL | -161.01 | | | | | |
| Res. LL | -194.74 | | | | | |
| Chi | 67.46 | | | | | |

* significant at the 1% level.
** significant at the 5% level
*** significant at the 10% level